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AN EXPERT SYSTEM APPLICATION TO THE INSPECTION ANALYSIS OF PAPER PRINTING QUALITY IN A PACKAGE PRINTING COMPANY

BY

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ABSTRACT

AN EXPERT SYSTEM APPLICATION TO THE INSPECTION ANALYSIS OF PAPER PRINTING QUALITY IN A PACKAGE PRINTING COMPANY

By

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The number of printing experts is gradually decreasing and the work imposed on experts inspecting printing quality is gradually increasing. These trends could lead to an increase in experts' careless mistakes, which, in turn, would decrease the overall quality of printed products. In this research project, an expert system for inspecting overall print quality in a package printing company was built and evaluated as a substitute for the printing experts. The knowledge needed for building the expert system for evaluating overall print quality was acquired through discussions with two printing experts and from two literature sources. The expert system expressed overall print quality as a numerical value. The expert system and the visual evaluation agreed on the score for the printing quality.

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CHAPTER I

INTRODUCTION

I.A Significance of the Paper Printing Industry in Japan

The paper printing industry in Japan is experiencing significant change. Two reasons for this change are : 1) the customer's consciousness of quality paper printing is rising, and 2) the paper printing industry, in general, is growing.

Customer demand for high quality printing is rising. Customers pay attention not only to the products but also to the quality of the packages, including the print quality. It is easy to understand that print quality is a significant influence on daily life. Ueno et al, in Houso Gijutsu Binran, stated that print quality is a significant factor in improving purchasing power. (Ueno, et al. 1983) They also observed that beautiful printing and the product explanation on the outside surface of a package are useful in sales promotion and throughout the whole period of transportation, storage, and shop window display. Therefore, neat and beautifully printed products which are made of corrugated cardboard and other materials have been developed, and attention has been paid to each product's inside and outside beauty.

The economic scale of the printing industry in Japan is shown in Table 1.1 with comparison data for manufacturing, bookbinding, and publishing. The table also shows growth rates compared to 1989.

Table 1.1 Total Value Shipment for the segments of a printing industry, a publishing, and the manufacturing industry (1990)

Industry	Total amount of shipment ($)	growth ratio (%) 1989 and 1990	
Manufacture	1,710,612,720	0.5	(-)
Paper	19,607,040	3.3	
Newspaper	12,857,100	4.6	
Publication	11,330,700	0.0	
PRINTING	36,989,970	4.6	
Plate Making	3,617,780	0.3	
Bookbinder	1,438,990	1.1	(-)
Printing Ink	1,112,650	9.4	
Printing Machine	4,193,610	5.2	

Source : Printing Industry, Sugita Sumio, March 30, 1990

It can be seen that the printing, printing ink, and printing machine industries have had relatively high expansion rates in comparison with the other industries, including publication, bookbinding and manufacturing. The expansion in the printing industry has lead, in turn, to the expansion of printing machine capacity and printing ink production. Iizuka reports that some printing machines now employ computer systems and other electronic improvements to maintain the quality of printing products and thousands of inks with special characteristics are prepared to meet customer's demands. (Iizuka,1985) It is expected that the printing industry will continue to expand in the near future. New products with the high quality printing which customers demand are coming into existence everyday. However, in order to maintain the high quality of printed products, the paper box printing industry will have to make changes. (Takahata, 1987)

I.B Why is Quality Control of Paper Printing Needed ?

The significance of the paper printing industry was discussed in the previous section. A primary reason for growth was shown to be the increased quality consciousness of the customer. Quality of the product and the package both have to be provided by the supplier to satisfy customer demands.

The quality of printed products has had a tendency to rise with the development of the packaging industry. This is a good trend, because high quality products sell well in comparison to inferior quality products. The print quality of a paper box has a direct bearing on the product image. The appearance of the package in which the product is packed must be of consistent high quality to appeal to customers. Suppliers avoid shipping products or packages which have defects because they lower customer confidence in the supplier. To get good quality products, the package manufacturer must use a quality control system. However, quality control of paper box printing is a complicated endeavor and dealing with quality control is not easy. (Matsuoka, 1987)

Suppliers should avoid shipping products which have defects. In particular, food and drug products have necessarily strict quality controls. It is not enough that the letters printed on the drug container are fine enough that the label can be read. Of course, it is impossible to get rid of all sub-standard products. It is important to take measures to eliminate situations that produce sub-standard products rather than having to discard sub-standard products. (Daimon, 1986)

I.C The Current Situation of Quality Control in Japan

The present quality control system in Japan is based on market response (customer side). According to the book, Quality Control Terminology in JISZ 8101, that is the "Japanese Industrial Standard", quality control is defined as a method which economically makes products or service matched to the customers' demands. (Ootsuki, 1990)

The first issue addressed in the quality control system is to confirm that the machine plate, raw material, printing ink and so forth conform to the production specification and the original. These confirmations are the responsibility of the printing machine operator. The operator compares the original to the specifications and gets approval from the printing expert. After this process is completed, the actual printing operation begins. During operation, random samples are taken for checking register conditions, scum, color drop off and color reproduction. These inspections compare samples to the specifications.

The checks are made by printing experts using visual inspection. In other words, the inspection depends on a printing expert's ability to see problems with the naked eye. However, the inspection done only by printing experts is not enough. There are many products produced every day and experts can't complete 100 % of the inspections. In spite of this situation, the supplier is expected to satisfy customer demands for all kinds of products. Thus, a quality control system which eliminates and prevents human error is needed. Detectors, sensors, and numerical control of color printing are examples of techniques for avoiding human error. (Matsuoka, 1987)

I.D The Expert System for Problem Solving (Need for the Expert System)

Experts check printed products visually to evaluate printing quality. This creates problems because the printing experts are "only human" and may make careless mistakes when they get tired. (Mizuraku, 1987). Also some experts depend on intuition when performing their tasks. It is dangerous to only use expert visual inspection and intuition and this approach must be avoided. Computerized expert systems show potential for solving this problem. Expert systems should be able to judge the quality of printed products, diagnose printing trouble, and give suggestions using knowledge about printing inspections gathered from human beings (experts) and literature. As a result, information about printing quality could be made available quickly and accurately without careless mistakes and fatigue. Akita et al. state that problems having the following characteristics are suitable for an expert system : (Akita, 1988)

1) Experienced knowledge and know how are clear.
2) Rules are complicated but logic is easy.
3) It is difficult for human beings to inspect.
4) The system can be backed up by experts.

The problems of printing quality control fit Akita's model and seem to be well suited to an expert system. Printing experts know how to inspect printing quality by evaluating visual impressions. Additionally, the knowledge necessary for judging the printing quality is so complicated that it is difficult for a non-expert to do inspections, but problems can be backed up by experts.

There are some specific tasks a computerized expert system for paper printing quality control could be used for : (Akita, 1988)

1) Judging the total quality of printed products
2) Diagnosing of printed products' quality defects
3) Giving possible reasons and suggestions for correcting the defects

Computerized expert systems could evaluate the overall quality of printed products and also diagnose specific printing problems such as out of register, scum, and color reproduction. An expert system could also give suggestions about and reasons for printing problems. Many kinds of expert system applications could be created.

I.E Problem Statement

Suppliers must avoid shipping products which have defects in order to maintain product quality. Currently, only experts can visually check samples of paper printing. This situation is expected to cause problems in the near future for three reasons. The number of experts is gradually decreasing. The available experts can't take enough time to relax and rest because of heavy work schedules. Also, the experts have their own defects such as making careless mistakes, getting tired over time, and being lazy. These circumstances will lead to an increase in errors, which in turn will decrease the overall quality of the product. To avoid these problems, an alternative is needed to substitute for the experts in the paper printing industry. One approach is to apply an expert system.

I.F Research objectives

There are three main objectives of this research.

1) To identify, quantify, and classify the knowledge which is acquired from printing experts and literature for paper printing quality inspection. (This knowledge will be used for developing the knowledge base.)

2) To develop a prototype expert system for evaluating the overall quality of printing products. (A prototype expert system will be built for evaluating the overall quality of printed products, by expressing quality as a numerical figure, and for diagnosing the printed product's defects.)

3) To test and evaluate the expert system for paper printing quality control. (The goal will be to compare the evaluation obtained from the prototype expert system with those from experts at a paper printing company.)

CHAPTER II

LITERATURE REVIEW

II. LITERATURE REVIEW

The purpose of this research was to develop an expert system for evaluating the overall quality of printed products. Five prototype expert systems related to the printing industry were developed according to Akita, but the prototypes have not yet reached practical use. (Akita, 1988) Expert systems, of course, are still a new approach, but it is anticipated that they will be practical for the printing industry.

The first part of this chapter addresses expert systems in general and examines how expert systems are being used to address particular problems. The second part of this chapter examines quality control systems in the paper printing industry.

II.A The Expert System Approach

II.A.1 What Is an Expert System

Many books and publications have been written about expert systems. Currently, an expert system is defined as a computer program that assists a non-expert to deal with problems which need the interpretation of experts. The user is able to solve the problem without expert help by using a computerized expert system. The computerized expert system is a tool which has stored the knowledge acquired from experts as the knowledge base. (Akita, 1988) Many expert system applications have been reported. According to Akita et al. problems in the field of law, finance, architecture, agriculture, medicine, and education can be solved well by

using computerized expert systems because the professional knowledge in these fields has been well established. It is predicted that hereafter the number of experts and workers will gradually decrease as the use of computerized expert systems increase.

According to Expert System, ten kinds of tasks are well suited for an expert system: interpretation, prediction, diagnosis, debugging, repair, monitoring, control, planning, design, and instruction. (Watermann, 1987)

1) Interpretation: analyze the results of the experts' evaluation of particular problems.
2) Prediction: forecast the future situation based on the past as well as present models.
3) Diagnosis: find the faults in a system according to the interpretation of potentially noisy data.
4) Debugging: prescribe remedies for diagnosed malfunctions.
5) Repair: prescribe a plan to administer a remedy.
6) Monitoring: continuously interpret signals that set off alarms when intervention from outside is needed.
7) Control: interpret, predict, and monitor system behavior.
8) Planning: a series of actions intended to reach a target.
9) Design: method of creating an object which satisfies a specific task.
10) Instruction: diagnose, monitor, and control student behavior.

When developing an expert system, it is important to first decide what kinds of tasks the expert system will address. Table 2.1 shows the tasks addressed by expert systems and the number of systems in use in Japan.

Table 2.1 The Tasks Approached by Expert System and Usage Number

Characteristic	Number
Interpretation	15
Prediction	25
Diagnosis	64
Design	44
Planning	35
Monitoring	9
Debugging	5
Repair	10
Instruction	18
Control	19
Others	8
Total	252

(Akita, 1988)

Source : Y. Hirai ; "Current Status of Expert System Developments in Japan" , ICOT JOURNAL, No. 15, 1987.

As the table shows, the task of diagnosis is popular in the field of expert systems. The task of control, on the other hand, has only had 19 uses. Building an expert system dealing with control is difficult and there are few examples.

On the other hand, many expert systems have been manufactured. These expert systems, of course, are being made for specific purposes. ICOT-JIPDEC Artificial Intelligence in Japan surveyed expert system development by six hundred computer users in the spring of 1986. Responses were received from 255 users. Table 2.2 shows the purposes for expert systems development. (Akita, 1988)

Table 2.2 PURPOSES OF EXPERT SYSTEMS

PURPOSE	Number
1. Reduction of expert's heavy work	60
2. Education and discipline of experts	26
3. Improvement and standardization for customer service	35
4. Systematization of knowledge	36
5. Improvement of productivity	45
6. Understanding of expert system technology	50
7. Others	2
8. No answers	1
TOTAL	255

(Akita, 1988)

Source : Y. Hirai ; "Current Status of Expert System Developments in Japan" , ICOT JOURNAL, No. 15, 1987

The survey of ICOT-JIPDEC AI center shows that the primary reason for expert system development was the reduction of experts' heavy work. The experts' heavy work loads and the lack of experts can be mitigated by using expert systems.

II.A.2 Components of an Expert System

The concept of the expert system was briefly discussed in the previous section. An expert system is useful when non-experts encounter problems which need the interpretation of experts. A computerized expert system has a knowledge base developed from experts, so non-experts can draw the similar conclusions.

The following section addresses expert system components. Akita et al point out that an expert system consists of seven components: (Akita, 1988)

1) Dialogue module
2) Knowledge acquisition function
3) Knowledge base and control module
4) Knowledge base and data base
5) Inference engine
6) Work memory
7) Inference process interpretation function.

The dialogue module is a program which is prepared in question form for interacting with the expert system. (Akita, 1988) The user answers the questions presented by the expert system.

The knowledge acquisition function is the most important and most difficult part of developing an expert system. Generally, the knowledge and know-how acquired from experts are not systematized, but the knowledge and know-how have to be put systematically into the computer. This is a key point in determining whether a system will be valuable . Currently, the knowledge engineer performs this job rather than the experts.

The knowledge base and control module are parts of the program that supply knowledge to the inference engine.

The knowledge base and data base are knowledge and data accumulators. The data is extracted when needed.

The inference engine is a computer program which uses knowledge and rules to reach inferences. Forward and backward chaining are examples of actions by the inference engine. Work memory is a memory area where the facts concerning inference are stored for a short time.

The inference process interpretation function is the part of the program where the conclusions are reached by the inference engine.

II.A.3 Knowledge Acquisition

Knowledge acquisition is the most difficult stage of the expert system development process. The success or failure of an expert system can depend on how effectively the knowledge is acquired from experts.

The person who acquires information and knowledge from experts and literature is referred to as the knowledge engineer. The knowledge engineer interviews experts, extracts the main characteristics of specific problems, and constructs a trial system. A knowledge engineer needs to be familiar with expert system methodology. Sometimes the expert and the knowledge engineer are the same person.

There are two types of expert knowledge; literature knowledge and heuristic knowledge. (Akita, 1988) Literature knowledge is the basic knowledge level required to be expert. (Badre, 1973) Literature knowledge is the most important information source for constructing an expert system. Heuristics, on the other hand, is an important form of knowledge which distinguishes experts from non-experts. Human experts offer detailed information concerning particular problems to the

knowledge engineer during interviews. Generally, the quantity and quality of heuristic knowledge is important in constructing practical expert systems. However, current prototype expert systems use less information from heuristic knowledge than literature knowledge. (Akita, 1988)

Finally, heuristic knowledge acquisition involves important difficulties. One of the most important is the disagreement in the forms of expression. The form of knowledge from human experts may differ from that expressed in the program. (Watermann, 1987) The other important difficulty is the inability of human experts to express themselves. Watermann pointed out that experts may not be good at expressing their knowledge. He also indicated that the human expert's knowledge often is inaccurate, incomplete, and untidy. Therefore, it is difficult to extract heuristic knowledge for use in an expert system. A knowledge engineer has to take these difficulties into consideration during knowledge acquisition.

II.A.4 Expert System Application in Packaging

The number of expert system applications in packaging are limited. Packaging Expertise on a Disk, points out that expert system technology could be applied in packaging research and development applications and packaging management applications. (Twede, et, al. 1990)
An application in packaging research and development is to design a package using data about product characteristics such as weight, shape, dimensions, and the sensitivity of product quality, in addition to data on logistical and marketing system characteristics such as customer needs,

dynamic force during transportation, and handling. Another application is to predict future events from packaging science. For example, it is possible to predict shelf life from permeability models, distribution damage from a damage boundary curve, and mass transport from diffusion models. Applications in package system management include: control of package purchasing, quality control of manufacturing operations, packaging machinery operation and maintenance, and monitoring a distribution system for damage causes.

II.A.4.1 Expert System for Inventory Control

The Federal-Mogul Corporation has created a logistics expert system by using a knowledge based technology in inventory management to provide advice on ordering, rescheduling, and packaging decisions plus elements of order entry and forecasting. (Kearney,1990) The main purpose of the expert system in inventory control application is to achieve desired availability with minimum inventory.

The Federal-Mogul project started in April of 1988 with an outside facilitator experienced in expert systems and logistics and was completed in March of 1990. The first phase was to design a concept and project plan for using the expert system. It required three months. The second phase was to develop a prototype expert system. The system was constructed by using the Aion Development System Tool from the Aion Company. During this phase, the system was constructed, tested, and evaluated. Six months were required to complete the second phase. The last phase of the project was to make the system operational for inventory control. It was completed after 15 months. The system was

validated by checking the accuracy of knowledge in the knowledge base and the correctness of recommendations. Five benefits from this operational expert system for inventory control have been reported. Inventory trade-offs became easily identified by individual part number. The system allowed access to the total inventory throughout multiple locations. Inventory balance was improved by repackaging for different customers. Inventory decisions became more consistent. As a result of this project, inventory productivity rose 10 or 15 percent. (Kearney, 1990)

II.B Quality Control in Printing

This section focuses on literature regarding the printing process and quality control in the paper printing industry.

II.B.1 Printing Process

It is necessary to understand the elements of the printing process before understanding the entire quality control program of paper printing. Four points are examined for satisfying complete quality control of paper printing: registering, the pre-printing process, the printing process, and maintenance after the real printing process. (Japan Graphic Arts Technology, 1988)

The first important point to consider is adjusting the printing register. The register is needed to print in the right position on the paper. This check is very important in ensuring printing quality because all printed products are defective when register is not correct. Therefore, adjusting

the printing register is the first stage of satisfying paper printing quality standards. There are three kinds of "out of register" placement: left and right gap, up and down gap, and bending gap. (JAGAT, 1988) The reason for out of register can be very complicated. The cause has to be analyzed and the machine has to be adjusted accurately until the register matches before the printing process begins. Moving the plate, the cylinder, and the position of the paper are examples of adjustments. (JAGAT, 1988)

After finishing the registering process, the pre-printing processes should be checked before proceeding to production. Character readability, odor, roughness of solid place, curling, doubling, scum, offsetting, mottle, pinhole, and ghost are checked. (JAGAT, 1988) When defects are detected, printing experts analyze the cause and make adjustments.

After satisfying the pre-printing process standards, production printing is started. Quality is checked by observation of the printed products, using random sampling inspection, and by monitoring changes in water and printing ink. (Offset, 1987) Random sampling inspection is required during the actual printing process because machine conditions do not stabilize in the early stage of the actual printing process and the amount of ink and water applied can change. After the machine conditions have been fixed, random sampling inspection is still needed to guarantee the quality. If the machine has to be stopped for any reason, ink and water conditions can change and cause the loss of a large amount of time. Frequent random sampling is preferable to avoid these defects.

The final stage of the quality control process is machine maintenance. Maintenance does not directly influence printing quality, but neglecting this last stage leads to lower quality of subsequent printed products because of the loss of machine accuracy. The following procedures are required after printing has been completed: treatment of the plate and washing of the ink roll, blanket, and impression cylinder. (JAGAT, 1988)

The next section focuses on literature relating to quality control in the paper printing industry. To illustrate, three methods of quality control are introduced.

II.B.2 Quality Scale for Color Printing

Few studies in the literature deal with quality control applied to a color scale. However, this topic is becoming more popular because quality control in the printing industry is changing from inspection using printing experts' visual evaluation to inspection using instruments which produce numerical data. One of the main reasons for this trend is the low reliability of experts. (Akita, 1988)

II.B.2.1 Graphic Arts Technical Foundation (GATF) Starter Get

GATF (Graphic Arts Technical Foundation) in the United States (Ito, 1990) researched methods of numerical quality control for printed products. "Starter Get", a scale which expresses color reproduction numerical figure, was reported in 1961. (Ito, 1985) The system is being widely used. Starter Get is very effective for checking the thickness of dot, slur, and double during the printing process. (Ito, 1985) It is easy to inspect the conditions by watching the scale of enlarging Starter Get. Also, Starter

Get can calculate the resolving power of printing products. The formula is:

Resolving power = 11.47 / the width of spread for center solid (Ito, 1985)

Starter Get is accurate for judging the conditions of halftone dot, slur, and double but it is difficult to control printing using the system because it uses data from a visual inspection.

II.B.2.2 Dot Gain Scale

The dot gain scale was designed for control of dot reproductivity in printing by GATF in 1965. Dot control is very important for controlling color. The ideal dot is a complete circle. However, the dots produced by most printing machines are not complete circles. The disparity of the dot is evaluated by the dot gain scale which consists of three parts: dot gain scale, slur gauge, and starter get. The dot gain scale was designed for inspection and yields numerical data. (Ito, 1985)

II.B.2.3 Compact Color Test Strip

The last example of printing quality color control is the compact color test strip designed by GATF. This system, a scale of color printing is controlled one, two or three piled up color. The following five checks can be performed: 1) the process ink, hue, and photographic density; 2) the hue of one or two colors and transparency of ink; 3) the thick or thin for halftone dot and slur and double; 4) the irregularity of dot reproductivity and the discrepancy of gray balance; 5) the uniformity of ink supply. (Ito, 1985) The compact test strip evaluation is expressed as a numerical

figure using data from a densitometer. By using the compact color test strip, quality control for color printing becomes easy.

All three quality control scales are needed for reliable color matching.

II.B.3 Color Reproduction

A study by the technical committee of the Japanese Society of Printing Science and Technology evaluated the parameters and methods for quality control in the color reproduction process. (Isono, et al. 1989) The committee reported that several abstract impressions such as brightness, darkness, clearness, unclearness, softness, and hardness are used in the printing. These abstract impressions are ambiguous and have not been standardized. The technical committee members point out (Isono, et al. 1989) that only five abstract impressions are needed to evaluate color printing quality: 1) color 2) gradation 3) sharpness 4) uniformity 5) gloss. It is difficult to individually evaluate the abstract impressions by human visual observations.

II.B.4 Evaluation Method for Color Reproduction

II.B.4.1 Measurement of Color

Two methods have been reported to evaluate the color quality of printed products. (Isono, 1989) In one, hue error, degree for ash color, and efficiency are calculated for sample sheets. These measure evaluate the relative inferiority to the original. When comparing color between an original sheet and a printed product, the color of the printed product may be inferior to the original because of the following : 1) distortion in the spectrum characteristics of practical printing ink. 2) surface

characteristic of printing paper. 3) the operating condition of the printing machine. To measure the degree of inferiority, the three items are calculated by the following formula:

Hue error = (M-L) / (H-L) * 100 %

Ash degree = L / H * 100 %

Efficiency = {1-(L+M) / 2 H } * 100 % (Isono,1989)

where L: the lowest value of divided color density

M: the middle value of divided color density

H: the highest value of divided color density

The ideal ink has hue error =0 %, ash degree = 0 %, and efficiency = 100 %.

A second measurement evaluation for color is achieved by calculating trapping efficiency; how the ink is applied on the previous ink during repeated printing. The trapping efficiency is calculated by the following formula:

Trapping efficiency = $(D_{1.2})_2$ - $(D_1)_2$ / $(D_2)_2$ * 100 % (Isono, 1989)

where $(D_1)_2$: divided color density for previous ink

$(D_2)_2$: divided color density for next ink

$(D_{1.2})_2$: divided color density for layered ink

The ideal trapping efficiency is 100 %.

II.B.4.2 Measurement of Gradation

Gradation is recognized as a second factor for controlling color. Gradation is used for controlling density from the highlight part, where color is bright and density is low, to the shadow part, where color is dark and

density is high. (Isono, et al 1989) Gradation is mainly controlled by the halftone dot. The important evaluation measurement item for the halftone dot is dot gain. (Isono, 1989) Dot gain is calculated by the following formula.

Dot gain = (Dot area ratio for printing products) - (Dot area ratio for plate or film) (Isono, 1989)

II.B.4.3 Measurement of Sharpness

The third factor for controlling printed color is sharpness. The shape coefficient is used to evaluate the dot's outside reproduction and is calculated by the following formula:

Shape coefficient = (the length of circumference)^2 / 2*π (area)

(Isono, 1989)

If the shape coefficient is 1.0, the sharpness condition of the portrait is perfect.

II.B.4.4 Measurement of Uniformity

The fourth approach to controlling printed color is to measure the uniformity of the printed products. There are two types of uniformity evaluation for printing portrait; micro-uniformity and macro-uniformity. Micro-uniformity is a measure of how the ink is applied, and macro-uniformity is a measure of the consumption patches of ink. (Isono, et al. 1989) The evaluation for uniformity of the printed products is

expressed by standard deviation of density trace measured by micro densitometer and change coefficient.

Change coefficient = Standard deviation of density trace / average density * 100 % (Isono, 1989)

II.B.4.5 Measurement of Gloss

The last factor for controlling the printing portrait is gloss; expressed as the rate of burnish for printing products. The gloss is expressed as a numerical quantity by using the photometer, using the following formula:

Gloss = The light quantity of positive reflection / the positive reflection light quantity of complete mirror * 100 %.

These studies emphasize that objective evaluation is possible using numerical control and that an objective expression for printing quality may be very helpful in judging printing quality.

CHAPTER III

METHOD

III. Method

III.A Introduction (General Overview of Quality Control System)

The primary objective of this research project was to develop and test a prototype expert system for color reproduction. There have been prior investigations into the development of a small scale expert systems, but there are few situations where an expert system has been put into practical use in the printing industry.

In this chapter, the procedure followed to develop the prototype expert system is explained. The steps included ; selection of the expert system tool, knowledge acquisition, and evaluation of the completed expert system for color reproduction

III.B Expert System Tool Selection

III.B.1 Selection of LEVEL 5

More than a dozen expert system shells or tools are now available in the field of artificial intelligence. The following are some key items to consider when selecting a particular tool. (Akita, 1988)

1. Price

Since the expert system is still a new approach in the field of packaging there is constant revision, reformulation, and augmentation. It was not necessary to select the highest priced tool.

2. Ease of learning

Ease of learning is important, especially if the author is neither a computer programmer nor computer expert. A highly developed expert system tool was not needed for this research. Therefore, the ease of learning was an important consideration.

3. Previous uses of tool

The extent of use was also an important factor in deciding on the optional tool. Widespread use of a tool indicates that the methods tend to need less debugging and fewer changes and that it is easy to get information about strengths and weaknesses.

4. Connection with other systems

When selecting the tool, connection with other software, hardware, and networks must be considered because the prototype expert system may be a practical expert system in the near feature. Thus, it was important to consider this feature.

5. Language dependency

It was important to recognize to what extent the tool itself depends on the computer language and how long the tool takes to interface, an important measure of the responsiveness of the expert system.

Since the purpose of this research was to build a prototype expert system for paper printing quality, and since limited time was available, the most important factor in choosing the tool was easy of learning.

The tool selected was Level 5/Macintosh, a rule based tool, produced by Information Builders.

III.B.2 Strength of Level 5/Macintosh

Level 5 uses a versatile knowledge representation language called Production Rule Language (PRL) for development of the knowledge base. In PRL, knowledge is represented as IF...AND...OR...THEN...ELSE rules, which contain the factual information comprising the domain of the expert system. (Level 5)

Level 5 had the follows advantages:

1) It was lower-priced.
2) It was easy to learn.
3) It had flexible application.
4) It had linked knowledge base.

The price of the expert system was an important factor in deciding on a tool or shell so the lower priced Level 5 was selected. Level 5/Macintosh was an adequate system for building the expert system in this research project.

Level 5 offered simple rules with mathematical capabilities. In short, the ease of learning was a strong factor because the research objective was to develop the prototype expert system in a short period of time.

Level 5 is flexible and can suit many applications. In most expert systems, designers must choose between a forward or backward inference engine. However, Level 5 can use both backward chaining and forward chaining to reach an inference.

The fourth factor was that Level 5 could be linked to HyperCard or Excel. The linked knowledge bases can communicate with one another dynamically and update global facts with the engagement of each knowledge base.

III.C Knowledge Acquisition

Knowledge acquisition was the most important activity in the development of the expert system for printing quality control. To acquire knowledge it was necessary to analyze the knowledge and determine how to obtain it from experts and literature. An optimal method of knowledge acquisition has not been established, so the process for acquiring knowledge of a specific printing quality problem can be difficult.

An expert's knowledge can be divided into two types of knowledge: literature knowledge and heuristic knowledge. (Akita, 1988) Literature knowledge is the minimum factual knowledge required to be an expert. Heuristics, on the other hand, includes the knowledge needed for distinguishing between experts and non-experts. Both kinds of knowledge were necessary to build the prototype expert system. Literature knowledge is more than 90 % of the total knowledge required for an expert system, (Akita, 1988) so it was important to ensure complete acquisition of this type of knowledge.

The researcher, acting as knowledge engineer, obtained knowledge from two printing publications and from two printing experts. The knowledge which was obtained is described in a later section.

The following sources of knowledge were accessed.

1. Knowledge acquisition from heuristics
   1) Inspection of Ueda Printing Company
   2) Computerized quality assurance system of Dossmann Printing Company
2. Knowledge acquisition from literature
   1) Printing quality evaluation method for color reproduction
   2) Diagnosis of printing problems

III.C.1.Conversation and Discussion with Experts

III.C.1.1 Inspection Analysis of Ueda Printing Company

The purpose of the knowledge acquisition in this section was to discover and collect information to describe how a printing expert checks the printed product samples during a quality inspection. The information was gathered through interviews with printing experts.

A printing company in Japan was selected. This company, UEDA Printing & Paper Box Company, has an excellent printing expert who was interviewed for the purpose of acquiring detailed knowledge.

There were three goals for this part of the knowledge base. The first goal was to discover the printing conditions. The printing conditions were the principal knowledge needed to understand the printing process, the beginning step for building a prototype expert system. In order to understand the conditions, questions were asked about four areas:

1) Product
   a. What kind of packages are printed ? (food, confectionery, medicine, cosmetics, and other miscellaneous)
   b. Are there regulations that apply ?
   c. Does the type of product influence the expert?
2) Material
   a. What kinds of materials are used ? (paperboard, E-flute, thin paper, etc.)
   b. Is there a relationship between paper type and printing quality ?
   c. Does material type influence procedures which are conducted before the actual printing process begins ?
3) Ink
   a. What kinds of printing inks are used ? (carton ink, corrugated ink, or special ink.)
   b. Are there specific print quality checks that apply when dealing with a particular medical or food product ?
4) Equipment
   a. What kinds of printing machines are used ?
   b. What features do the machines have ?
   c. How does the coating system work ?
   d. What does the expert observe when evaluating coating and printing quality ?

The second goal of the interview was to locate checklists for inspecting printing products and to determine the meaning of each check item. In most printing companies, only the expert checks printing samples visually to determine whether the sample is satisfactory. Printing

experts have the inspection knowledge in their brains. Thus, the second goal was to discover the inspection items and their meaning from the printing experts. The following questions were asked.

a. What are the details of the checklists used by printing experts to examine quality ?
b. Are there more checklists ?
c. Which checklist does the printing expert use ?
e. What is the meaning of each checklist item ?

The third goal of the knowledge acquisition process was to determine how experts check the printed products. The printing experts do not check the printing samples by reference to inspection manuals. They have individualized knowledge and procedures for inspecting printed products. This part of the knowledge base was considered to be the most critical for the development of the expert system, and a large amount of time was committed to discover how the expert performs the inspection. The following questions were posed:

a. Do printing experts actually inspect printing samples according to inspection checklists ?
b. Are there any experiments involved in the inspection process ?
c. What tests are used ?
d. Which checklists do printing experts use for the visual inspection ?
e. Which checklists are most important for evaluating printing quality.

III.C.1.2 Computerized Quality Assurance System of the Dossmann Printing Company

The knowledge in this section was obtained from a discussion with Dr.

Friedrich Dossmann, president of the Dossmann Printing Company in West Germany. Dossmann has created several systems for improvement of quality and productivity including systems for quality assurance by computers. The knowledge acquired from Dossman has been included in the knowledge base of the program. (Dossmann, 1990)

The following procedure was used to complete the knowledge acquisition.

1. Determine the general procedure for quality assurance by computer.
2. Examine the flow chart.
3. Acquire the checklist for quality control.
4. Determine the procedure used by the computer to promote quality control and quality assurance.
5. The structure for basic data, including basic classification, quality classification, and defect classification.

III.C.2 Literature Review

III.C.2.1 Method of Evaluating Printing Quality

The third method was knowledge acquisition from the publication OFFSET PRINTING MACHINE. (Isono, et al, 1989) The printing machine section personnel conducted on evaluation of printing quality. The results of the study are summarized briefly in the next section.

The group established a mathematical formula for the evaluation of the overall quality of printing using the multivalent analysis method. Ten quality items are transformed in a single formula, expressing the overall quality of printed products as numerical values. (Isono et, al., 1989)

Evaluation for the overall quality of printed products were inspected by measuring ten evaluation items. The score for color reproduction was calculated from the numerical values for ten items. The score was a numerical value with a maximum 100 points.

III.C.2.2 Information for diagnosis of Printing Problems

This section of the knowledge base was set up to provide information to assist in the diagnosis of printing problems such as out of register, scum, and curling. Generally, it is difficult to diagnose when printing problems happen in an offset printing machine. Offset printing machine problems result because the machine and the process are complicated. (Takayanagi, 1986) This problem was approached by using the cause and effect diagram.

III.D Evaluation of Prototype Expert System

The completed prototype expert system was tested to determine if the results agreed with the expert's evaluation. Only the section for color reproduction was evaluated because it relied most heavily on the printing expert. The method was comparison of the expert opinion with non-expert system result.

Two cases, pictures of Japanese tea and rice crackers, were tested to determine whether the prototype expert system could be applied effectively. The correlation coefficient was calculated to measure the relationship between overall quality score obtained from the expert system and expert's visual evaluation score.

1) Sample

Each sample was classified into five quality levels: highest quality, high quality, medium quality, low quality, and lowest quality. A total of 5 sample products were prepared by printing experts to be highest, high quality, etc from Japanese tea sample. The five rice cracker samples were prepared similarly. Data were recorded in tables, as shown below.

A) Japanese Tea #1

	Highest quality	High quality	Medium quality	Low quality	lowest quality
Sample					

B) Rice Cracker #2

	Highest quality	High quality	Medium quality	Low quality	lowest quality
Sample					

2) Evaluation by Prototype Expert System

Ten samples, 5 samples of Japanese tea and 5 samples of rice crackers, were evaluated using the prototype expert system and given an overall quality point rating for color reproduction. The score was 100 points as a maximum.

3) Evaluation by Printing Expert

Fifty printing experts from five different printing companies; Ueda Printing & Paper Box Co., Ltd, Dainippon Ink & Chemical, Inc, Sumida Paper Industry, and Total Packaging Co., Ltd evaluated the same products. Printing experts checked the printing samples and rated the overall quality, with a maximum of 10 points. Based on the expert' scores and the score from the expert system, the correlation coefficient was calculated. The expert's reliability was also examined by having each person score two times in the same day (morning and afternoon). The correlation coefficient was calculated based on the scores.

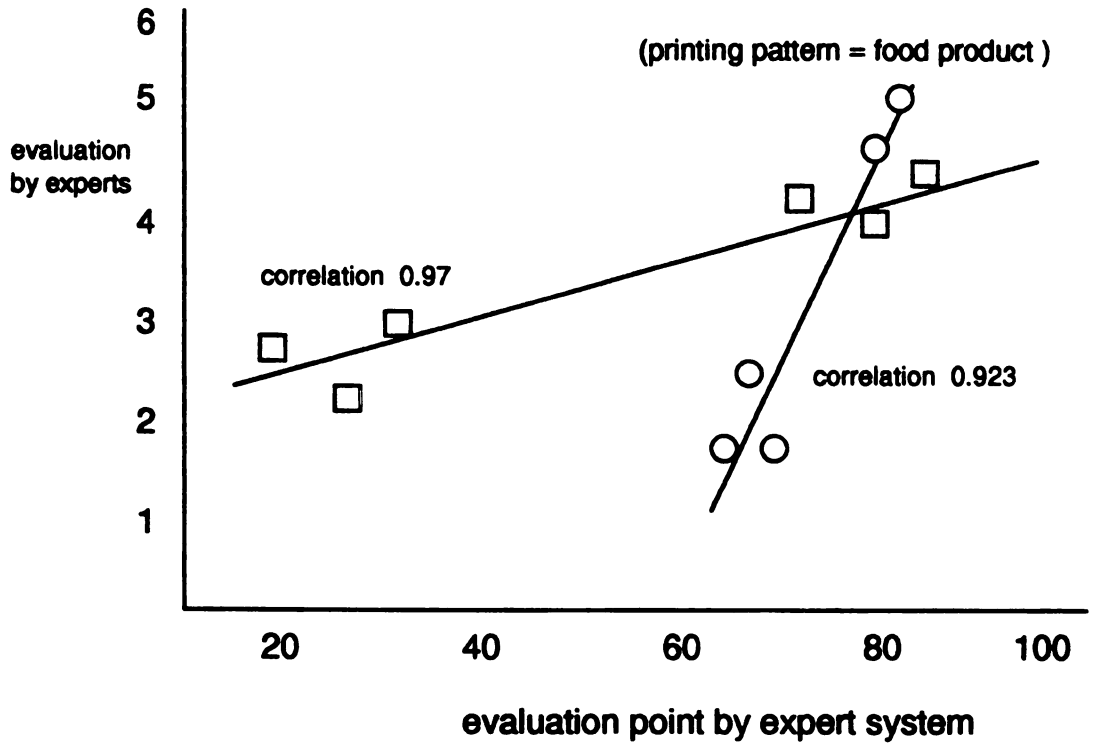
4) Method

The overall quality point ratings by the experts and the prototype expert system operated by a non-expert were compared. Based on this data, the correlation coefficient between these overall quality points was calculated in order to evaluate the developed expert system. The graph which follows is an example which illustrates the correlation between evaluation points from the expert system and printing experts.

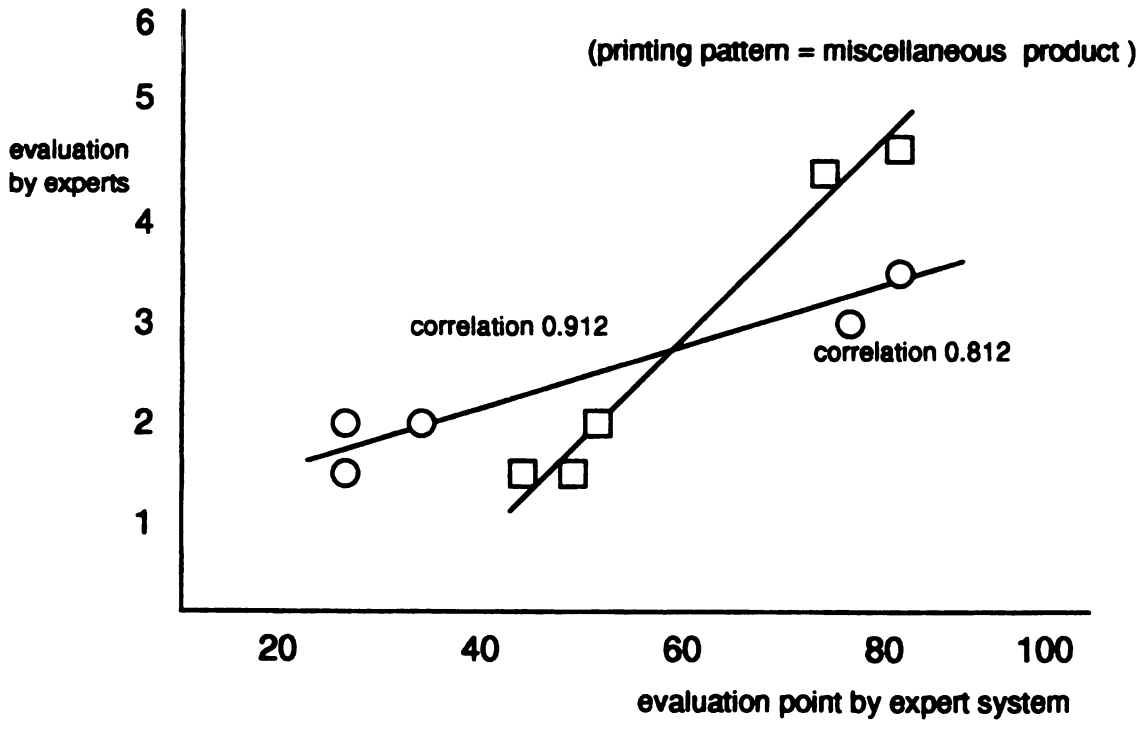
The statistically significant test ($p<0.05$) was applied to the correlation coefficient.

FIGURE 3.1 Illustration of the Correlation between Evaluation Points from the Expert System and Printing Experts.

a) In the case of **Japanese tea** products



b) In the case of **rice cracker** products



CHAPTER IV

BUILDING THE EXPERT SYSTEM

IV. Building the Expert System

IV.A Introduction

This chapter describes how the prototype expert system for printing quality was built using the knowledge acquired from printing experts and the literature. Level Five for Macintosh was used as the tool, as discussed previously.

The expert system used knowledge from four sources, two printing experts, one from Japan and one from West Germany, and two literature sources.

IV.B Knowledge Acquisition

IV.B.1 How Experts Inspect Printing Products

The first knowledge base for building this prototype expert system was obtained from printing experts who work at the UEDA Printing & Paper Box Company in Japan. The researcher acting as knowledge engineer, interviewed printing experts to get knowledge which was needed for building the expert system. The main goal for the first stage was to find out what types of check lists exist for inspecting printing quality, what each check item means, and how the printing experts check printing products based on the check lists.

IV.B.1.1 Check Lists

Currently, only printing experts can check samples visually to determine

whether the quality of the printing product is good or not, because the printing expert has these check lists stored in his or her memory.

The following 11 check items for quality inspection were identified during the discussions with the printing experts. These items were the main categories in the knowledge base.

1. Is the printing out of register ?
2. What is the condition of the character and picture on the surface ?
3. Is there a strange odor from the surface ?
4. How is the roughness of solid place ?
5. Is there a curling problem ?
6. Is there a doubling problem ?
7. Are there stains, spots, or blots on the printing surface ?
8. Is there an offsetting problem ?
9. Is there a mottling problem ?
10. Are there pinholes on the surface ?
11. Is there a ghost image on the surface ?

The overall printing quality inspection is based on these check lists. In the next section, each check lists is classified into the four categories which were gathered from the discussion with Mr. Dossmann.

IV.B.2 Analysis of Quality Assurance

This section of the knowledge base was obtained from the discussion with Dr. Friedrich Dossmann who is a president of Dossmann Printing Company in West Germany. He has created numerous systems for

improving quality and productivity in paper printing companies. The main purpose of this discussion was to acquire information about quality classification and defect classification according to the quality assurance system created by Dossmann.

The knowledge base for quality classification of paper printing was divided into four categories. The knowledge in these four categories was acquired from the quality assurance system for paper printing through the discussion with Dossmann. The four categories were :

1) Color reproduction
2) Printing register
3) Overall quality immediately after printing operation
4) Scumming

Each of these four categories are discussed in the following sections.

IV.B.2.1 Color Reproduction

The first step in inspecting print quality was to check color reproduction. Color reproduction indicates how well the original color tone is reproduced. (Isono, 1989) To inspect color reproduction for paper printing quality, Dossmann arranged the following items into the quality assurance checking system:

1. Is the color of the printing surface bright or dark ?
2. Is there enough gloss ?
3. Is the color tone uniform ?
4. Is there any doubling phenomenon ?

These items were used when the answer was neither completely true nor completely false; however, it was difficult for the non-printing experts

to describe the color of the printed products. Inspecting color of the printed products is the most important phase of evaluating paper printing quality and it had to be done very well. After careful discussion with the printing expert, the method from the literature, a standardized mathematical formula for color reproduction, was selected, making it possible to evaluate color reproduction by one numerical value based on the measured data.

Each inspection element for color reproduction consisted of the following ten individual measures: (Isono, 1989)

1) Relative contrast
2) Solid density
3) Saturation
4) Hue error
5) Three piled up color degree
6) Degree for ash color
7) Effective density in halftone dot
8) Environs scumming of halftone dot
9) Dot gain
10) Shape coefficient in halftone dot

A more detailed discussion about color reproduction is included in a following section.

IV.B.2.2 Printing Register

The second step in the evaluating of printing quality was to check the printing register. There are several kinds of out of register defects such as right and left, up and down, and bending out of register. If the out of register phenomenon occurs in the printing operation, it is necessary to adjust the machine using the results of the out of register inspection.

President Dossmann expressed the tolerance limit of printing register by numerical value in the quality assurance system for printing quality. Previously, the printing expert inspected the printing register phenomenon visually.

The following tolerance limits for out of register have been included in the knowledge base of the program.

1) out of register is over 1 mm
2) out of register is between 0.3 mm and 1.0 mm
3) out of register is between 0.3 mm and 0.1 mm
4) out of register is less than 0.1 mm

The decision rule for the printing register will be outlined and discussed in detail in the following section.

IV.B.2.3 Overall Quality Immediately after Printing Operation

Dossmann classified overall quality immediately after printing operation as the third classification for printing quality. Overall quality also required skilled printing experts to inspect the quality. The inspection items were :

1) to check readability of character
2) to check clearness of picture
3) to check strange odor
4) to check roughness of solid place
5) to check curling condition
6) to check doubling condition

Printing experts had a variety of ways to inspect the overall quality immediately after a printing operation. It depended on the printing

experts impression, whether these inspection items were accepted or rejected as measures of the printing quality. All the items were addressed in the knowledge base which is discussed the following section. These inspection items were not necessarily used at every printing company for maintaining paper printing quality. This classification was adopted in order to build the prototype expert system for printing quality. More efficient classifications are possible.

IV.B.2.4 Scumming

The last classification measure for the quality assurance system created by Dossmann was to check the scumming. Scumming is a phenomenon which occurs either during the printing operation or after the printing operation and happens during delivering, rubbing machine, and some other substances. Five inspection items for checking scumming were drawn from the discussion with the printing experts at Ueda printing company. The following scumming inspection items were considered:

1) check overall scumming (tinting, stable scumming, partial scumming, line plumps overall, and scumming in a vertical direction.)
2) check offsetting
3) check mottling condition of surface
4) pinhole problem
5) check ghost phenomenon

Scumming could be quality controlled by inspecting the above items. This was, of course, not enough to perfectly control scumming; however, the overall scumming inspection was satisfied by inspecting these items. Printed products with scumming lose quality so serious inspections were necessary. The prototype expert system for overall quality of paper

printing was built by classifying : color reproduction, printing register, overall quality and scumming. Decision rules that needed to evaluate overall quality of paper printing are outlined and discussed in the next section.

IV.3 Building the Expert System

As was described in previous sections, the prototype expert system evaluated four items color reproduction, printing register, overall quality immediately after the printing operation, and scumming. The following sections describe how the prototype expert system for printing quality was organized and developed.

1. Printing Register

The out of printing register is the most serious printing problem. Out of register means that lines drawing for multi-color printing or repeated printing shift up and down or right and left. (Takayanagi, 1986) Printing experts usually check this shift by a magnifier

The limits on out of register were obtained from printing experts. If the shift of printing register was over 1mm, printing experts classified the product as out of register, and the product had to be diagnosed to understand the reasons. Therefore, the knowledge base automatically shifts to the diagnosis section. If the shift of printing register is less than 0.3mm, the product was defined to not be out of register and the knowledge base continue through the inspection process.

Figure 4.1 is a decision rule example for this section of the knowledge base. The knowledge base is written in the versatile knowledge representation language called Production Rule Language. In PRL, knowledge is represented as IF...AND...OR...THEN...ELSE rules. (Level 5) The first line is the name of the rule, in this case, "excellent register". The second line is a condition. The knowledge base asks the user to state the size of the shift in printing register. The operator measures the shift of the printing register and responds. In this case, the knowledge base draws the conclusion that the condition of the printing register is excellent.

FIGURE 4.1 DECISION RULE EXAMPLE: PRINTING REGISTER

RULE Excellent register
IF Shift of printing register is less than 0.1 mm
THEN The condition of printing register is excellent
AND CHAIN readability of character

2. Readability of Character to Ghost Image Problem

As mentioned in a previous section, many abstract expressions such as brightness, darkness, clearness, unclearness, softness, and hardness are used to express the quality of printing. In inspection analysis of paper printing applications, decisions are often made on the basis of uncertain or unreliable information. Many check lists include abstract expressions, such as readability of character, clearness of picture, strange odor, roughness of solid place, curling conditions, surface doubling, overall scum condition, offset condition, surface mottle, and ghost image problem. The answers to the above inspection items are neither completely true nor completely false but are believed with a greater or

lesser degree of confidence. A confidence factor of 100 indicates complete confidence that the statement is true, a confidence factor of 0 indicates complete confidence that the statement is false, and a confidence factor of 50 is interpreted as noncommittal, statement might be true or false. A confidence factor was applied to evaluate the abstract expressions, using a scale from 0 % to 100 %.

The inspection items which were evaluated with confidence factors were: readability of character, clearness of picture, strange odor problem, roughness of solid place, curling conditions, surface doubling, overall scum condition, offset condition, surface mottle, and ghost image problem. The minimum degree of confidence required for a fact to assumed to be true was set at 70 points. If the user expressed a confidence evaluation of over 70 points, the knowledge base assumed that the condition for the item was true and was directed to inspect the next item by the CHAIN command. On the other hand, if the user gave a confidence factor of less than 70 points, the knowledge base assumed that the condition for the item was false and automatically proceeded to the diagnosis section to find out the possible reasons for the condition and made suggestions for corrective actions for the printing trouble.

A decision rule example for readability of character is shown in Figure 4.2 The top line is title, "Readability of character". The item next to TITLE is a description of the knowledge base printed on the screen by the DISPLAY command. The next line is CONFIDENCE ON, a control statement that turns on confidence prompting for a knowledge base. The next line is THRESHOLD=70 which sets the minimum degree of confidence required

for a fact to be assumed to be true. The next line is a goal outline for the inference engine. In this case, "the condition of characters on the printing surface IS WHAT" is a goal outline. The following lines are rules for readability of character. TEXT express the declaration to be substituted for the name of a fact in query displays. The last line is END which defines the end of a knowledge base.

FIGURE 4.2 DECISION RULE EXAMPLE : READABILITY OF CHARACTER

```
TITLE   Readability of Character DISPLAY

************************************************************
 #2  SECOND CHECK POINT / READABILITY OF CHARACTER
************************************************************

 THIS SECTION IS GOING TO CHECK THE CONDITION OF
 CHARACTER ON THE PRINTING SURFACE.

  "CONFIDENCE FACTOR" IS USED FOR CHECKING THE CONDITION OF
  CHARACTER ON THE PRINTING SURFACE BECAUSE THE DECISIONS ARE
  OFTEN MADE ON THE BASIS OF UNCERTAIN OR UNRELIABLE INFORMATION.

  A "CONFIDENCE FACTOR" OF 100 MEANS THAT THE FACT IS TRUE.
  A "CONFIDENCE FACTOR" OF 0 MEANS THAT THE FACT IS FALSE.

************************************************************
 PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.
 THE PROCEDURE IS THE NEXT SECTION.

CONFIDENCE ON

THRESHOLD=70

1. the condition of characters on the printing surface IS WHAT
RULE  readability of character
IF      readability of character
THEN  the condition of character in printing surface IS ok
AND   CHAIN clearness of picture
```

Fig 4.2 (Con't)

ELSE CHAIN diagnosis letter problem

TEXT readability of character

HOW MUCH CONFIDENCE DO YOU HAVE ABOUT READABILITY OF CHARACTER ?

PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINTS, BY USING THE ABOVE SCALE.

0 50 100

CAN NOT READ MIDDLE CAN READ WELL

END

The knowledge base for the rest of the inspection items can be seen in Appendix E.

3. Pinhole Problem

The following four classifications were used for pinholes.

critical condition - the diameter of the pinhole is over 4 mm.

major condition - the diameter of the pinhole is between 2 mm and 4 mm.

minor condition - the diameter of the pinhole is between 1mm and 2 mm.

excellent condition - the diameter of the pinhole is less than 1mm.

The printing expert judges the condition of pinholes by using the classification system listed above. The diameter of pinhole can be measured by a magnifier.

If the pinhole diameter is over 4 mm, the quality of printing is greatly degraded. The knowledge base proceeds directly to the diagnosis section to find out the reasons for the critical pinhole condition.

If the pinhole diameter is between 2 mm and 4 mm, it affects the printed quality of the product to a lesser extent. Products with pinhole diameter between 2 mm and 4 mm indicate that pinholes may become a critical condition later in the operation. The knowledge base assumes it should proceed to the diagnosis section to find out the reasons for the pinhole problem.

If the diameter of the pinhole, is less than 1 mm, the pinhole condition is excellent and the knowledge base assumes that this product is good quality. As a result, the user goes to the next case to check the quality of paper printing.

If the diameter of the pinhole is between 1 mm and 2 mm, it will not affect printing quality too much. The knowledge base assumes that a diameter at this limit is ok and goes to the next section to check the printing condition.

A decision rule example is shown in Figure 4.3.

FIGURE 4.3 DECISION RULE EXAMPLE : PINHOLE PROBLEM

RULE critical condition
IF the pinhole diameter is over 4 mm
THEN The pinhole condition is critical condition
AND DISPLAY quality

Fig 4.3 (Con't)

AND CHAIN diagnose pinhole problem

DISPLAY quality

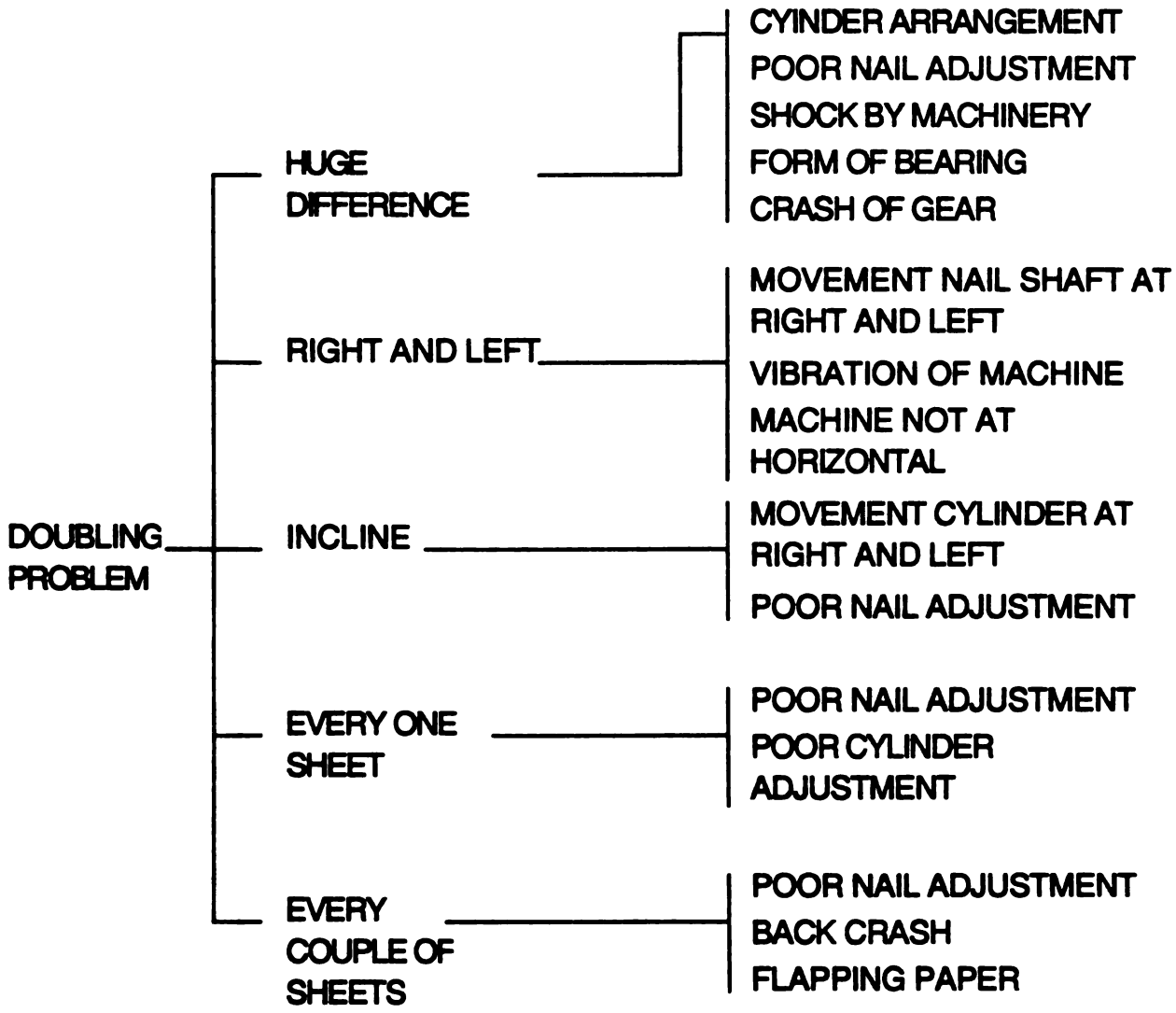
The diameter of pinhole over 4 mm is a critical condition.
The product affects printing quality seriously.
It is necessary to investigate the reasons for this critical condition.

IV.B.4 Diagnosis of Printing Problems

This section of the knowledge base, taken from Offset Printing Machine, is used to diagnose printing trouble to find out the reasons for and make suggestions about printing problems such as out of register, scumming and doubling. (Takayanagi, et al, 1986)

It is difficult to express the reasons for and suggestions for correcting printing trouble, because many elements, such as chemistry, physics, and machine mechanism are involved. (Takayanagi, 1986) The cause and effect diagram shown in Figure 4.4 was taken from Offset Printing Machine. (Takayanagi, 1986)

FIGURE 4.4 CAUSE AND EFFECT DIAGRAM FOR DOUBLING



The cause and effect diagram was used to identify the reasons for problems. The cause and effect diagram for each printing quality item was included in the knowledge base of the program.

The decision rule example for the doubling problem is shown below in figure 4.5.

FIGURE 4.5 DECISION RULE EXAMPLE : DIAGNOSIS OF DOUBLING PROBLEM

RULE right and left for double
IF printing product doubles at right and left
THEN doubling problem for right and left IS ok

AND DISPLAY right and left

DISPLAY right and left

Please check the following items for doubling:

1 move nail shaft at right and left
2 vibration of machine
3 machine not at horizontal level

* Click Continue *

The knowledge base for this doubling problem diagnosis asked the user about the doubling condition. The user chooses a condition from the selection menu :

1) printing product doubles with big difference
2) printing product doubles at right and left
3) printing product doubles at incline
4) printing product doubles at every one sheet
5) printing product doubles every couple of sheets

Based on the user's answer, the knowledge base gave possible reasons and suggestions for the doubling problem. If the user chose big difference as near doubling condition, the knowledge base gave the following reasons and suggestions for the doubling problem by using the DISPLAY command.

Please check the following items for doubling :

1. cylinder arrangement
2. poor nail adjustment
3. machine part
4. form of bearing
5. gear

IV.B.5 Evaluation of Color Reproduction

The knowledge base for this section was taken from Offset Printing Machine (Takayanagi, 1986). Critical information for evaluating the overall quality of color reproduction on printed products is presented in Offset Printing Machine (Takayanagi, 1986).

There are four stages in the evaluation of the overall quality of color reproduction: decide the measurement item for overall quality of color reproduction, get the conversion diagram which converts the measurement value for evaluation item to the evaluation point, decide the weight of each evaluation item, that is, the relative importance in relation to overall printing quality, and get the overall quality point according to each measurement value.

The quality points for color reproduction were calculated by using the following formula.

$$Y = \sum W_i P_i \text{----------(1)}$$

where Y : Total quality point (100 points as maximum)

W_i : Weight of evaluation item i

P_i : Evaluation point of evaluation item i

IV.B.5.1 Measurement of Evaluation Items

To define the quality of printed products, the evaluation items for color reproduction had to be measured. The following items, found to be valid and reliable measures (Takayanagi, 1986), were used for this study.

1. Relative Contrast (RC)
2. Solid density (D)
3. Saturation point (A)
4. Hue error (I_3)
5. Three color (I_2)
6. Ash color degree (C)
7. Effective density in the halftone dot (DP)
8. Environs scumming of halftone dot (SD)
9. Dotgain (DG)
10. Shape coefficient in halftone dot (SF)

These items do not have meaning individually, but each item is related to the others.

IV.B.5.2 Evaluation Point and Weight

The measurement value for each item was not important in itself because the value didn't directly interpret the quality of the printed product. Therefore, the measured values were converted.

IV.B.5.2.1 Evaluation Point

The data were standardized and expressed on an eleven-point scale from 0 to 10 points. To find the value, a diagram for converting to the evaluation point from the measured value was used.

The conversion diagram for solid density is presented in table 4.1. It can be seen that from 1.59 to 1.66, solid density was worth 9 points and from

1.06 to 1.13, solid density was worth 1 point. Each of the 10 items had its own conversion diagram and all 10 items were converted from the measured value to evaluation points. The evaluation points were used as data in the decision rule for overall quality of color reproduction.

TABLE 4.1 CONVERSION DIAGRAM EXAMPLE : SOLID DENSITY

Evaluation point	Value for solid density
0	less than 1.06
1	between 1.06 and 1.13
2	between 1.13 and 1.19
3	between 1.19 and 1.26
4	between 1.26 and 1.33
5	between 1.33 and 1.39
6	between 1.39 and 1.46
7	between 1.46 and 1.53
8	between 1.53 and 1.59
9	between 1.59 and 1.66
10	over 1.66

IV.B.5.2.2 Evaluation Weight

The next step was to decide the weight of each evaluation item. The evaluation items were not equivalent but the ratios affected the total quality. (Takayanagi et. al, 1986) To estimate the weight of each item, multiple regression analysis was applied taking the ten evaluation items as independent variables and visual evaluation as a dependent variable. However, since the independent variables were highly correlated with each other, this process violated one of the assumptions of regression analysis. Therefore, in order to make these ten evaluation variables statistically independent, principal component analysis was employed to combine these variables into a smaller set of composite variables (statistically independent from each other). The result is shown in the Table 4.2

TABLE 4.2 A Set of Composite Variables

$$\begin{bmatrix} Z1 \\ Z2 \\ Z3 \end{bmatrix} = \begin{bmatrix} 0.37 & -0.31 & -0.33 & 0.28 & 0.39 & -0.12 & -0.24 & 0.30 & 0.39 & 0.34 \\ 0.31 & 0.43 & 0.40 & -0.31 & 0.06 & -0.05 & 0.40 & 0.37 & 0.21 & 0.33 \\ 0.05 & 0.15 & 0.21 & 0.37 & -0.06 & 0.84 & -0.18 & 0.22 & 0.05 & 0.04 \end{bmatrix} \times \begin{bmatrix} (TE) \\ (D) \\ (A) \\ (I3) \\ (I2) \\ (G) \\ (DP) \\ (SD) \\ (DG) \\ (SF) \end{bmatrix}$$

Each component was interpreted as follows;

where Z_1 = reproduction for halftone dot shape

Z_2 = low and high density at ink transition place of printing surface

Z_3 = color difference at place where a repeated printing was taken

Eighty-six percent of total variance was explained by these three components.

Finally, multiple regression analysis was applied to the three components (independent variables) on the visual evaluation score (dependent variables) to assess reliability and validity of the evaluation items for color reproduction measurements. The third component (Z_3) was not used because it was not a significant indicator of the dependent variable.

The result follows:

$$V = 0.183\ Z_1 + 0.247\ Z_2 - 0.095 \text{----------(3)}$$

V : visual evaluation result

In this case, the multiple regression coefficient was 0.970. ($P<0.01$)

Weight of the evaluation was calculated using the following formula.

$$W_i = 10 * (a_i l_{1i} + a_2 l_{2i}) / \sum (a_1 l_{1i} + a_2 l_{2i}) \text{----------(3)}$$

W_i : weight of evaluation for each evaluation item i

a_1, a_2 : coefficient of characteristics Z_1 and Z_2.

l_{1i}, l_{2i} : coefficient is indicated in the relationship between evaluation item i and characteristics Z_1 and Z_2.

Evaluation weight calculated by the above formula is indicated in Table 4.3.

TABLE 4.3 ABBREVIATION and WEIGHT for EACH EVALUATION ITEM

	Evaluation Item	Sign	Weight
1.	Relative Contrast	(RC)	1.7
2.	Shape Coefficient in Halftone Dot	(SF)	1.7
3.	Scumming of Halftone Dot	(SD)	1.6
4.	Dot Gain	(DG)	1.5
5.	Three Piled up Color Degree	(I2)	1.0
6.	Effective Density in Halftone Dot	(DP)	0.6
7.	Solid Density	(D)	0.6
8.	Saturation	(A)	0.5
9.	Degree for Ash Color	(G)	0.5
10.	Hue Error	(I3)	0.3

IV.B.5.3 Overall Score of Printing Quality

The overall quality point for color reproduction was expressed as a numerical value, calculated using the following formula,

$$Y = \sum W_i P_i \quad \text{----------(1)}$$

where Y : Total Quality Point $Y = 0 \sim 100$ point

W_i : Weight for evaluation item $_i$

$\sum W_i = 10$

P_i : Evaluation point for evaluation item $_i$

$P_i = 0 \sim 10$ point

n : The total number of evaluation items

The overall quality scale for color reproduction has a maximum of 100 points. If the number of overall quality points is high, the quality of the printed product is good.

The next section describes the decision rule for overall quality of color reproduction.

IV.B.5.3.1 Decision Rule for Color Reproduction

The last part of the knowledge base for the expert system of print quality was to check the color reproduction, introduced in the previous section. Color reproduction was expressed by one score based on measurement data. (Isono, 1987). Figure 4.6 is an example of a decision rule that determines overall quality points.

The knowledge base asks the user to input the measured value for relative contrast, decides the evaluation point for relative contrast, and calculates the total score for the relative contrast. This procedure is followed each time so it takes place 10 times to get the overall quality rating for color reproduction. After examining these procedures, the knowledge base returns the overall quality rating value which becomes the index for color reproduction.

FIGURE 4.6 DECISION RULE EXAMPLE : RELATIVE CONTRAST

```
RULE   for density < 0.17
IF     have the facts
AND    relative contrast < 0.17
THEN   #1
AND    evaluation point for relative contrast:=0
```

Fig 4.6 (Con't)

```
RULE   for density >= 0.17
IF     have the facts
AND    relative contrast >= 0.17
AND    relative contrast < 0.21
THEN   #1
AND    evaluation point for relative contrast:=1

RULE   for density >= 0.21
IF     have the facts
AND    relative contrast >= 0.21
AND    relative contrast < 0.25
THEN   #1
AND    evaluation point for relative contrast:=2

RULE   for density >= 0.25
IF     have the facts
AND    relative contrast >= 0.25
AND    relative contrast < 0.29
THEN   #1
AND    evaluation point for relative contrast:=3

RULE   for density >= 0.29
IF     have the facts
AND    relative contrast >= 0.29
AND    relative contrast < 0.33
THEN   #1
AND    evaluation point for relative contrast:=4

RULE   for density >= 0.33
IF     have the facts
AND    relative contrast >= 0.33
AND    relative contrast < 0.37
THEN   #1
AND    evaluation point for relative contrast:=5

RULE   for density >= 0.37
IF     have the facts
AND    relative contrast >= 0.37
```

Fig 4.6 (Con't)

```
AND     relative contrast < 0.41
THEN   #1
AND      evaluation point for relative contrast:=6

RULE    for density >= 0.41
IF       have the facts
AND     relative contrast >= 0.41
AND     relative contrast < 0.45
THEN   #1
AND      evaluation point for relative contrast:=7

RULE    for density >= 0.45
IF       have the facts
AND     relative contrast >= 0.45
AND     relative contrast < 0.49
THEN   #1
AND      evaluation point for relative contrast:=8

RULE    for density >= 0.49
IF       have the facts
AND     relative contrast >= 0.49
AND     relative contrast < 0.53
THEN   #1
AND      evaluation point for relative contrast:=9

RULE    for density >= 0.53
IF       have the facts
AND     relative contrast >= 0.53
THEN   #1
AND      evaluation point for relative contrast:=10

RULE    for getting score
IF      #1
THEN    sub score is \ ok
AND    #2
AND     sub total score for density error:=1.7* evaluation point for
          relative contrast
```

IV.C Development of the Expert System

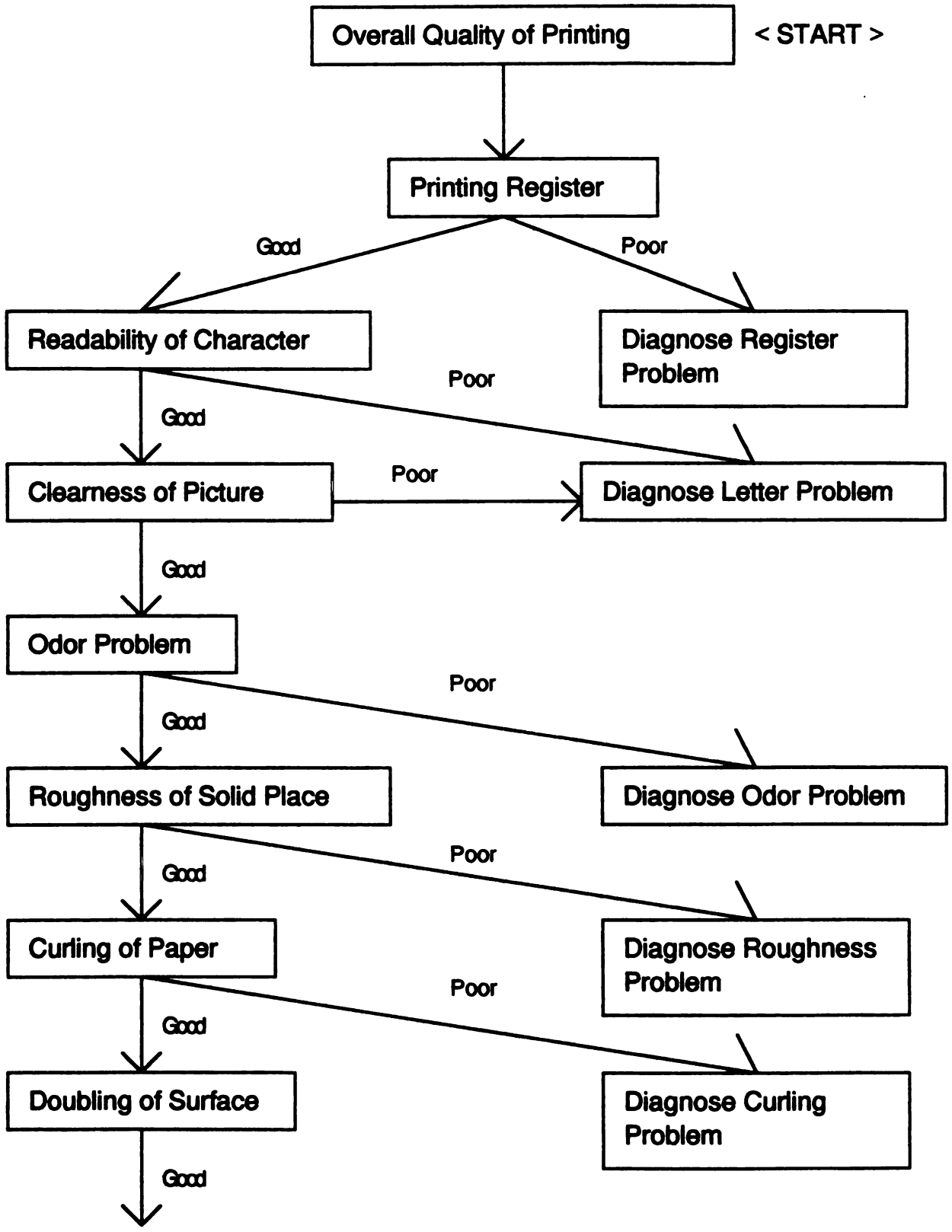
IV.C.1 Diagram of the Expert System

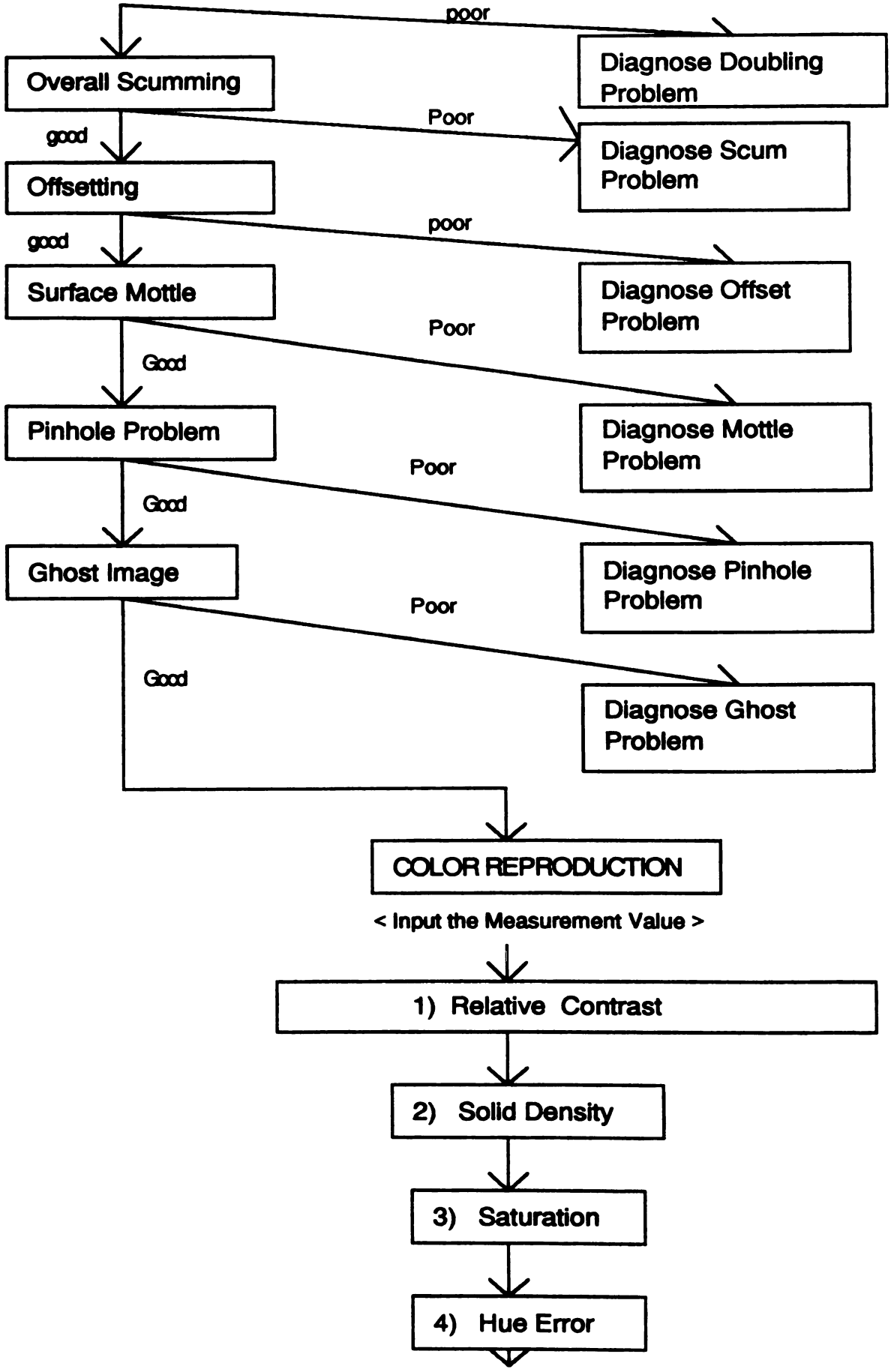
This section presents organization of the expert system. The diagram for overall quality consists of fourteen main parts which were discussed in previous sections. The knowledge base asks the user about the condition of the printing register. If the answer is satisfactory, the knowledge base continues on to the section for checking print quality. If not, the knowledge base goes to the diagnosis section to determine the reasons for being out of register. Once satisfied with the printing condition, the knowledge base checks the overall quality. The knowledge base asks the user six questions, and uses the confidence factors to express overall quality. Then the knowledge base goes to the next section which is inspecting the scum condition. The scum section consists of 5 questions. If the condition of scum is satisfied with a high enough confidence factor, the knowledge base continues on to the most important element of the which is checking the condition of color reproduction. The color reproduction item is important because a very skilled person is required to check the color in the printing operation. However, when using the expert system, the user only answers the ten questions concerning color reproduction, and the knowledge base gives the user the overall quality for color reproduction.

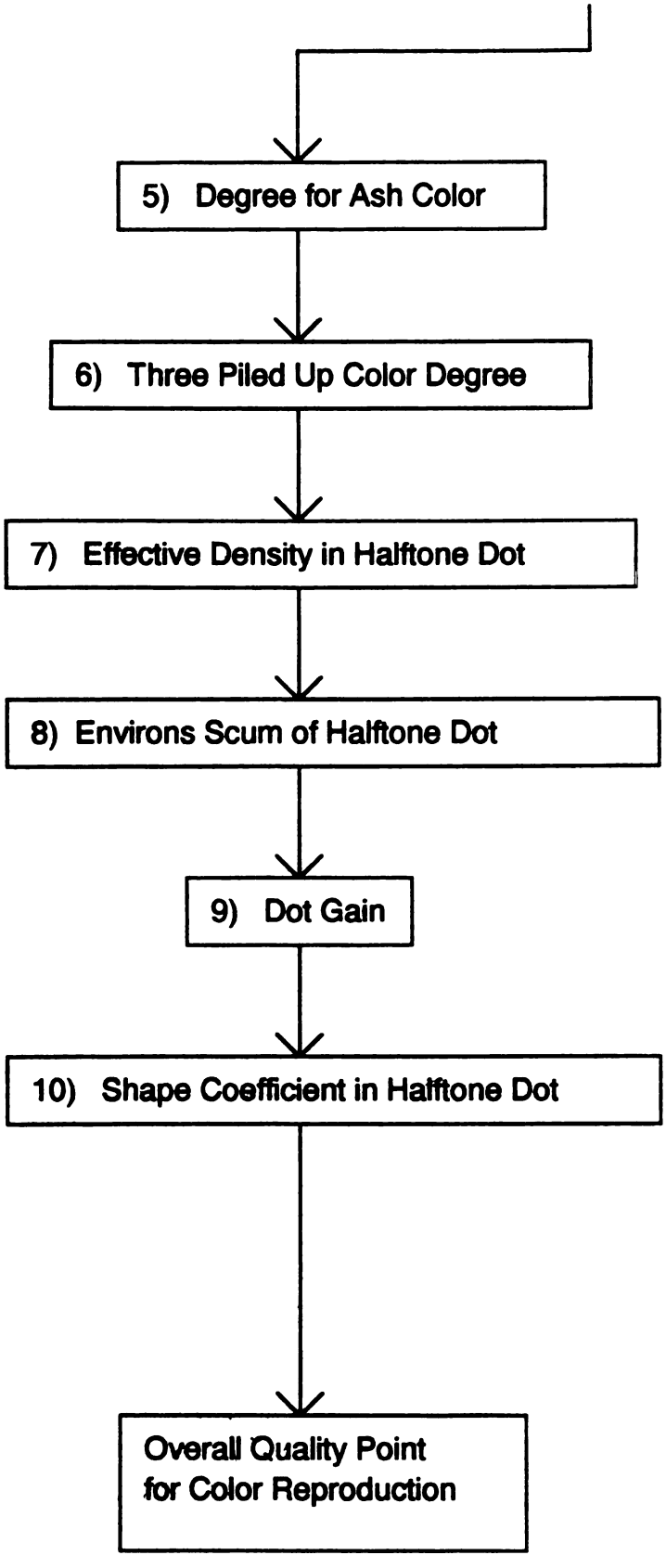
Figure 4.7 is a diagram of this prototype expert system that is shown in the below.

FIGURE 4.7 Diagram of Overall Quality for Paper Printing

FIGURE 4.7 Diagram of Overall Quality for Paper Printing




poor
Overall Scumming
Diagnose Doubling Problem
Poor
good
Offsetting
Diagnose Scum Problem
poor
good
Surface Mottle
Diagnose Offset Problem
Poor
Good
Pinhole Problem
Diagnose Mottle Problem
Poor
Good
Ghost Image
Diagnose Pinhole Problem
Poor
Good
Diagnose Ghost Problem
COLOR REPRODUCTION
< Input the Measurement Value >
1) Relative Contrast
2) Solid Density
3) Saturation
4) Hue Error


5) Degree for Ash Color
6) Three Piled Up Color Degree
7) Effective Density in Halftone Dot
8) Environs Scum of Halftone Dot
9) Dot Gain
10) Shape Coefficient in Halftone Dot
Overall Quality Point
for Color Reproduction

CHAPTER V

EXPERT SYSTEM EVALUATION AND RESULTS

V.A Introduction

The final objective was to evaluate the expert system for evaluating color reproduction, a component of the expert system for paper printing quality. The printing samples were prepared by Ueda Printing & Paper Box Co., Ltd. in Japan and the instruments were manufactured by Dainippon Ink and Chemicals, Inc. and Mitsubishi Heavy Industry.

The samples prepared by Ueda Printing Company were normal products that can be seen at any food shop and super market in Japan. The samples were selected by the printing supervisor. The printed samples were measured at Dainippon Chemical and Mitsubishi Heavy Industry to get data needed for the expert system. The next step was for the printing experts to perform visual inspections. Fifty printing experts were chosen for the evaluation. The system was evaluated by comparing the results from the expert system operated by a non-expert and with the results developed by printing experts.

A. Limitations of the Data

Two printing samples were evaluated for this expert system. The ideal approach to this evaluation would have been to use as many printing experts as possible and for each person to perform the evaluation in the morning and afternoon or on different days to judge the reliability of the experts. However, because of time limitations and the heavy work

loads, only 10 printing experts participated in this portion of the comparison.

If the correlation was high, the prototype expert system for color reproduction might see practical use in the near future. If the correlation was low, other factors besides the ten selected measurement items might be considered.

C. Evaluation Expert System for Color Reproduction

The printing samples measured for evaluation were picture patterns depicting Japanese tea and rice crackers. Printed products which can be seen at super markets and food shops were selected to make the evaluation realistic. Each sample was determined to be "the highest quality", "high quality", "medium quality", "low quality", and "the lowest quality" by a printing expert.

For each sample, the ten different variables that are illustrated in the figure 5.1. were measured by the densitometer and picture processing analysis instrument. The data can be found in Appendix C. Each item measured by the instrument was input to the expert system when requested by the knowledge base for color reproduction, and then overall printing quality point for color reproduction was calculated. This knowledge base was made up of 124 decision rules and 65.

To evaluate the prototype expert system, the ten samples were further evaluated by the printing experts. Fifty printing experts participated in the evaluation giving each evaluation a maximum of ten points. The

evaluation of printing quality for color reproduction took place in two stages: the comparison between the printing experts' scores and the expert system's scores, and the correlation coefficient between scores from the expert system and printing experts.

FIGURE 5.1 TEN VARIABLES FOR COLOR REPRODUCTION

1) Relative Contrast - evaluates how closely the printed product resembles the proof sheet.

2) Solid Density - checks the highest density in the printed product.

3) Saturation - evaluates the degree of color inferiority for the printed product. The color of the printed product is usually inferior to the proof sheet.

4) Hue Error - evaluates the degree of color inferiority for the printed product, similar saturation.

5) Degree for Ash Color - evaluates the degree of color impurity in comparison to the proof sheet.

6) Three Layered Color Degree - evaluates the degree of color inferiority for the printed product.

7) Effective Density of halftone Dot - evaluates the halftone dot's inside density reproduction. The halftone dot's density profile is distorted in comparison to the ideal.

8) Environs Scum of Halftone Dot - evaluates the halftone dot's circumference density reproduction.

9) Dot Gain - evaluates the degree of halftone dot's area in comparison to the proof. The area of the printed product's dot is larger than the proofs.

10) Shape Coefficient in Halftone Dot - evaluates the degree of halftone dot's outline reproduction.

V.C.1 Individual Outputs

Table 5.1 and 5.2 present the measurement data for each sample. Any item with over 70 points satisfies the minimum quality standard.

TABLE 5.1 QUALITY RATINGS BY THE EXPERT SYSTEM

SAMPLE : JAPANESE TEA

	#1	#2	#3	#4	#5
Relative Contrast	0.396	0.348	0.376	0.376	0.388
Solid Density	1.207	1.13	1.093	1.18	1.137
Saturation	0.96	0.95	0.85	0.95	0.92
Hue Error	0.207	0.204	0.212	0.208	0.212
Three Piled up	0.24	0.52	0.42	0.46	0.48
Ash Color of Degree	14.87%	12.85%	13.57%	14.50%	14.63%
Effective Density	21.83	20.78	20.62	21.97	22.38
Environs Scumming	0	4.22	5.48	2.95	4.29
Dot Gain	-1.53	-0.83	-3.67	-1.67	-3.17
Shape Coefficient	1.366	1.468	1.327	1.501	1.406
TOTAL POINT	78.5	69.1	72.2	72.3	70.7

TABLE 5.2 QUALITY RATINGS BY THE EXPERT SYSTEM

SAMPLE : RICE CRACKER

	#1	#2	#3	#4	#5
Relative Contrast	0.318	0.326	0.243	0.236	0.306
Solid Density	1.127	1.037	1.287	1.43	1.48
Saturation	0.93	0.92	1.05	1.14	1.19
Hue Error	0.199	0.206	0.194	0.192	0.198
Three Piled up	0.21	0.35	0.12	0.23	0.2
Ash Color of Degree	13.42%	13.09%	13.46%	13.44%	13.86%
Effective Density	22.15	23.24	21.94	21.21	21.87
Environs Scumming	0	2.67	6.52	5.92	12.25
Dot Gain	-3.53	1.07	6	13.03	16.97
Shape Coefficient	1.434	1.655	2.574	2.2	1.946
TOTAL POINT	73.8	65.5	56.9	58.1	57.5

V.C.2. Evaluation of Expert System

Table 5.1 and 5.2 present the scores for color reproduction obtained from two sets of samples. As the table shows, in sample #1 there was little variation in the overall score between samples. The difference between the highest quality and the lowest quality was only 9.4 points (the score of the highest quality is 78.5 and the lowest score is 69.1). Additionally, the overall score between quality level #2 and quality level #5 was only 3.2. Sample #2, on the other hand, shows larger differences between samples. The score difference between the highest quality and the lowest quality was 16.9. These results indicate that sample #2 would be evaluated more easily by the experts' visual inspections than sample #1 because of the overall score differences. It also indicates that the correlation coefficient would be higher for sample #2 than for sample #1 because of the easy inspection.

Four items, quality level #1, #3, #4, and #5 from the sample #1 had more than 70 points, the minimum acceptable quality standard, so the overall quality of these four items was good. On the other hand, only one printing item, quality level #1 from sample #2, satisfied the quality standard so the overall quality of the rest of the items, quality level from #2 to #5, were not good.

V.D Evaluation by Printing Experts

As discussed in the previous section, the correlation coefficient was calculated based on the points obtained from the printing experts and the expert system to evaluate the expert system for color reproduction. The score obtained from the expert system was explained in the

previous section. The next thing to do is to examine the visual evaluation.

There were two goals for the visual evaluation. The first was to collect data needed to calculate the correlation coefficient between the visual evaluation and the expert system. The printing experts rated the overall quality of each of the ten samples by comparing them to the standard printed sample. The score of the visual evaluation was a maximum of 10 points. The other task was to examine the reliability of the printing experts. As previously discussed, the reliability of the printing experts was examined by having the same individuals the ten printed samples twice in the same day. Fifty people contributed data for calculating the correlation coefficient between the visual evaluation and the expert system. Ten of the fifty participated in examining the reliability of the printing experts. The printing experts who participated in this evaluation were gathered from the Ueda Printing Paper Box Co., Ltd., Dainippon Ink & Chemical, Inc, Sumida Paper Industry, and Total Packaging.

V.D.1 Visual Evaluation

Table 5.3 presents the summary of the visual evaluation points obtained from the fifty printing experts. As the table shows, the mean and standard deviation were calculated based on the visual evaluation ratings shown in Appendix B.

Many printing experts gave few high visual points for sample #1 in comparison to sample #2. In fact, the average rating of each sample

was 6.596 for sample #1 and 5.6 for sample #2: In other words, the overall quality of sample #1 was higher than sample #2. The expert system and the visual evaluation agreed on the score for this inspection point.

Most of the printing experts felt that sample #2 was easier to inspect than sample #1. This may have been because sample #2 had a greater differences in quality. The data in table 5.3, show that there was more visual difference between each item in sample #2 than in sample #1. In summary, the printing experts found quality differences between the #2 samples similar to the differences shown by the expert system.

Table 5.3 OVERALL QUALITY POINT BY EXPERTS' VISUAL EVALUATION : SAMPLE OF JAPANESE TEA AND RICE CRACKER

	SAMPLE #1		SAMPLE #2	
LEVEL	MEAN	SD	MEAN	SD
#1	7.92	1.482	7.78	1.682
#2	7.02	1.879	6.9	1.344
#3	5.3	1.555	4.66	1.479
#4	6.58	1.642	5.1	1.619
#5	6.16	1.754	3.56	1.643
Average	6.596	1.662	5.60	1.553

V.D.2. Reliability of the Printing Experts

The second purpose of the visual evaluation experiment was to examine the reliability of the printing experts. This was accomplished by asking each expert to evaluate the ten printed samples two times in the same day (morning and afternoon). Table 5.4 presents the results. The visual evaluation point difference between morning and afternoon can

be seen Appendix E. It was important to examine the reliability of the printing experts before calculating the correlation coefficient between the expert system and the printing experts. If the reliability of the printing experts was low, the correlation coefficient between expert system and the printing experts would have also been expected to be low. From table 5.4, the reliability of the experts when evaluating sample #1 was 0.519. For sample #2, the reliability was 0.457 and for sample #1 plus sample #2, it was 0.490. The data shows that the reliability of the printing experts was relatively low. In other words, to some extent, the visual inspection was not very accurate. It should be emphasized that there were only ten individuals used to examine the reliability of the printing experts. So, the estimation of the reliability may be inaccurate because of the small sample size.

Table 5.4 RELIABILITY OF PRINTING EXPERTS
CORRELATION COEFFICIENT

Sample	Reliability
Sample #1	0.519
Sample #2	0.457
Sample #1 + #2	0.490

V.E. Comparison of the Expert System Results with Non-Expert Evaluations

The overall quality of color reproduction was evaluated by the expert system and the printing experts and the data were discussed in the previous section. The correlation coefficient was calculated using those data. Table 5.5 shows the correlation coefficient between the expert system and the actual printing experts.

Table 5.5. CORRELATION COEFFICIENT OBTAINED FROM OVERALL QUALITY POINT BETWEEN THE EXPERT SYSTEM AND THE PRINTING EXPERT

	Correlation Coefficient
Sample #1	0.258
Sample #2	0.652
Sample #1 + #2	0.525

As the table shows, the correlation coefficient of sample #1 was low in comparison to sample #2 and sample #1 plus #2. The following reasons are possible. First, the reliability of the printing experts was found to be relatively low. Visual inspection skill is not highly reliable. Second, there were no only small quality differences between samples #1, as shown Table 5.1 and Table 5.3. It is difficult for the printing reliably identify differences inspecting samples without big quality differences. Third, the overall quality of sample #1 was relatively higher than sample #2. Four items of sample #1 exceeded the quality standard of 70 points. The printing experts have good ability for inspecting defective samples. However, it is difficult for them to evaluate satisfactory quality samples. The correlation coefficient for sample #2 was relatively high: in other words, the printing experts has the ability to ascertain differences between low quality samples.

It appears that the expert system may be able to replace printing experts for inspecting the paper printing quality by setting the quality threshold of the expert system at 70 points. The printing experts gave a higher rating to the samples having the overall quality points at 70. The expert system can be used for inspecting paper printing quality.

CHAPTER VI

CONCLUSIONS AND IMPLICATIONS

VI.A. Conclusions

VI.A.1 Summary

In the paper printing industry, the number of experts is gradually decreasing and the heavy work imposed on experts for inspecting paper printing quality is gradually increasing. An alternate to the printing expert is required to reduce the experts' heavy work load. An expert system was built as to substitute for the printing experts. The expert system evaluated color reproduction of the printed products by calculating and expressing a single number. The expert system examined many inspection points to evaluate product quality. The expert system diagnosed printing problems and made suggestions for solutions. By using the expert system, an unskilled worker can evaluate printed paper quality as well as a printing expert. The expert system reduces the experts' heavy work.

VI.A.2 The Objective

One objective of this research was to identify, quantify, and classify the knowledge which could be used to evaluate paper printing quality. This procedure, knowledge acquisition, required detailed preparation, a lot of time, and much investigation to succeed. The person who acquires knowledge must identify, quantify, and classify the information. The information becomes the center of the knowledge base and key factor for achieving the research.

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The second objective was to develop a prototype expert system for evaluating the overall quality of the printed products based on the information obtained from knowledge acquisition. The following conclusions were drawn.

1. The expert system may substitute for the printing experts.
2. The expert system will reach the same conclusion as the experts.
3. The expert system can evaluate color reproduction of printed products by express the evaluation as a numerical figure.
4. The expert system can examine subjective inspection items, using the confidence factor that expresses the user confidence in the fact.
5. The expert system can diagnose printing trouble so that the possible reasons and suggestions for the printing trouble are expressed.

The third objective was to evaluate the expert system for inspecting paper printing quality. Due to time and budget constraints, only the color reproduction section was evaluated. However, color reproduction requires the most expert knowledge. The following conclusions reached.

1. The reliability of the printing experts was relatively low.
2. It is difficult for printing experts to inspect printed products with small quality differences.
3. The printing experts are more effective when working on products

VI.B. Implications for Practical Application and Further Research

The expert system was shown to be a possible replacement for printing experts. From the perspective of practical applications and further research, the following points are considered.

1. The threshold of the overall quality point for color reproduction was set at over 70 points.
2. To reduce the time to measure each evaluation item, the densitometer and the picture processing analysis instrument may be installed in the printing machine so that data is automatically measured.
3. Because of the time and budget constraints, the researcher could not classify the subjective items such as clearness of picture, surface mottling, and scum problem of the printed product. More work is needed to classify the subjective items as objective items.

Since expert system development is still a new area, many applications of expert systems have not been developed. The expert system for printing quality control has not reached the level of practical application. Further knowledge acquisition and other development must continue for the system to reach the level of practical application.

APPENDIX A

OVERALL QUALITY POINT BY EXPERT SYSTEM

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Relative Contrast	0.396	0.348	0.376	0.376	0.388
Solid Density	1.207	1.13	1.093	1.18	1.137
Saturation	0.96	0.95	0.85	0.95	0.92
Hue Error	0.207	0.204	0.212	0.208	0.212
Three Piled up	0.24	0.52	0.42	0.46	0.48
Ash Color of Degree	14.87%	12.85%	13.57%	14.50%	14.63%
Effective Density	21.83	20.78	20.62	21.97	22.38
Environs Scumming	0	4.22	5.48	2.95	4.29
Dot Gain	-1.53	-0.83	-3.67	-1.67	-3.17
Shape Coefficient	1.366	1.468	1.327	1.501	1.406
Overall Point	78.5	69.1	72.2	72.3	70.7

SAMPLE #2 RICE CRACKER

	#1	#2	#3	#4	#5
Relative Contrast	0.318	0.326	0.243	0.236	0.306
Solid Density	1.127	1.037	1.287	1.43	1.48
Saturation	0.93	0.92	1.05	1.14	1.19
Hue Error	0.199	0.206	0.194	0.192	0.198
Three Piled up	0.21	0.35	0.12	0.23	0.2
Ash Color of Degree	13.42%	13.09%	13.46%	13.44%	13.86%
Effective Density	22.15	23.24	21.94	21.21	21.87
Environs Scumming	0	2.67	6.52	5.92	12.25
Dot Gain	-3.53	1.07	6	13.03	16.97
Shape Coefficient	1.434	1.655	2.574	2.2	1.946
Overall Point	73.8	65.5	56.9	58.1	57.5

APPENDIX B

OVERALL QUALITY POINT BY EXPERTS' VISUAL EVALUATION

SAMPLE #1 **JAPANESE TEA**

EXPERTS	#1	#2	#3	#4	#5
#001	6	7	5	4	6
#002	7	4	5	9	6
#003	7	8	6	7	8
#004	7	8	5	7	5
#005	7	9	6	8	9
#006	9	9	6	7	8
#007	9	8	4	6	7
#008	10	9	5	7	4
#009	9	8	6	8	7
#010	6	9	5	8	4
#011	6	8	10	4	2
#012	9	7	4	7	6
#013	8	9	7	6	5
#014	10	9	6	8	7
#015	4	5	8	6	2
#016	8	9	6	5	7
#017	9	8	5	4	6
#018	6	6	5	8	7
#019	9	8	5	4	3
#020	8	9	6	7	5
#021	9	5	4	7	8
#022	9	7	5	6	8
#023	7	8	6	9	5
#024	8	6	5	9	7
#025	8	9	7	5	6
#026	9	8	6	7	5
#027	8	6	7	5	9
#028	10	4	2	6	8
#029	8	9	6	7	5
#030	8	9	5	6	7
#031	5	7	6	4	8
#032	9	5	4	7	8
#033	5	8	3	3	5
#034	8	3	2	4	6
#035	7	8	6	9	5
#036	9	7	5	6	8
#037	9	7	6	8	5
#038	8	6	5	9	7
#039	9	6	6	8	7
#040	9	10	6	8	7

SAMP

EXPE

#04
#04
#04
#04
#04
#04
#04
#04
#04
#05

SAMPLE #1 JAPANESE TEA

EXPERTS	#1	#2	#3	#4	#5
#041	9	5	5	8	6
#042	7	8	3	6	4
#043	7	4	5	9	6
#044	9	5	5	8	6
#045	9	6	6	8	7
#046	9	10	5	6	6
#047	10	4	2	6	8
#048	8	3	2	4	6
#049	4	5	8	6	2
#050	8	6	7	5	9

OVERALL QUALITY POINT BY EXPERTS' VISUAL EVALUATION

SAMPLE #2 **RICE CRACKER**

EXPERTS	#1	#2	#3	#4	#5
#001	9	4	3	6	2
#002	4	5	3	2	3
#003	9	7	6	6	5
#004	9	8	3	6	4
#005	8	8	6	4	5
#006	7	8	6	5	6
#007	4	7	2	7	4
#008	10	8	5	4	3
#009	6	9	7	8	5
#010	5	6	3	8	4
#011	10	6	4	2	0
#012	8	7	5	6	4
#013	8	7	6	5	4
#014	10	7	6	3	5
#015	8	7	5	4	7
#016	9	7	5	6	4
#017	9	6	3	5	1
#018	8	4	3	3	2
#019	8	7	2	5	1
#020	8	9	4	7	5
#021	8	7	4	6	5
#022	7	8	4	5	3
#023	9	8	6	5	4
#024	9	7	5	6	4
#025	8	7	5	6	4
#026	6	7	2	3	1
#027	6	7	4	5	2
#028	8	6	3	5	2
#029	8	7	5	6	4
#030	7	9	4	5	3
#031	10	7	6	3	5
#032	6	9	4	3	4
#033	8	4	3	3	2
#034	7	8	7	6	4
#035	10	6	4	2	0
#036	9	8	5	6	4
#037	9	8	5	6	4
#038	4	7	4	4	3
#039	8	5	6	4	3
#040	7	9	9	9	6

SAMPLE #2 RICE CRACKER

EXPERTS	#1	#2	#3	#4	#5
#041	5	7	6	8	4
#042	9	7	5	6	4
#043	8	5	6	4	3
#044	9	6	3	5	1
#045	8	7	6	7	5
#046	9	4	3	6	2
#047	7	7	5	4	3
#048	9	8	6	5	4
#049	4	5	6	6	8
#050	10	8	5	4	3

APPENDIX C

10 EVALUATION VARIABLES MEASURED BY DENCITOMETER AND IMAGE PROCESSING ANALYSIS INSTRUMENT

1. RELATIVELY CONTRAST

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Cyan	0.404	0.339	0.311	0.396	0.373
Magenta	0.411	0.354	0.358	0.391	0.411
Yellow	0.379	0.35	0.362	0.367	0.383
Block	0.388	0.349	0.3338	0.351	0.385
Mean	0.3955	0.348	0.376	0.376	0.388

SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
Cyan	0.267	0.302	0.301	0.262	0.355
Magenta	0.388	0.324	0.174	0.276	0.274
Yellow	0.226	0.221	0.245	0.221	0.229
Block	0.392	0.457	0.252	0.183	0.366
Mean	0.318	0.326	0.243	0.236	0.306

2. SOLID DENSITY

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Cyan	1.14	1.06	1.06	1.06	1.02
Magenta	1.24	1.13	1.06	1.28	1.24
Yellow	1.24	1.2	1.16	1.2	1.15
Mean	1.207	1.13	1.093	1.18	1.137

SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
Cyan	1.16	0.96	1.43	1.41	1.41
Magenta	1.29	1.11	1.49	1.52	1.64
Yellow	0.93	1.04	0.94	1.36	1.4
Mean	1.127	1.037	1.287	1.43	1.48

3. SATURATION

SAMPLE #1 JAPANESE TEA

#1	#2	#3	#4	#5
0.96	0.95	0.85	0.95	0.92

SAMPLE #2 GERBER SENBEI

#1	#2	#3	#4	#5
0.93	0.92	1.05	1.14	1.19

4. HUE ERROR

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Cyan	0.168	0.177	0.171	0.166	0.176
Magenta	0.427	0.412	0.438	0.432	0.422
Yellow	0.0258	0.024	0.0258	0.027	0.0377
Mean	0.2069	0.2043	0.2116	0.2083	0.2119

SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
Cyan	0.18	0.176	0.16	0.158	0.174
Magenta	0.398	0.412	0.402	0.402	0.397
Yellow	0.0212	0.0285	0.0212	0.015	0.0222
Mean	0.1997	0.2055	0.1944	0.1917	0.1977

5. THREE PILED UP COLOR DEGREE

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
H-L	0.28	0.59	0.48	0.53	0.51
M-L	0.16	0.34	0.25	0.34	0.41
Length	1.2 cm	2.6 cm	2.1 cm	2.3 cm	2.4 cm
Three Pilec up Color Degree	0.24	0.52	0.42	0.46	0.48

SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
H-L	0.24	0.4	0.04	0.21	0.23
M-L	0.11	0.22	0.03	0.01	0.12
Length	1.05 cm	1.75 cm	0.6 cm	1.15 cm	1.0 cm
Three Pilec up Color Degree	0.21	0.35	0.12	0.23	0.2

6. DEGREE FOR ASH COLOR

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Cyan	12.04	10.23	11.63	11.76	12.37
Magenta	2.36	2.68	2	1.57	3.15
Yellow	0.854	0.72	0.776	0.811	0.849
Red	2.174	1.399	0.758	1.418	2.21
Green	26.613	19.12	20.97	25	24.17
Blue	45.16	42.98	45.28	46.46	45.04
Mean	14.87%	12.85%	13.57%	14.50%	14.63%

SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
Cyan	8.257	8.602	8.09	8.696	8.696
Magenta	2.38	0.869	2.79	2.041	1.887
Yellow	0.957	0.857	0.957	0.677	0.667
Red	1.515	2.19	1.43	1.852	2.47
Green	24.55	24.32	26.47	25.36	25.9
Blue	42.86	41.74	41.04	42.03	43.54
Mean	13.42%	13.09%	13.46%	13.44%	13.86%

7. EFFECTIVE DENSITY OF HALFTONE DOT

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Cyan	25.97	26.91	25.95	26.83	27.1
Magenta	21.4	21.51	22.86	23.79	23.96
Yellow	24.15	22.84	22.67	25.67	23.99
Block	15.8	11.85	11	11.6	14.38
Mean	21.83	20.78	20.62	21.97	22.38

SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
Cyan	24.19	24.88	25.51	27.63	26.52
Magenta	22.39	22.87	22.17	20.45	25.92
Yellow	25.66	25.29	26.84	22.12	22.29
Block	16.34	19.93	13.24	14.63	12.74
Mean	22.15	23.24	21.94	21.21	21.87

8. ENVIRONS SCUMMING OF HALFTONE DOT

SAMPLE #1 JAPANESE TEA

#1	#2	#3	#4	#5
0	4.22	5.48	2.95	4.29

SAMPLE #2 GERBER SENBEI

#1	#2	#3	#4	#5
0	2.67	6.52	5.92	12.25

9. DOT GAIN

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Cyan	-3.7	-8.7	-9.9	-7.5	-6.8
Magenta	-0.7	1.7	-3.6	-1.5	-3.5
Yellow	-0.2	4.5	2.5	4.2	0.8
Mean	-1.53	-0.83	-3.67	-1.67	-3.17

SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
Cyan	-6.3	-6.2	-3.3	0.4	-3.4
Magenta	-3.4	1.7	13.7	11.7	25.3
Yellow	-0.9	7.7	7.5	27	29
Mean	-3.53	1.07	6	13.03	16.97

10. SHAPE COEFFICIENT OF HALFTONE DOT

SAMPLE #1 JAPANESE TEA

	#1	#2	#3	#4	#5
Cyan	1.332	1.196	1.208	1.34	1.296
Magenta	1.229	1.476	1.285	1.36	1.299
Yellow	1.537	1.733	1.488	1.802	1.623
Mean	1.366	1.468	1.327	1.501	1.406

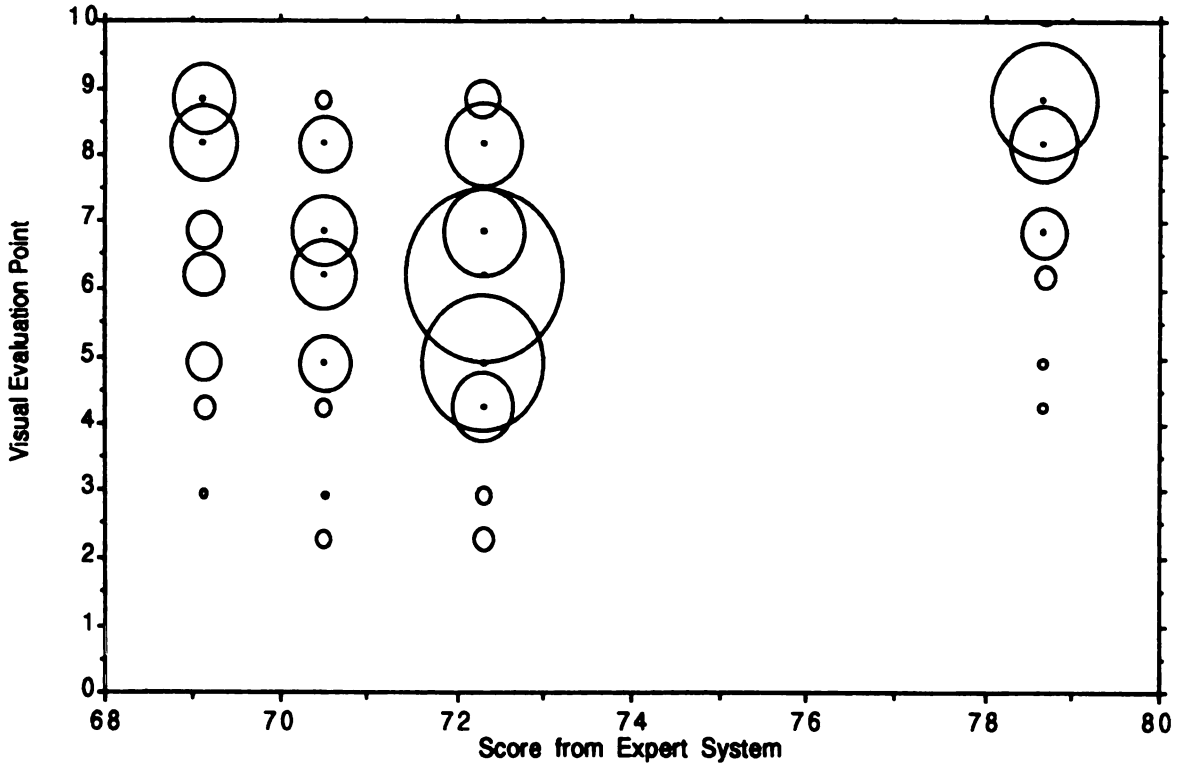
SAMPLE #2 GERBER SENBEI

	#1	#2	#3	#4	#5
Cyan	1.409	1.292	1.518	2.074	1.638
Magenta	1.333	1.506	3.184	2.977	2.036
Yellow	1.561	2.167	3.021	1.55	2.163
Mean	1.434	1.655	2.574	2.2	1.946

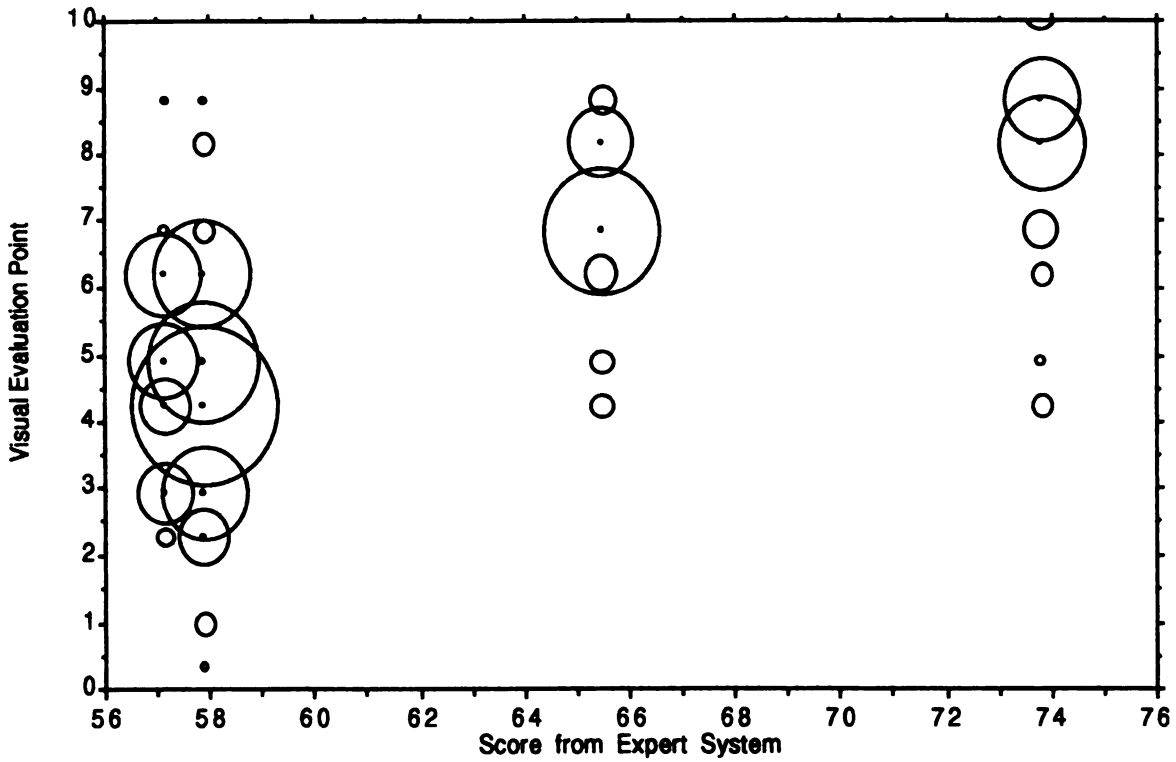
APPENDIX D

GRAPH OF THE RELATIONSHIP BETWEEN EXPERT SYSTEM EVALUATION AND EXPERTS' VISUAL EVALUATION

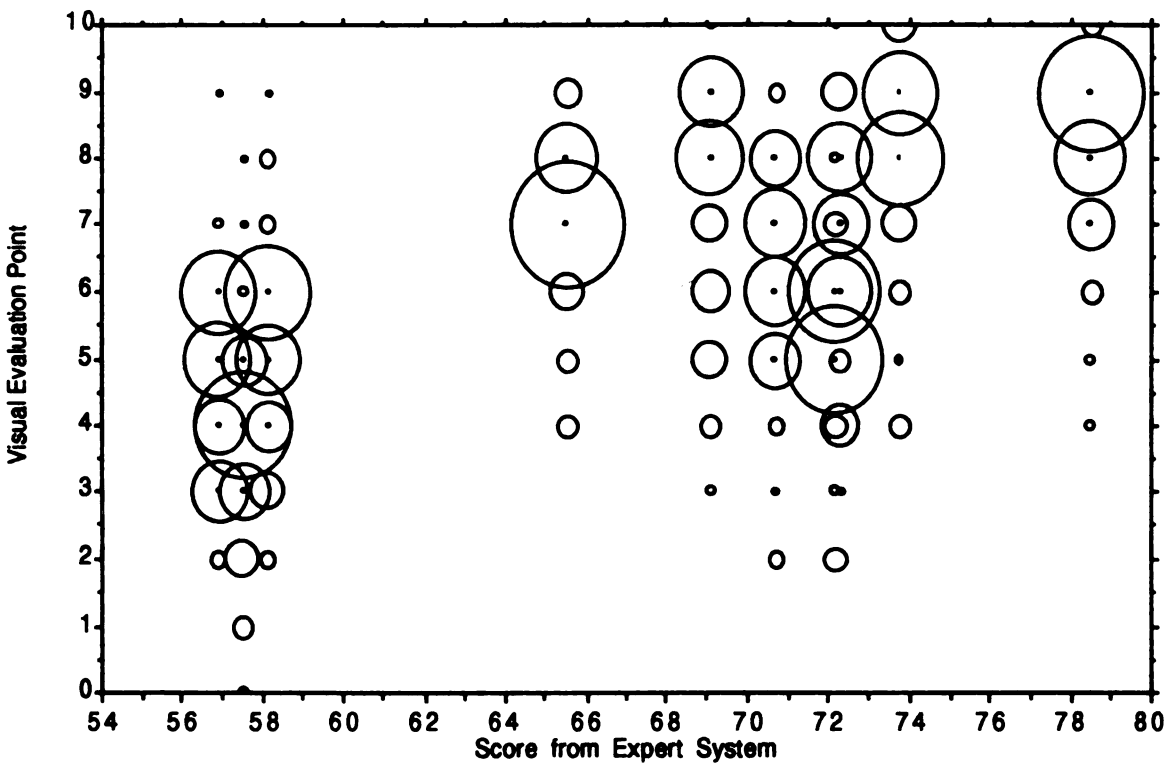
Sample #1 Japanese Tea



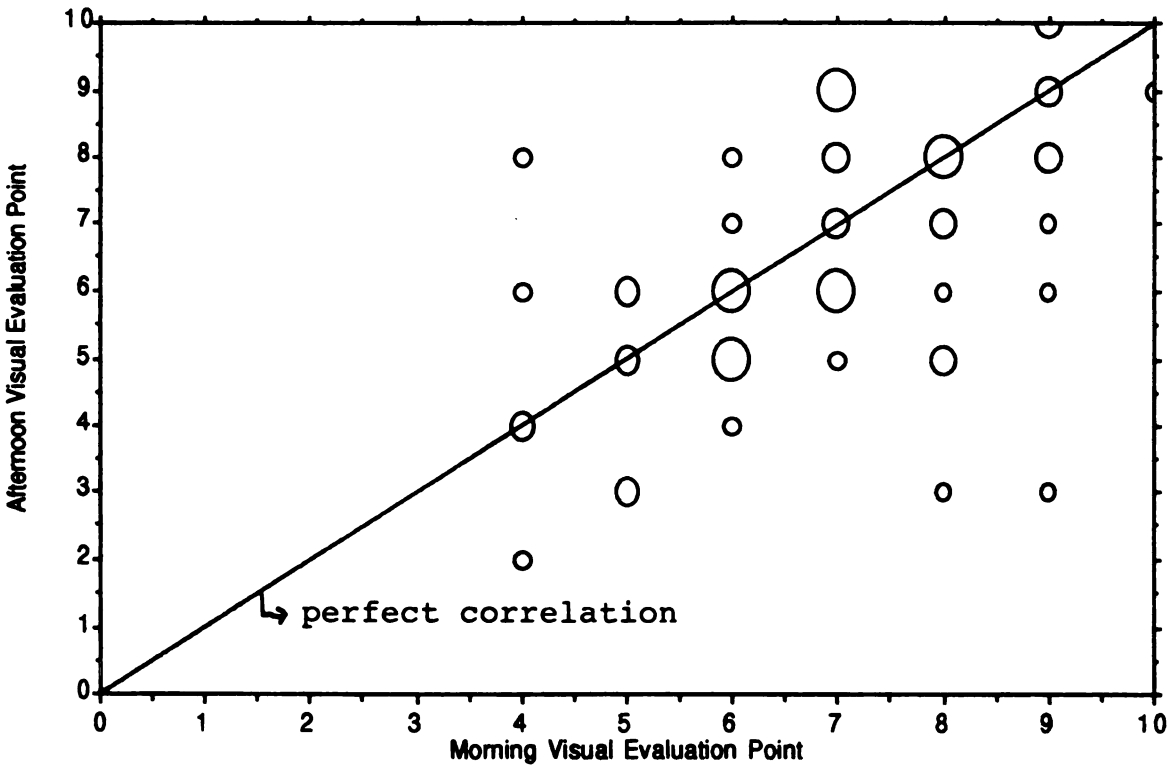
Sample #2 Rice Cracker



Sample: Japanese Tea and Rice Cracker

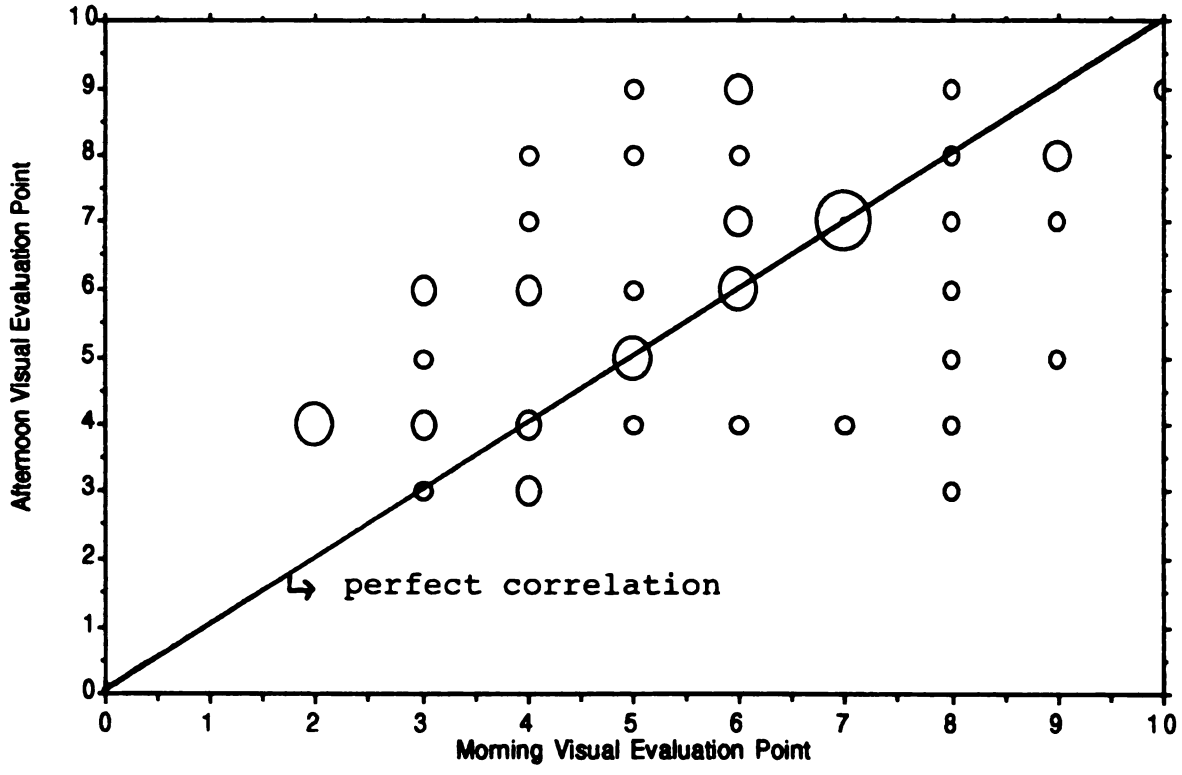


Reliability of Printing Experts
Sample #1 Japanese Tea



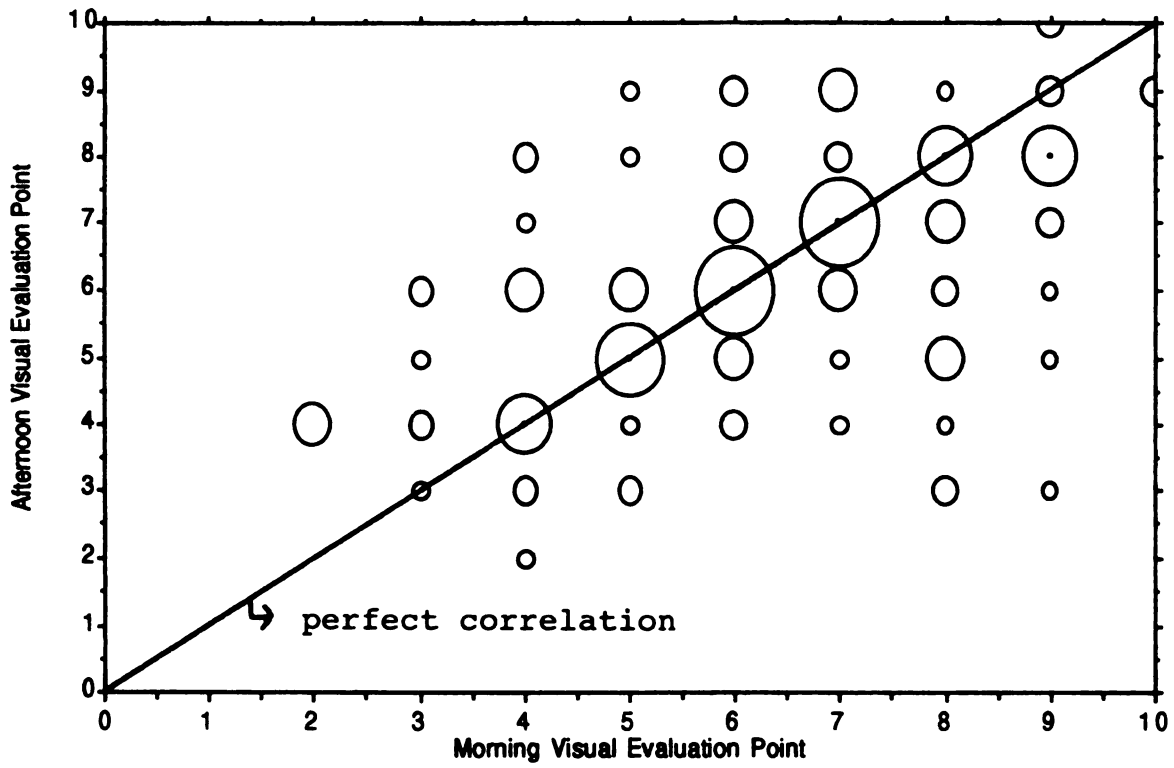
Reliability of Printing Experts

Sample #2 Rice Cracker



Reliability of Printing Experts

Sample: Japanese Tea and Rice Cracker



APPENDIX E

VISUAL EVALUATION SCORE TAKEN FROM SAME PERSON AT MORNING AND AFTERNOON

SAMPLE #1 JAPANESE TEA

EVALUATED BY MORNING

EXPERTS	#1	#2	#3	#4	#5
#001	6	7	5	4	6
#002	7	4	5	9	6
#003	7	8	6	7	8
#004	7	8	5	7	5
#005	7	9	6	8	9
#006	9	9	6	7	8
#007	9	8	4	6	7
#008	10	9	5	7	4
#009	9	8	6	8	7
#010	6	9	5	8	4

EVALUATED BY AFTERNOON

EXPERTS	#1	#2	#3	#4	#5
#001	5	7	6	4	8
#002	5	8	3	3	5
#003	7	8	6	9	5
#004	9	7	6	8	5
#005	9	6	6	8	7
#006	9	10	6	8	7
#007	8	3	2	4	6
#008	9	10	5	6	6
#009	9	5	5	8	6
#010	7	8	3	6	4

SAMPLE #2 RICE CRACKER

EVALUATED BY MORNING

EXPERTS	#1	#2	#3	#4	#5
#001	9	4	3	6	2
#002	4	5	3	2	3
#003	9	7	6	6	5
#004	9	8	3	6	4
#005	8	8	6	4	5
#006	7	8	6	5	6
#007	4	7	2	7	4
#008	10	8	5	4	3
#009	6	9	7	8	5
#010	5	6	3	8	4

EVALUATED BY AFTERNOON

EXPERTS	#1	#2	#3	#4	#5
#001	5	7	6	8	4
#002	8	5	6	4	3
#003	8	7	6	7	5
#004	7	7	5	4	3
#005	4	5	6	6	8
#006	7	9	9	9	6
#007	4	7	4	4	3
#008	9	8	5	6	4
#009	7	8	7	6	4
#010	6	9	4	3	4

APPENDIX F

KNOWLEDGE BASE EXAMPLE RULES

```
A)  PRINTING REGISTER

B)  OVERALL QUALITY
        2-1)  READABILITY OF CHARACTER
        2-2)  COLOR PROBLEM ON PRINTING SURFACE
        2-3)  ROUGHNESS OF SOLID PLACE
        2-4)  CURLING OF PAPER
        2-5)  DOUBLING OF SURFACE

C)  OVERALL SCRUBBING
        3-1)  SCRUBBING
        3-2)  OFFSETTING
        3-3)  ROTTLING OF PRINTING SURFACE
        3-4)  FISHOLE ON PRINTING SURFACE
        3-5)  GHOST IMAGE

D)  COLOR REPRODUCTION

PLEASE CLICK < CONTINUE > WHEN YOU ARE READY TO GO ON.
.....

END
```

```
!=============================================================
!                        KNOWLEDGE BASE
!=============================================================
TITLE Description of Overall Quality of Paper Printing DISPLAY

..........  A  SIMPLE  KNOWLEDGE  BASE  SYSTEM  ..........

          QUALITY CONTROL SYSTEM FOR PAPER PRINTING

                          Prepared by

                        Yoshinori Ueda

                  School of Packaging
                Michigan State University
                East Lansing, Michigan 48823

.....

1. expert system for overall quality of paper printing IS WHAT

RULE expert system
IF description
THEN expert system for overall quality of paper printing IS ok
AND DISPLAY #1
AND DISPLAY #2
AND CHAIN printing register

TEXT description

.....

          WELCOME TO THE EXPERT SYSTEM FOR OVERALL QUALITY
          OF PAPER PRINTING.

          THIS KNOWLEDGE BASE FOR PAPER PRINTING QUALITY
          CONSISTS AN EXPERT SYSTEM THAT ASKS A SERIES OF QUESTIONS
          TO DETERMINE THE OVERALL QUALITY OF PAPER PRINTING.

.....

          PLEASE CLICK <TRUE> TO START THE KNOWLEDGE BASE
          WHEN YOU ARE READY TO GO ON.

DISPLAY #1

          DO YOU WANT TO INSPECT THE OVERALL QUALITY
          OF PAPER PRINTING BY USING EXPERT SYSTEM ?

          IF YOUR ANSWER IS CORRECT, CLICK < CONTINUE > AND THEN
          READ THE MENU FOR THIS EXPERT SYSTEM OF PAPER
          PRINTING QUALITY.

DISPLAY #2
.....
THIS EXPERT SYSTEM WILL ASK A SERIES OF QUESTIONS
REGARDING THE QUALITY OF PAPER PRINTING.

THE KNOWLEDGE BASE IS CONSISTED FROM 4 PARTS THAT ARE;
```

```
TITLE   Diagnosing Register Problem DISPLAY

        ********************************************************************
        01   DIAGNOSIS PART / OUT OF REGISTER
        ********************************************************************

        THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
        SUGGESTIONS WHY OUT OF REGISTERING PHENOMENON HAPPENED.

        THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
        POSSIBLE REASONS AND SUGGESTIONS FOR OUR OF REGISTERING.

        ********************************************************************

        PLEASE CLICK < CONTINUE > WHEN YOU ARE READY TO GO ON.


ATTRIBUTE register problem for whole
AND register problem for partial

GOALSELECT ON

1. out of register is whole
1.1 register problem for whole
2. out of register is partial
2.1 register problem for partial

RULE register problem is partial
IF   middle cylinder is a reason for out of register
THEN register problem for partial IS ok
AND  DISPLAY 01
AND  MAIN readability of character

RULE register problem is partial
IF   moisted water is a reason for out of register
THEN register problem for partial IS ok
AND  DISPLAY 02
AND  CHAIN readability of character

RULE register problem is partial
IF   blanket is a reason for out of register
THEN register problem for partial IS ok
AND  DISPLAY 03
AND  CHAIN readability of character

RULE register problem is partial
IF   the part of cylinder is a reason for out of register
THEN register problem for partial IS ok
AND  DISPLAY 04
AND  CHAIN readability of character

RULE register problem is partial
IF   paper is a reason for out of register
THEN register problem for partial IS ok
AND  DISPLAY 05
AND  CHAIN readability of character

RULE register problem is partial
IF   front gauge is a reason for out of register
AND  the above items do not relate to the reasons for that
THEN register problem for partial IS ok
AND  DISPLAY 06
AND  CHAIN readability of character

RULE register problem is whole
```

```
TITLE   Printing Register DISPLAY

        ********************************************************************
        01   FIRST CHECK POINT /  PRINTING REGISTER
        ********************************************************************

        THIS SECTION IS GOING TO CHECK THE CONDITION
        OF PRINTING REGISTER.

        PRINTING REGISTER MEANS THAT LINE DRAWING (AT REPEATED
        PRINTING) SHIFTS AT TOP AND BOTTOM OR RIGHT AND LEFT OR
        PARTIALLY.

        THE PRINTING QUALITY DOES NOT GUARANTEE IF PRINTING REGISTER IS
        SHIFTING AT TOP AND BOTTOM OR LEFT AND RIGHT OR PARTIALLY.


        THEREFORE, PLEASE CHECK THE DISPARITY OF PRINTING REGISTER
        BY USING SCOPE.

        ********************************************************************

1. the condition of printing register IS WHAT

RULE  out of register
IF    shifting of printing register IS over 1mm
THEN  the condition of printing register IS out of register
AND   CHAIN diagnosis register problem

RULE  may be out of register
IF    shifting of printing register IS between 0.3mm and 1.0mm
THEN  the condition of printing register IS may be out of register
AND   CHAIN diagnosis register problem

RULE  good register
IF    shifting of printing register IS between 0.3mm and 0.1mm
THEN  the condition of printing register IS good register
AND   CHAIN readability of character

RULE  excellent register
IF    shifting of printing register IS less than 0.1mm
THEN  the condition of printing register IS excellent register
AND   CHAIN readability of character

END
```

among these items.

• Click <Continue> •

DISPLAY 03

Please check the following items

1 tension of blanket
2 solid blanket
3 air blanket

It is caused by blanket if there is some reason among these items

• Click <Continue> •

DISPLAY 04

Please check the following items

1 hitting the nail
2 uniformity of nail pressure
3 too strong nail pressure
4 uneven of nail seat
5 the distance between cylinder and nail seat

It is caused by cylinder if there is some reason among these items

• Click <Continue> •

DISPLAY 05

Please check the following items

1 machine direction
2 whether there is seasoning or not
3 cross direction
4 expansion and contraction of paper

It is caused by paper if there is some reason among these items

• Click <Continue> •

DISPLAY 06

Please check the following items

1 space between front gauge board
2 perpendicular of front gauge

IF poor setting position for plate is a reason for that
THEN register problem for whole IS ok
AND DISPLAY 07
AND CHAIN readability of character

RULE register problem is whole
IF nail connection of is a reason for out of register
THEN register problem for whole IS ok
AND DISPLAY 08
AND CHAIN readability of character

RULE register problem is whole
IF feeding or register device is a reason for out of register
THEN register problem for whole IS ok
AND DISPLAY 09
AND CHAIN readability of character

RULE register problem is whole
IF something related to actual machine is a reason for that
THEN register problem for whole IS ok
AND DISPLAY 010
AND CHAIN readability of character

RULE register problem is whole
IF something related to paper is a reason for out of register
THEN register problem for whole IS ok
AND DISPLAY 011
AND CHAIN readability of character

RULE register problem is whole
IF the above item does not relate to the reasons for that
THEN register problem for whole IS ok
AND DISPLAY 012
AND CHAIN readability of character

EXPERT SYSTEM SUBDARY

DISPLAY 01

Please check the following items.

1 applied uneven paper.
2 back up.

It is caused by blanket if there is some defect among these items.

• Click <Continue> •

DISPLAY 02

Please check the following items

1 too much supplied water.
2 uniformity water.

It is caused by moisted water if there is some defect

It is caused by feeder or register device if there is some reason among these items

* Click <Continue> *

DISPLAY 811

Please check the following items

1 poor a right angle of paper
2 too much difference big and small paper
3 poor paper
4 too much expansion and contraction of paper
5 too much static electricity, ink, paper, undulation, and curl
6 poor storage for machine plate
7 poor selection of paper direction (MD and CD)
8 extreme change of temperature and humidity
9 poor seasoning
10 paper wrinkle
11 paper thickness and unsuitable speed

It is caused by something related to paper if there is some reason among these items

* Click <Continue . *

DISPLAY 810

Please check the following items

1 out of register sometimes happened right after blanket washing
2 poor fixed plate
3 poor blanket material
4 flapping at intermediate cylinder
5 change cylinder arrangement while at work
6 poor cylinder arrangement
7 move cylinder at back and forth
8 loosen blanket
9 poor swing
10 irregular blanket thickness
11 scratch pin and key
12 loosen bolt
13 while changing printing speed
14 shock by machinery
15 poor attach bolt
16 loosen right and left adjustment device

It is caused by something related to actual printing machine if there is some reason among these items

* Click <Continue> *

DISPLAY 813

Please check the following items

1 too much a humid water at partly
2 plate expansion

It is caused by front gauge if there is some reason among these items

* Click <Continue> *

DISPLAY 87

Please check the following item

1 adjust setting position for plate

It is caused by poor setting position for plate if there is some reason among these items

* Click <Continue> *

DISPLAY 88

Please check the following items

1 twist of nail shaft
2 too strong of nail pressure
3 too weak of nail pressure
4 be dusty at nail device
5 nail grow
6 nail touches at the other cylinder
7 wear of nail shaft and bearing
8 wear of nail and nail seat
9 up and down for nail seat
10 right and left aberration of nail shaft
11 out of refual and spring pressure
12 out of refual for nail device
13 poor nail adjustment
14 poor nail
15 out of nail seat's height

It is caused by nail connection if there is some reason among these items.

* Click <Continue> *

DISPLAY 89

Please check the following items

1 be dust at the bottom of needle
2 poor needle and movement
3 wear of needle
4 poor installed shaft
5 space between board and swing nail seat
6 obstacle at board
7 rake's adjustment and timing
8 poor needle's timing
9 poor drawing amount of needle
10 poor spring pressure of needle
11 poor height of needle
12 poor right and left parallel
13 timing paper against printing machine
14 paper bend for feeding
15 a right angle for needle paper
16 board for holding paper and poor selection of ball

```
TITLE   Readability of Character DISPLAY


        ****************************************************************
        02   SECOND CHECK POINT / READABILITY OF CHARACTER
        ****************************************************************

        THIS SECTION IS GOING TO CHECK THE CONDITION OF
        CHARACTER ON THE PRINTING SURFACE.

        "CONFIDENCE FACTOR" IS USED FOR CHECKING THE CONDITION OF
        CHARACTER ON THE PRINTING SURFACE BECAUSE THE DECISIONS ARE
        OFTEN MADE ON THE BASIS OF UNCERTAIN OR UNRELIABLE INFORMATION.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ****************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.
        THE PROCEDURE IS THE NEXT SECTION.


CONFIDENCE ON

THRESHOLD=70

1. the condition of character in printing surface IS WORT

RULE readability of character
IF   readability of character
THEN the condition of character in printing surface IS ok
AND  CHAIN clearness of picture
ELSE CHAIN diagnosis letter problem

TEXT readability of character


     HOW MUCH CONFIDENCE DO YOU HAVE ABOUT READABILITY OF CHARACTER ?

     PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
     BY USING THE ABOVE SCALE.


     |-------------------------|-------------------------|
     0                         50                        100

  CAN NOT READ                 MIDDLE                    CAN READ WELL

END
```

```
3  poor adapt paper of blanket
4  caused by original blanket
5  caused by plate making

.....................................................................

It does relate to the other reasons, not relate to mail, feeder,
register device , paper and actual machine if there is some reason
among these items

* Click <Continue> *

END
```

```
                an article apart.
.................................................................
 * Click <Continue> *

DISPLAY #2
.................................................................
Please check the following items.
.................................................................
AS A RESULT OF DIAGNOSING, THE FOLLOWING POSSIBLE REASONS AND
SUGGESTIONS ARE CONSIDERED.

Possible Reasons:      The following possible reasons for this problem
                       are considered.

                       1.  Plate depth is too shallow (character is small)
                       2.  Check the plate whether it is filled up or not.
Possible Suggestions:  The following possible suggestions for this

                       1.  Inspect the plate
                       2.  Wash thoroughly plate after machine stop
                       3.  Doing delay ink drying
                       4.  Change the solvent
.................................................................
 * Click <Continue> *

END
```

```
TITLE  Diagnosis Badly Printed Problem DISPLAY

       ************************************************************
       #2   DIAGNOSIS PART / READABILITY OF CHARACTER
       #3   DIAGNOSIS PART / CLEANNESS OF PICTURE
       ************************************************************

       THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
       SUGGESTIONS FOR BADLY PRINTED PROBLEM REAGADING CHARACTER COMPRESSED
       AND CHARACTER BLURRED.

       THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE POSSIBLE
       REASONS AND SUGGESTIONS FOR BADLY PRINTED PROBLEM.

       ************************************************************

       PLEASE CLICK < CONTINUE > WHEN YOU ARE READY TO GO ON.

ATTRIBUTE badly printed problem for character compressed
AND badly printed problem for character blurred

GOALSELECT ON

1.  the character on the printing surface is compressed
1.1 badly printed problem for character compressed
2.  the character on the printing surface is blurred
2.1 badly printed problem for character blurred

RULE character compressed
IF   the character on the printing surface is compressed
THEN badly printed problem for character compressed IS ok
AND  DISPLAY #1
AND  CHAIN odor

RULE character blurred
IF   the character on the printing surface is blurred
THEN badly printed problem for character blurred IS ok
AND  DISPLAY #2
AND  CHAIN odor

|------------------------------------------------------------------
|                    EXPERT SYSTEM SUMMARY
|------------------------------------------------------------------

DISPLAY #1

 ..................................................................
 Please check the following items.
 ..................................................................

 AS A RESULT OF DIAGNOSING, THE FOLLOWING POSSIBLE REASONS AND
 SUGGESTIONS ARE CONSIDERED.

 Possible Reasons:      The following possible reasons for this problem
                        are considered.

                        1.  Plate depth is too deep  (character is small)
                        2.  Check the viscosity of ink
                        3.  Check the pressure and angle of doctor

 Possible Suggestions:  The following possible suggestions for this

                        1.  Inspect plate cylinder for small character
                        2.  Standardize pressure and angle setting
```

```
TITLE odor DISPLAY

        ************************************************************
        04   FOURTH CHECK POINT / ODOR PROBLEM
        ************************************************************

        THIS SECTION IS GOING TO CHECK THE ODOR PROBLEM. ODOR
        PROBLE IS USUALLY RELATED TO PRINTING INK.


        "CONFIDENCE FACTOR" IS USED FOR CHECKING THE ODOR PROBLEM.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.


CONFIDENCE ON

THRESHOLD=70

1. the condition for an odor on the printing surface IS WHAT

RULE odor
IF   condition of odor
THEN the condition for an odor on the printing surface IS ok
AND  CHAIN roughness of solid place
ELSE CHAIN diagnosis odor problem
TEXT condition of odor


     HOW MUCH CONFIDENCE DO YOU HAVE ABOUT ODOR PROBLEM ?

     PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
     BY USING THE ABOVE SCALE.

     |-------------------|-------------------|
     0                   50                  100

   STRANGE                 MIDDLE            NONE STRANGE
   ODOR                                      ODOR

END
```

```
TITLE   Clearness of Picture DISPLAY

        ************************************************************
        03   THIRD CHECK POINT / CLEARNESS OF PICTURE
        ************************************************************

        THIS SECTION IS GOING TO CHECK THE CONDITION OF CLEARNESS OF
        PICTURE.

        "CONFIDENCE FACTOR" IS USED FOR CHECKING THE CONDITION
        CLEARNESS OF PICTURE BECAUSE THE DECISIONS ARE OFTEN MADE ON
        THE BASIS OF UNCERTAIN OR UNRELIABLE INFORMATION.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.
        THE PROCEDURE IS THE NEXT SECTION.


CONFIDENCE ON

THRESHOLD=70

1. the condition of picture on the printing surface IS WHAT

RULE clearness of picture
IF   clearness of picture
THEN the condition of picture on the printing surface IS ok
AND  CHAIN odor
ELSE CHAIN diagnosis letter problem

TEXT clearness of picture

     HOW MUCH CONFIDENCE DO YOU HAVE ABOUT CLEARNESS  OF PICTURE ?

     PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
     BY USING THE ABOVE SCALE.

     |-------------------|-------------------|
     0                   50                  100

  COMPLETELY               MIDDLE            EXTREMELY
  NOT CLEAR                                  CLEAR

END
```

```
    IF YOU DO NOT WANT TO CONTINUE THE INSPECTION,
    THEN PLEASE CLICK <FALSE> BOTTON TO GO STARTING POINT.

END
```

```
TITLE   Diagnosis Strange Odor Problem DISPLAY

        ..................................................................
        #4   DIAGNOSIS PART / STRANGE ODOR PROBLEM
        ..................................................................

        THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
        SUGGESTIONS FOR STRANGE ODOR PROBLEM

        THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
        POSSIBLE REASONS AND SUGGESTIONS FOR STRANGE ODOR PROBLEM.

        ..................................................................

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.


1. diagnosing system for strange odor problem IS WHAT

RULE strange odor problem
IF   strange odor rises from the printing surface
THEN strange odor problem IS ok
AND  DISPLAY #1
AND  have the facts

RULE expert system
IF   have the facts
AND  start point
THEN diagnosing system for strange odor problem IS ok
AND  CHAIN roughness of solid place
ELSE  CHAIN description

DISPLAY #1
 ------------------------------------------------------------------------
 Please check the following items
 ------------------------------------------------------------------------

  AS A RESULT OF DIAGNOSING,  THE FOLLOWING POSSIBLE REASONS AND
  SUGGESTIONS ARE CONSIDERED.

  Possible Reasons:      The following possible reasons for strange odor
                         on the printing surface are considered.

                         1. Not enough drying
                         2. Usage the ink having poor solvent deserting
                         3. Sticking solvent to printing products

  Possible Suggestions:  The following possible suggestions for strange
                         odor on the printing surface are considered.

                         1. Enough drying
                         2. Usage the ink having well solvent deserting
                         3. Usage the ink having less sticking solvent
                            to printing products.
                         4. Deal with conversations with ink maker
 ------------------------------------------------------------------------
 • Click <Continue> •

TEXT start point

    IF YOU WANT TO CONTINUE TO INSPECT THE PAPER PRINTING QUALITY,
    THEN PLEASE CLICK <TRUE> BOTTON TO GO THE NEXT SECTION.
```

```
TTTLE   Diagnosis Roughness Problem DISPLAY

        ************************************************************
        #5   DIAGNOSIS PART / ROUGHNESS OF SOLID PLACE
        ************************************************************

        THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
        SUGGESTIONS FOR ROUGHNESS OF PRINTING SURFACE.

        THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
        POSSIBLE REASONS AND SUGGESTIONS.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.

1. diagnosing system for roughness problem IS WHAT

RULE roughness problem
IF   the printing surface becomes rough and the gloss go downs
THEN roughness problem of printing surface IS ok
AND  DISPLAY #1
AND  have the facts

RULE expert system
IF   have the facts
AND  start point
THEN diagnosing system for roughness problem IS ok
AND  CHAIN curling
ELSE CHAIN description

|-------------------------------------------------------------------
|                        EXPERT SYSTEM SUMMARY
|-------------------------------------------------------------------

DISPLAY #1
-------------------------------------------------------------------
 Please check the following items
-------------------------------------------------------------------
 AS A RESULT OF DIAGNOSING, THE FOLLOWING POSSIBLE REASONS AND SUGGESTIONS
 ARE CONSIDERED.

 Possible Reasons:                    Possible Suggestions:

 The following possible reasons       The following possible suggestions
 for roughness problem are considered.  for roughness problem are considered.

 1. Ink is too soft                   1. Give the elasticity into the ink
 2. Sending ink too much                 adding gelation varnish.
 3. Dryer too much                    2. Being proper quantity of ink supply
 4. The quantity of fountain          3. Change ink
    solution is too less              4. Being proper quantity of fountain
 5. Unsuitable of fountain               solution
    solution (P.H. etc)               5. Proper usage of fountain solution
 6. Poor plate making                 6. Replate making or later adjustment
 7. Excessive roller pressure,        7. Being proper of pressure
    damping pressure,                 8. Change printing paper
    blanket pressure.
-------------------------------------------------------------------
  * Click (Continue) *

TEXT start point

    IF YOU WANT TO CONTINUE TO INSPECT THE PAPER PRINTING QUALITY,
```

```
TTTLE   Roughness of Solid Place DISPLAY

        ************************************************************
        #5   FIFTH CHECK POINT / ROUGHNESS OF SOLID PLACE
        ************************************************************

        THIS SECTION IS GOING TO CHECK THE CONDITION OF PRINTING
        SURFACE WHICH IS WHETHER THE PRINTING SURFACE IS TOO ROUGH
        OR NOT.

        "CONFIDENCE FACTOR" IS USED FOR CHECKING THE CONDITION OF
        ROUGHNESS.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.
        THE PROCEDURE IS THE NEXT SECTION.

CONFIDENCE ON

THRESHOLD=70

1. the condition for roughness of solid place IS WHAT

RULE roughness of solid place
IF   roughness of solid place
THEN the condition for roughness of solid place IS ok
AND  CHAIN curling
ELSE CHAIN diagnosis rough problem

TEXT roughness of solid place

    HOW MUCH CONFIDENCE DO YOU HAVE ABOUT ROUGHNESS OF SOLID PLACE ?

    PLEASE ENTER THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
    BY USING THE ABOVE SCALE.

    |-------------------|-------------------|
    0                   50                  100

 EXTREMELY              MIDDLE              EXTREMELY
 ROUGH                                      SMOOTH

END
```

```
TITLE   Curling Condition DISPLAY

        ****************************************************************
        06   SIXTH CHECK POINT / CURLING CONDITION OF PAPER
        ****************************************************************

        THIS SECTION IS GOING TO CHECK THE CURLING CONDITION OF
        PRINTING PAPER.

        CURLING IS THAT THE PRINTING SURFACE CURLS
        BY OUTSIDE CONDITIONS. THE PRODUCT WHICH IS PRODUCED WITH
        CURLED PAPER IS GOING TO LOSE THE STRENGHT.

        "CONFIDENCE FACTOR" IS USED FOR CHECKING THE CURLING CONDITION.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ****************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.


CONFIDENCE ON

THRESHOLD=70

1. the condition of curling on printing paper IS WHAT

RULE curling condition
IF   curling condition
THEN the condition of curling on printing paper IS ok
AND  CHAIN double
ELSE CHAIN diagnosis curling problem

TEXT curling condition

     HOW MUCH CONFIDENCE DO YOU HAVE ABOUT CURLING PROBLEM FOR PAPER ?

     PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
     BY USING THE ABOVE SCALE.

     |-------------------|-------------------|
     0                   50                  100

   EXTREMELY                    MIDDLE                    NONE CURL
   CURL

END
```

```
     THEN PLEASE CLICK <TRUE> BOTTON TO GO THE NEXT SECTION.

     IF YOU DO NOT WANT TO CONTINUE THE INSPECTION,
     PLEASE CLICK <FALSE> BOTTON TO GO THE STARTING POINT.

END
```

```
IF YOU WANT TO CONTINUE TO INSPECT THE PAPER PRINTING QUALITY,
THEN PLEASE CLICK <TRUE> BOTTON TO GO THE NEXT SECTION.

IF YOU DO NOT WANT TO CONTINUE TO INSPECT,
THEN PLEASE CLICK <FALSE> BOTTON TO GO STARTING POINT

END
```

```
TITLE   Diagnosis Curling Problem DISPLAY

        ************************************************************
        04   DIAGNOSIS PART / CURLING OF PAPER
        ************************************************************

        THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
        SUGGESTIONS FOR CURLING PROBLEM.

        THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
        POSSIBLE REASONS AND SUGGESTIONS FOR CURLING PROBLEM.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.


1. expert system for curling problem IS WHAT

RULE curling problem
IF   printing surface for paper and film curls
THEN curling problem IS ok
AND  DISPLAY #1
AND  have the facts

RULE expert system
IF   have the facts
AND  start point
THEN expert system for curling problem IS ok
AND  CHAIN double
ELSE CHAIN description
```

```
|=============================================================
|                    EXPERT SYSTEM SUMMARY
|=============================================================

DISPLAY #1
 ..........................................................
 Please check the following items
 ..........................................................
 AS A RESULT OF DIAGNOSING,  THE FOLLOWING POSSIBLE REASONS FOR
 THIS PROBLEM ARE CONSIDERED.

 Possible Reasons:     The following possible reasons for this problem
                       are considered.

                       1. Using the water based ink for paper printing
                       2. Being existence of remaining solvent
                       3. Contraction of ink membrane during ink drying

 Possible Suggestions: The following possible reasons for this problem
                       are considered.

                       1. Should be used ink which is fitting material
                          of printing products.

 ..........................................................

  * CLICK <CONTINUE> *

TEXT start point
```

```
TITLE   Diagnosing Doubling Problem DISPLAY

        ********************************************************************
        07   DIAGNOSIS PART / DOUBLING) OF PRINTING SURFACE
        ********************************************************************

        THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
        SUGGESTIONS FOR DOUBLING PROBLEM

        THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN POSSIBLE
        REASONS AND SUGGESTIONS.

        ********************************************************************

        PLEASE CLICK (CONTINUE) WHEN YOU ARE READY TO GO ON.

ATTRIBUTE doubling problem for too much difference
AND doubling problem for right and left
AND doubling problem for incline
AND doubling problem for mutual at every one sheet
AND doubling problem for every a couple of sheets
AND the possible reasons for doubling more detail

GOALSELECT ON

1. printing product doubles at too much difference
1.1 doubling problem for too much difference
2. printing product doubles at right and left
2.1 doubling problem for right and left
3. printing product doubles at incline
3.1 doubling problem for incline
4. printing product doubles mutual at every one sheet
4.1 doubling problem for mutual at every one sheet
5. printing product doubles at every a couple of sheets
5.1 doubling problem for every a couple of sheets
6. In order to know more detail for reason of doubling
6.1 the possible reasons for doubling more detail

RULE too much difference for double
IF   printing product doubles at too much difference
THEN doubling problem for too much difference IS ok
AND  DISPLAY @13
AND  CHAIN overall scumming

RULE right and left for double
IF   printing product doubles at right and left
THEN doubling problem for right and left IS ok
AND  DISPLAY @14
AND  CHAIN overall scumming

RULE incline for double
IF   printing product doubles at incline
THEN doubling problem for incline IS ok
AND  DISPLAY @15
AND  CHAIN overall scumming

RULE mutual at every one sheet
IF   printing product doubles mutual at every one sheet
THEN doubling problem for mutual at every one sheet IS ok
AND  DISPLAY @16
AND  CHAIN overall scumming

RULE every a couple of sheets
IF   printing product doubles at every a couple of sheets
THEN doubling problem for every a couple of sheets IS ok
```

```
TITLE   Double Image DISPLAY

        ********************************************************
        07   SEVENTH CHECK POINT / DOUBLING OF PRINTING SURFACE
        ********************************************************

        THIS SECTION IS GOING TO CHECK THE DOUBLING CONDITION
        OF PRINTING SURFACE.

        DOUBLING IS THAT PRINTING LINE DRAWING OF THE SAME PLATE
        IS PRINTED WITH SHIFTED DOUBLE AND TRIPLE. THE PRODUCT
        HAVING DOUBLE ON THE PRINTING SURFACE LOSSES THE ORIGINAL
        PRODUCT PURPOSE.

        "CONFIDENCE FACTOR" IS USED FOR THE DOUBLING CONDITION.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ********************************************************

        PLEASE CLICK (CONTINUE) WHEN YOU ARE READY TO GO ON.
        THE PROCEDURE IS THE NEXT SECTION.

CONFIDENCE ON

THRESHOLD=70

1. the condition of double on printing surface IS WHAT

RULE doubling condition
IF   doubling condition
THEN the condition of double on printing surface IS ok
AND  CHAIN overall scumming
ELSE CHAIN diagnosis doubling problem

TEXT doubling condition

    HOW MUCH CONFIDENCE DO YOU HAVE ABOUT DOUBLING PROBLEM ?

    PLEASE ENTER THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
    BY USING THE ABOVE SCALE.

    |-----------------------|-----------------------|
    0                      50                     100

  EXTREMELY                MIDDLE                 SOME DOUBLE
  DOUBLE

END
```

```
        ------------------------------------------------------
        Please check the following items for doubling
        ------------------------------------------------------

        1  move cylinder at right and left
        2  poor nail adjustment

        ------------------------------------------------------

        The above reasons are considered for doubling at incline

        • Click <Continue> •

DISPLAY #16

        ------------------------------------------------------
        Please check the following items for doubling
        ------------------------------------------------------

        1  poor nail adjustment
        2

        ------------------------------------------------------

        The above reasons are considered for doubling mutual at
        every one sheet

        • Click <Continue> •

DISPLAY #17

        ---------------------------------------------
        Please check the following items for doubling
        ---------------------------------------------

        1  poor nail adjustment
        2  flapping of paper
        3  poor back crash

        ---------------------------------------------

        • Click <Continue> •

DISPLAY #18

        ------------------------------------------------------
        Please check the following items for doubling
        ------------------------------------------------------

        1  poor timing
        2  nail adjustment
        3  machine balance (should be parallel)
        4  poor plate

        ------------------------------------------------------

        If there is some reason among these items,
        the reason of doubling is caused by machine adjustment.

        • Click <Continue> •

DISPLAY #19
        ------------------------------------------------------
        Please check the following items for doubling
        ------------------------------------------------------

AND  DISPLAY #17
AND  CHAIN overall scanning

RULE more detail doubling problem
IF   there is something reasons in the machine adjustment
THEN the possible reasons for doubling more detail IS ok
AND  DISPLAY #18
AND  CHAIN overall scanning

RULE more detail doubling problem
IF   there is something reasons in the handling procedure
THEN the possible reasons for doubling more detail IS ok
AND  DISPLAY #19
AND  CHAIN overall scanning

RULE more detail doubling problem
IF   there is something reasons in printing material
THEN the possible reasons for doubling more detail IS ok
AND  DISPLAY #20
AND  CHAIN overall scanning

RULE more detail doubling problem
IF   here is something reasons in machine accuracy
THEN the possible reasons for doubling more detail IS ok
AND  DISPLAY #21
AND  CHAIN overall scanning

|=============================================================
|                    EXPERT SYSTEM SUMMARY
|=============================================================

DISPLAY #13

        ------------------------------------------------------
        Please check the following items for doubling
        ------------------------------------------------------

        1  cylinder arrangement
        2  poor nail adjustment
        3  shock by machinery
        4  form of bearing
        5  crash of gear

        ------------------------------------------------------

        The above reasons are considered for doubling too much

        • Click <Continue> •

DISPLAY #14

        ------------------------------------------------------------
        Please check the following items for doubling
        ------------------------------------------------------------

        1  move nail shaft at right and left
        2  vibration of machine
        3  machine at not horizontal level

        ------------------------------------------------------------

        The above reasons are considered for doubling at right and left

        • Click <Continue> •

DISPLAY #15
```

• Click <Continue> •

END

1 printing speed is too fast against machine's quality
2 printing pressure is too high
3 loosen tension of blanket
4 too soft make up
5 too much supplied water
6 loose the installation of plate
7 plate cylinder and blanket are etching
8 an alien substance is mixing in the bottom
9 irregular tension of blanket at right and left

If there is some reason among these items,
the reason of doubling is caused by handling procedure.

• Click <Continue> •

DISPLAY 030

Please check the following items for doubling

---

1 roller
- 1.1 greasing

2 ink
- 2.1 too much tack

3 paper
- 3.1 waving of paper
- 3.2 direction of paper
- 3.3 paper quality
- 3.4 curling
- 3.5 seasoning

4 blanket
- 4.1 blanket texture
- 4.2 greasing
- 4.3 uneven thickness
- 4.4 uneven (blanket0

5 plate
- 5.1 uneven thickness of plate
- 5.2 uneven thickness of sketch
- 5.3 smoothing plate

If there is some reason among these items,
the reason of doubling is caused by printing material.

• Click <Continue> •

DISPLAY 031

Please check the following items for doubling

---

1 machine vibration
2 wear bearing
3 poor cylinder at right and left
4 poor nail plate at right and left
5 wear nail seat
6 changing the height of nail seat
7 weak main spring of nail
8 wear of nail plate
9 poor nail and nail seat
10 poor plate cylinder's adjustment device
11 irregular rotation of prime mover
12 miss at cummotion

If there is some reason among these items,
the reason of doubling is caused by machine accuracy.

```
TITLE   Diagnosis Scumming Problem DISPLAY
        ************************************************************
        00   DIAGNOSIS PART / OVERALL SCUBBING
        ************************************************************

        THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
        SUGGESTIONS FOR SCUBBING PROBLEM.

        Scumming problem is occurred during either printing operation or
        except printing operation.

        The following five types scumming are considered as a scum occurred
        during printing operation that are :

        tinting
        stable scumming
        a partial scumming
        line plumpe at overall
        scumming toward vertical direction

        ************************************************************
        PLEASE CLIK <CONTINUE> WHEN YOU ARE READY TO GO ON.

ATTRIBUTE scumming during printing operation
AND scumming during except printing operation

GOALSELECT ON

1. scumming problem during printing operation
1.1 scumming during printing operation
2. scumming problem during except printing operation
2.1 scumming during except printing operation

RULE scumming problem during printing operation
IF   scumming occure during except printing operation
THEN scumming during except printing operation IS ok
AND  DISPLAY 01
AND  CHAIN offsetting

RULE scumming like a tinting
IF   scumming is like a tinting
THEN scumming during printing operation IS ok
AND  DISPLAY 02
AND  CHAIN offsetting

RULE scumming like a stable
IF   scumming is like a stable
THEN scumming during printing operation IS ok
AND  DISPLAY 03
AND  CHAIN offsetting

RULE scumming like a partial
IF   scumming is like an partial
THEN scumming during printing operation IS ok
AND  DISPLAY 04
AND  CHAIN offsetting

RULE scumming like an overall
IF   scumming is like an overall
THEN scumming during printing operation IS ok
AND  DISPLAY 05
AND  CHAIN offsetting

RULE scumming like a toward vertical direction
IF   scumming is like a toward vertical direction
THEN scumming during printing operation IS ok
```

```
TITLE   Overall scumming for printing surface DISPLAY

        ************************************************************
        08   EIGHTH CHECK POINT / OVERALL SCUBBING
        ************************************************************

        THIS SECTION IS GOING TO CHECK THE OVERALL SCUBBING
        FOR PRINTING SURFACE.

        SCUBBING IS THAT PRINTING SURFACE SCUBBS BY INK OR
        ALIEN SUBSTANCE AND BY RUBBING MACHINE PARTS
        DURING PRINTING OPERATION, AND DELIVERING AFTER PRINTING OPERATION.

        "CONFIDENCE FACTOR" IS USED FOR THIS PROBLEM.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.
        THE PROCEDURE IS THE NEXT SECTION.

CONFIDENCE ON

THRESHOLD=70

1. the condition of overall scumming for printing surface IS WANT

RULE overall scumming
IF   overall scumming
THEN the condition of overall scumming for printing surface IS ok
AND  CHAIN offsetting
ELSE CHAIN diagnosis scum problem

TEXT overall scumming

        HOW MUCH CONFIDENCE DO YOU HAVE ABOUT OVERALL SCUBBING
        OF PRINTING SURFACE ?

        PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
        BY USING THE ABOVE SCALE.

        |_____________|_____________|
        0            50           100

      SCUBBING                MIDDLE                NONE
      TOO MUCH                                      SCUBBING

END
```

3.1 too much soft
3.2 poor ingredient
3.3 emulsification
3.4 obesity
3.5 too much dryer

4 it is caused by plate
4.1 remaining light sensitive coating
4.2 poor treatment after modification
4.3 fog
4.4 poor grain
4.5 left out of rubber
4.6 partially oxidation

5 it is caused by handling operation
5.1 mixing oil
5.2 lack of N solution
5.3 putrefaction of rubber
5.4 partially oxidation
5.5 poor cylinder arrangement

•Click <Continue> •

DISPLAY #4

The following main five reasons are considered
Please check each situation.

---

1 it is caused by water
1.1 poor P.H. value
1.2 remaining oil

2 it is caused by ink
2.1 poor drying of previous ink
2.2 poor hardness
2.3 too much dryer
2.4 poor ingredient
2.5 poor water resistance for pigment

3 it is caused by handling
3.1 remaining rubber
3.2 poor arrangement
3.3 dropping water and oil on the paper
3.4 scumming eliminator

4 it is caused by paper
4.1 scattering dust
4.2 paper picking
4.3 too high P.H.

5 it is caused by machinery
5.1 swollen roller
5.2 overlay
5.3 poor decision for roller
5.4 touching at machinery part

• Click <Continue> •

DISPLAY #5

The following main four reasons are considered
Please check each situation.

---

1 it is caused by ink
1.1 too much dryer
1.2 high tendency of piling
1.3 obesity

2 it is caused by paper
2.1 fussing remains at roller

3 it is caused by machinery
3.1 poor decision of ink roller (high pressure)
3.2 poor decision of water

4 it is caused by handling operation
4.1 poor tincture
4.2 poor cylinder arrangement
4.3 poor gumming up
4.4 water supple too much or less

• Click <Continue> •

DISPLAY #6

AND DISPLAY #6
AND CHAIN offsetting

EXPERT SYSTEM SUMMARY

DISPLAY #1

Please check the following items

The following main two situations are considered.
Please check each situation

1 it is caused by something related to machinery
1.1 rubbing at paper guide
1.2 rubbing at intermediate cylinder
1.3 rubbing at delivery cylinder
1.4 rubbing at chain gripper
1.5 rubbing at standing operation

2 it is caused by something related to paper thickness and the direction of paper
2.1 the direction of paper
2.2 rubbing with machinery parts because of hardness

• Click <Continue> •

DISPLAY #2

Please check the following items

The following main three situations are considered.
Please check each situation

1 it is caused by fountain solution:
1.1 unsuitable P.H. for N solution
1.2 lack of water
1.3 remaining oil in the fountain solution

2 it is caused by handling operation
2.1 poor cylinder arrangement
2.2 partially swollen at roller
2.3 poor roller setting

3 it is caused by ink
3.1 too much dryer
3.2 poor ink ingredient
3.3 too much soft
3.4 emulsification
3.5 poor water resistance of pigment

• Click <Continue> •

DISPLAY #3

The following main five reasons are considered
Please check each situation.

---

1 it is caused by paper
1.1 unsuitable P.H. value
1.2 poor surface intensity

2 it is caused by roller
2.1 poor setting roller
2.2 bending a shaft
2.3 partially swollen at roller

3 it is caused by ink

```
TITLE   Offsetting DISPLAY

        ************************************************************************
        09   NINTH CHECK POINT / OFFSETTING CONDITION
        ************************************************************************.

        THIS SECTION IS GOING TO CHECK THE CONDITION OF OFFSETTING.


        OFFSETTING IS THAT WHEN BEING PILED UP OR ROLLING PAPER,
        INK OF PRINTING PRODUCT STICKS TO BACKSIDE SURFACE OF ACCUMULATING
        PRINTING PRODUCT.

        "CONFIDENCE FACTOR" IS USED FOR CHECKING THE OFFSETTING PROBLEM.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ************************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.
        THE PROCEDURE IS THE NEXT SECTION.

CONFIDENCE ON

THRESHOLD=70

1. the condition of offsetting on backside printing paper IS WORST

RULE offsetting problem
IF   offsetting problem
THEN the condition of offsetting on backside printing paper IS ok
AND  CHAIN mottle of surface
ELSE CHAIN diagnosis offset problem

TEXT offsetting problem


     HOW MUCH CONFIDENCE DO YOU HAVE ABOUT OFFSETTING CONDITION ?

     PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT.
     BY USING THE ABOVE SCALE.

     |-------------------|-------------------|
     0                   50                  100

   EXTREMELY                MIDDLE            NONE
   OFFSETTING                                 OFFSETTING


END
```

```
.....................................................
The following main five reasons are considered
Please check each situation.
.....................................................

1  it is caused by ink roller
   1.1  hurting at plate by entering sand into the inkroller
   1.2  partially greasing

2  it is caused by poor dryer for previous ink
   2.1  rubbing at paper feeder
   2.2  rubbing at register device
   2.3  rubbing at paper guide
   2.4  rubbing swing nail

3  it is caused by water stick
   3.1  being scratch by dust of water stick
   3.2  poor molleton

.....................................................

• Click <Continue> •
```

```
END
```

```
        ------------------------------------------------------
        Please check the following items.
        ------------------------------------------------------

        1  it is installed shutter and
        2
        3
        4  it is good timing
        5  it is installed spray
        6
        7  it is lack of printing pressure
        8  poor cylinder arrangement

        ------------------------------------------------------

        It is caused by printing machine, especially anti set off
        device, if there is some reason among these above items.

        • Click <Continue> •

DISPLAY #2

        ------------------------------------------------------
        Please check the following items
        ------------------------------------------------------

        1  it is installed static eliminator
        2  it is running effectively
        3  it is lack of printing pressure
        4  poor cylinder arrangement

        ------------------------------------------------------

        It is caused by printing machine, especially static
        eliminator If there is some reason among these above items.

        • Click <Continue> •

DISPLAY #3

        ------------------------------------------------------------------
        Please check the following items for offsetting
        ------------------------------------------------------------------

        1  poor absorption
        2  poor transmission
        3  it is high smoothness
        4  It is too much high or low P H.
        5  too thick paper
        6  heavy paper
        7  it is occuring static electricity
        8  curling too much
        9  waving too much
       10  folding too much

        ------------------------------------------------------------------

        It is caused by something related to paper If there is some
        reason among these above items.

        • Click <Continue> •

DISPLAY #4

        ------------------------------ ------------------------------
```

```
TITLE  Diagnosing Offsetting Problem DISPLAY

       ••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
       #9   DIAGNOSIS PART / OFFSETTING PROBLEM
       ••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

       THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
       SUGGESTIONS FOR OFFSETTING PROBLEM.

       THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
       POSSIBLE REASONS AND SUGGESTIONS.

       ••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••

       PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.

ATTRIBUTE the possible reasons for offsetting

GOALSELECT ON

1. the possible reasons for offsetting

RULE offsetting problem
IF   printing machine is a reason for offsetting
AND  it is an anti offset off device
THEN the possible reasons for offsetting IS ok
AND  DISPLAY #1
AND  CHAIN mottle of surface

RULE offsetting problem
IF   printing machine is a reason for offsetting
AND  it is a static eliminator
THEN the possible reasons for offsetting IS ok
AND  DISPLAY #2
AND  CHAIN mottle of surface

RULE offsetting problem
IF   something related to paper is a reason for offsetting
THEN the possible reasons for offsetting IS ok
AND  DISPLAY #3
AND  CHAIN mottle of surface

RULE offsetting problem
IF   something related to ink is a reason for offsetting
THEN the possible reasons for offsetting IS ok
AND  DISPLAY #4
AND  CHAIN mottle of surface

RULE offsetting problem
IF   fountain solution is a reason for offsetting
THEN the possible reasons for offsetting IS ok
AND  DISPLAY #5
AND  CHAIN mottle of surface

RULE offsetting problem
IF   handling operation is a reason for offsetting
THEN the possible reasons for offsetting IS ok
AND  DISPLAY #6
AND  CHAIN mottle of surface

!=============================================================
!                    EXPERT SYSTEM SUMMARY
!=============================================================

DISPLAY #1
```

```
TITLE   Mottle of Surface DISPLAY

        ************************************************************
        @10   TENTH CHECK POINT / MOTTLING CONDITION
        ************************************************************

        THIS SECTION IS GOING TO CHECK THE CONDITION OF MOTTLING
        ON THE PRINTING SURFACE.

        MOTTLING IS THAT THE PARTIAL DENSITY AT PRINTING PRODUCT
        OR THE DENSITY OF EVERY SHEET OF PAPER ARE NOT UNIFORM.

        "CONFIDENCE FACTOR" IS USED FOR MOTTLING CONDITION.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.
        THE PROCEDURE IS THE NEXT SECTION.

CONFIDENCE ON

THRESHOLD=70

1. the condition for mottle of printing surface IS WHAT

RULE mottle of surface
IF   mottle of surface
THEN the condition for mottle of printing surface IS ok
AND  CHAIN pinhole
ELSE CHAIN diagnosis mottling problem

TEXT mottle of surface


     HOW MUCH CONFIDENCE DO YOU HAVE ABOUT MOTTLING CONDITION
     OF PRINTING SURFACE ?

     PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
     BY USING THE ABOVE SCALE.

     |----------|----------|
     0         50        100

   EXTREMELY                MIDDLE                  NONE
   MOTTLING                                         MOTTLING

END
```

```
        Please check the following items
        ------------------------------------------------------------
        1
        2
        3  ink supplied too much
        4  lack of drier
        5  drying too slow
        6  use varnish and compound too much
        7  lack of corn starch
        8  poor light resistance of pigment
        9  ink too much soft

        ------------------------------------------------------------

        It is caused by something related to ink If there is some
        reason among these above items.

        • Click <Continue> •

DISPLAY 05

        ------------------------------------------------------------
        Please check the following items
        ------------------------------------------------------------

        1  check the degree of P.H.
        2  supplied water too much

        ------------------------------------------------------------

        It is caused by something related to fountain solution If
        there is some reason among these above items.

        • Click <Continue> •

DISPLAY 06
        ------------------------------------------------------------
        Please check the following items
        ------------------------------------------------------------

        1  poor take care of paper
        2  continues printing operation as long as ink is get emulsification
        3  use a narrow wedge on the delivery plate
        4
        5
        6
        7  wrong air supply
        8  wrong time air supply
        9  the number of air supply
       10  too early time to move the printing products
       11  stack like stick

        ------------------------------------------------------------

        It is caused by something related to handling operation and
        stock If there is some reason among these above items.

        • Click <Continue> •

END
```

```
IF   mottling problem occurs at whole printing paper
AND  it is a mottle of right and left direction
THEN mottling problem for whole printing paper IS ok
AND  DISPLAY 05
AND  CHAIN pinhole

RULE for whole printing paper
IF   mottling problem occurs at whole printing paper
AND  it is a mottle of partly
THEN mottling problem for whole printing paper IS ok
AND  DISPLAY 06
AND  CHAIN pinhole

RULE for whole printing paper
IF   mottling problem occurs at whole printing paper
AND  it is a mottle of ink roller
THEN mottling problem for whole printing paper IS ok
AND  DISPLAY 07
AND  CHAIN pinhole

RULE occasionally occurs
IF   mottling problem occasionally occurs after printing
THEN mottling problem for occasionally IS ok
AND  DISPLAY 08
AND  CHAIN pinhole
```

```
|=============================================================|
|                    EXPERT SYSTEM SUBPART                    |
|=============================================================|

DISPLAY 01

        ------------------------------------------------------
        Please check the following items for mottling.
        ------------------------------------------------------

        1  is it changing the rotation quantity for inking roller
        2  is it changing water quantity
        3  is plate gradually being inferior
        4  is ink becoming emulsification
        5  is blanket gradually being inferior

        ------------------------------------------------------

        * Click <Continue> *

DISPLAY 02

        ------------------------------------------------------------
        Please check the following items for mottling.
        ------------------------------------------------------------

        1  adjust the ink roller (it is impossible to solve perfectly)
        2  put the waste sheets

        ------------------------------------------------------------

        * Click <Continue> *

DISPLAY 03

        ---------------------------------------------
        Please check the following items for mottling.
        ---------------------------------------------

        1  check the streak
```

```
TITLE   Diagnosis Mottling Problem DISPLAY

    ************************************************************
    @10   DIAGNOSIS PART / MOTTLING PROBLEM
    ************************************************************

    THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
    SUGGESTIONS FOR MOTTLING PROBLEM.

    THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
    POSSIBLE REASONS AND SUGGESTIONS FOR MOTTLING.

    FOUR POSSIBLE SITUATIONS ARE CONSIDERED FOR MOTTLING PROBLEM.

    MOTTLING GRADUALLY OCCURS DURING PRINTING OPERATION.
    MOTTLING OCCURS IMMEDIATELY AFTER HALTING PRINTING OPERATION.
    MOTTLING OCCURS AT WHOLE PRINTING PAPER.
    MOTTLING OCCASIONALLY OCCURS AFTER PRINTING MANY SHEETS OF PAPER.

    ************************************************************

    PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.

ATTRIBUTE mottling problem for gradually changing
AND mottling problem after halting operation
AND mottling problem for whole printing paper
AND mottling problem for occasionally

GOALSELECT ON

1. mottling problem occurs gradually
1.1 mottling problem for gradually changing
2. mottling problem occurs immediately
2.1 mottling problem after halting operation
3. mottling problem occurs at whole printing paper
3.1 mottling problem for whole printing paper
4. mottling problem occurs occasionally
4.1 mottling problem for occasionally

RULE gradually changing
IF   mottling problem gradually occurs during printing operation
THEN mottling problem for gradually changing IS ok
AND  DISPLAY 01
AND  CHAIN pinhole

RULE after halting printing operation
IF   mottling problem immediately occurs after halting operation
THEN mottling problem after halting operation IS ok
AND  DISPLAY 02
AND  CHAIN pinhole

RULE for whole printing paper
IF   mottling problem occurs at whole printing paper
AND  it is caused by streak
THEN mottling problem for whole printing paper IS ok
AND  DISPLAY 03
AND  CHAIN pinhole

RULE for whole printing paper
IF   mottling problem occurs at whole printing paper
AND  it is caused by picture pattern
THEN mottling problem for whole printing paper IS ok
AND  DISPLAY 04
AND  CHAIN pinhole

RULE for whole printing paper
```

```
        10  old roller
        ----------------------------------------
        • Click <Continue> •

DISPLAY 00
        ----------------------------------------
        Please check the following items for mottling.
        ----------------------------------------
        1  check the reasons for out of register
        2  check the reasons for streak
        3  check the reasons for doubling
        ----------------------------------------
        • Click <Continue> •

END
```

```
        ----------------------------------------
        • Click <Continue> •

DISPLAY 04
        ----------------------------------------------------
        Please check the following items for mottling.
        ----------------------------------------------------
        1  check the combination between solid place and screen
        2  poor printing down for plate
        3  check the ghost image
        ----------------------------------------------------
        • Click <Continue> •

DISPLAY 05
        ----------------------------------------
        Please check the following items for mottling.
        ----------------------------------------
        1  is the surface of roller being hydrophilic
        2  is the part of roller wearing
        3  irregular supply water
        4  poor adjustment for ink fountain
        5  greasing of roller
        ----------------------------------------
        • Click <Continue> •

DISPLAY 06
        ----------------------------------------
        Please check the following items for mottling.
        ----------------------------------------
        1  poor printing down for plate
        2  poor trapping
        3  poor getting ready for printing
        4  uneven gap for paper
        5  irregular thickness for plate and blanket
        ----------------------------------------
        • Click <Continue> •

DISPLAY 07
        ----------------------------------------
        Please check the following items for mottling.
        ----------------------------------------
        1  check the viscosity and hardness for ink
        2  poor balance between ink and water
        3  check the roller mark
        4  check the material for roller adjustment
        5  roller adjustment
        6  adjustment D.P.
        7  check the hardness of rubber
        8  vibration of plate
        9  check the roller timing
```

```
     The diameter of pinhole between 1mm and 2mm is minor defect
     The product does not affect printing quality too much
     The condition of this limit is ok

     • Click Continue •

DISPLAY 08

     The diameter of pinhole less than 1mm is no problem
     The condition of product is good

     • Click Continue •

END
```

```
TITLE   Pinhole DISPLAY

        ************************************************************
        #11   ELEVENTH CHECK POINT / PINHOLE CONDITION
        ************************************************************

        THIS SECTION IS GOING TO CHECK THE PINHOLE PROBLEM ON THE
        PRINTING SURFACE.

        PINHOLE IS THAT A SMALL DOT WHICH DOES NOT STICK INK ON
        THE PRINTING SURFACE COMES OUT.

        "CONFIDENCE FACOTR" IS USED FOR CHECKING PINHOLE.

        A "CONFIDENCE FACTOR" OF 100 MEAN THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.

1. the condition of pinhole IS WHAT

RULE critical condition
IF   the diameter of pinhole IS over 4mm
THEN the condition of pinhole IS critical condition
AND  DISPLAY 05
AND  CHAIN diagnosis pinhole problem

RULE bad condition
IF   the diameter of pinhole IS between 2mm and 4mm
THEN the condition of pinhole IS major defect
AND  DISPLAY 06
AND  CHAIN diagnosis pinhole problem

RULE minor condition
IF   the diameter of pinhole IS between 1mm and 2mm
THEN the condition of pinhole IS minor defect
AND  DISPLAY 07
AND  CHAIN ghost image

RULE good condition
IF   the diameter of pinhole IS less than 1mm
THEN the condition of pinhole IS good condition
AND  DISPLAY 08
AND  CHAIN ghost image


DISPLAY 05

     The diameter of pinhole over 4mm is critical defect.
     The product does affect printing quality too much.
     It is necessary to inspect the reasons of this critical defect.

     • Click Continue •

DISPLAY 06

     The diameter of pinhole between 2mm and 4mm is major defect
     The product does affect printing quality.
     however, it has possibility of being critical defect later operation

     • Click Continue •

DISPLAY 07
```

```
TITLE   Ghost Image DISPLAY

        ********************************************************************
        #12   TWELEVTH CHECK POINT / GHOST IMAGE
        ********************************************************************

        THIS SECTION IS GOING TO CHECK THE GHOST IMAGE ON THE
        PRINTING SURFACE.

        GHOST IS THAT THERE ARE SOME PARTS WHICH PRINTING INK DOES NOT
        STICK ON THE PART OF SOLID PLACE WELL.

        "CONFIDENCE FACTOR" IS USED FOR CHECKING THE GHOST PROBLEM.

        A "CONFIDENCE FACTOR" OF 100 MEAN! THAT THE FACT IS TRUE.
        A "CONFIDENCE FACTOR" OF 0 MEAN THAT THE FACT IS FALSE.

        ********************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.

CONFIDENCE ON

THRESHOLD=70

1. the condition of ghost image on printing surface IS WHAT

RULE ghost image
IF   ghost image
THEN the condition of ghost image on printing surface IS ok
AND  CHAIN color reproduction
ELSE CHAIN diagnosis ghost problem

TEXT ghost image

     HOW MUCH CONFIDENCE DO YOU HAVE ABOUT GHOST PROBLEM ?

     PLEASE SHOW THE CONFIDENCE POINT BETWEEN 0 AND 100 POINT,
     BY USING THE ABOVE SCALE.

     |----------|----------|
     0          50        100

   GHOST                 MIDDLE              NONE
   TOO MUCH                                  GHOST

END
```

```
TITLE   Diagnosis Pinhole Problem DISPLAY

        ********************************************************************
        #11   DIAGNOSIS PART / PINHOLE PROBLEM
        ********************************************************************

        THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
        SUGGESTIONS FOR PINHOLE PROBLEM.

        THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
        POSSIBLE REASONS FOR PINHOLE PROBLEM.

        ********************************************************************

        PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.

ATTRIBUTE pinhole problem

1. diagnosing system for pinhole problem IS WHAT

RULE pinhole problem
IF   white point or pinhole occure on the picture design
AND  especially the solid place is remarkable
THEN the reason and suggestion for pinhole IS ok
AND  DISPLAY #1
AND  have the facts

RULE expert system
IF   have the facts
AND  start point
THEN diagnosing system for pinhole problem IS ok
AND  CHAIN ghost image
ELSE CHAIN description

DISPLAY #1

        ------------------------------------------------------------------
        The following reasons for pinhole phenomenon are considered.
        ------------------------------------------------------------------

        Ink film (ink drops ), paper dust, senility of roller,
        the dust for the material of water stick, and so forth
        sticks to plate surface and on the blanket.

        The following suggestions for pinhole phenomenon are considered.

        Washing the plate and blanket and then remove the ink drops,
        paper dust and so on.

        ------------------------------------------------------------------

        * CLICK <CONTINUE> *

TEXT start point

     IF YOU WANT TO CONTINUE TO INSPECT THE PAPER PRINTING QUALITY,
     THEN PLEASE CLICK <TRUE> BOTTON TO GO THE NEXT SECTION.

     IF YOU DO NOT WANT TO CONTINUE THE INSPECTION,
     PLEASE CLICK <FALSE> BOTTON TO GO THE STARTING POINT.
```

```
IF YOU WANT TO CONTINUE TO INSPECT THE PAPER PRINTING QUALITY,
THEN PLEASE CLICK <TRUE> BOTTON TO GO THE NEXT SECTION.

IF YOU DO NOT WANT TO CONTINUE THE INSPECTION,
THEN PLEASE CLICK <FALSE> BOTTON TO GO STARTING POINT.

END

TITLE  Diagnosis ghost image problem DISPLAY

       ***************************************************************
       #13   DIAGNOSIS PART / GHOST IMAGE PROBLEM
       ***************************************************************

       THIS SECTION IS GOING TO FIND OUT THE POSSIBLE REASONS AND
       SUGGESTIONS FOR GHOST IMAGE PROBLEM.

       THIS EXPERT SYSTEM WILL ASK SOME QUESTIONS AND THEN GIVE THE
       POSSIBLE REASONS AND SUGGESTIONS.

       ***************************************************************

       PLEASE CLICK <CONTINUE> WHEN YOU ARE READY TO GO ON.

1. diagnosing problem for ghost image IS WHAT

RULE ghost image problem
IF   ghost image happens on the part of solid place
THEN possible suggestions for ghost image problem IS ok
AND  DISPLAY #1
AND  have the facts

RULE expert system
IF   have the facts
AND  start point
THEN diagnosing problem for ghost image IS ok
AND  CHAIN color reproduction
ELSE CHAIN description

!----------------------------------------------------------------
!                     EXPERT SYSTEM SUMMARY
!----------------------------------------------------------------

DISPLAY #1
..................................................................
The best way to solve the ghost image problem on the printing
surface is to perfectly agree with demand and supply of ink on
the ink roller.  However,  it is too difficult to do so.
Thus,  the following suggestions are considered for solving
the problem of ghost image.
..................................................................
1.  High quality and intermediate quality paper are difficult to happen ghost
    in comparison to coated paper so that high and intermediate quality paper
    should be used.
2.  ghost is difficult to happen when using a transparent ink.
3.  Perform the adjustment of blade corresponding to picture pattern.
4.
5.  Alcohol density is that 8 % ·· 2 0 % is a proper.
6.  Roller hardness is that transition is good as high as hard is.
7.  Nip against plate cylinder of finishing roller had better be small.
8.  Nip for roller should be a proper quantity and uniform as well as
    with water and ink relation.
9.  Ghost is easy to happen when the dirt of molleton is terrible
    so that check the molleton's dirt.
10. Adjustment the picture pattern.
11. Arrange the solid part on the ghost plate.
..................................................................
* Click <Continue> *

TEXT start point
```

```
AND DISPLAY 8100
AND correct
THEN have the facts
ELSE 880

RULE repeat
IF 880
AND ASK relatively contrast
AND ASK solid density
AND ASK saturation
AND ASK hue error
AND ASK degree for ash color
AND ASK three piled up color degree
AND ASK effective density
AND ASK environs scumming
AND ASK dot gain
AND ASK shape coefficient
THEN 850

RULE SURE
IF 850
AND DISPLAY 855
AND wrong
THEN have the facts
ELSE 830

RULE repeat again
IF 830
AND ASK relatively contrast
AND ASK solid density
AND ASK saturation
AND ASK hue error
AND ASK degree for ash color
AND ASK three piled up color degree
AND ASK effective density
AND ASK environs scumming
AND ASK dot gain
AND ASK shape coefficient
THEN this is \ ok
AND DISPLAY 825
AND have the facts


RULE for density < 0.17
IF have the facts
AND relatively contrast < 0.17
THEN 81
AND aaa:=0

RULE for density >= 0.17
IF have the facts
AND relatively contrast >= 0.17
AND relatively contrast < 0.21
THEN 81
AND aaa:=1

RULE for density >= 0.21
IF have the facts
AND relatively contrast >= 0.21
AND relatively contrast < 0.25
THEN 81
AND aaa:=2

RULE for density >= 0.25
IF have the facts
```

```
|-------------------------------------------------------------------------
|                    KNOWLEDGE BASE FOR COLOR REPRODUCTION
|-------------------------------------------------------------------------

TITLE overall quality for color reproduction DISPLAY
      ************************************************************************
      81)  THIRTEENTH CHECK POINT / COLOR REPRODUCTION
      ************************************************************************

      THIS SECTION IS GOING TO CALCULATE THE OVERALL PAPER
      PRINTING QUALITY.  THE KNOWLEDGE BASE WILL ASK TEN
      QUESTIONS REGARDING COLOR REPRODUCTION THEY ARE:

      81  FOR COMPARING THE DENSITY BETWEEN THE PRODUCED PRINTING
          PRODUCTS AND THE ORIGINAL ONE,  RELATIVELY CONTRAST AND SOLID
          DENSITY ARE MEASURED.

      82  FOR COMPARING COLOR BRIGHTLY BETWEEN THE PRODUCED PRINTING
          PRODUCT AND THE ORIGINAL ONE,  SATURATION,  HUE ERROR,
          THREE PILED UP COLOR DEGREE,  AND DEGREE FOR ASH COLOR
          ARE MEASURED.

      83  FOR COMPARING THE HALFTONE DOT ON THE PRINTING SURFACE
          BETWEEN THE PRODUCED PRINTING PRODUCT AND THE ORIGINAL ONE,
          EFFECTIVE DENSITY IN HALFTONE DOT,  ENVIRONS SCUMMING OF
          HALFTONE DOT,  DOT GAIN AND SHAPE COEFFICIENT IN HALFTONE DOT
          ARE MEASURED.

      ************************************************************************
      PLEASE INPUT THE FOLLOWING 10 MEASUREMENTS DATA.

|-------------------------------------------------------------------------
|                    KNOWLEDGE BASE
|-------------------------------------------------------------------------

NUMERIC relatively contrast
AND solid density
AND saturation
AND hue error
AND degree for ash color
AND three piled up color degree
AND effective density
AND environs scumming
AND dot gain
AND shape coefficient
AND ttt

1. The Overall Quality Point for Color Reproduction is \ WHAT


RULE getting
IF ASK relatively contrast
AND ASK solid density
AND ASK saturation
AND ASK hue error
AND ASK degree for ash color
AND ASK three piled up color degree
AND ASK effective density
AND ASK environs scumming
AND ASK dot gain
AND ASK shape coefficient
THEN 890

RULE make sure
IF 890
```

```
LE hue error >= 0.28
 86
D hue error >= 0.28
D hue error < 0.30
EN 87
D ggg:=6

LE hue error >= 0.26
 86
D hue error >= 0.26
D hue error < 0.28
EN 87
D ggg:=7

LE hue error >= 0.24
 86
D hue error >= 0.24
D hue error < 0.26
EN 87
D ggg:=8

LE hue error >= 0.22
 86
D hue error >= 0.22
D hue error < 0.24
EN 87
D ggg:=9

LE hue error < 0.22
 86
D hue error < 0.22
EN 87
D ggg:=10

LE for getting score
 87
EN sub score is \ ok
D 88
D hhh:=0.3*ggg*fff

LE for ash color >= 21.1
 88
D degree for ash color >= 21.1
EN 89
D iii:=0

LE for ash color >= 20.4
 88
D degree for ash color >= 20.4
D degree for ash color < 21.1
EN 89
D iii:=1

LE for ash color >= 19.6
 88
D degree for ash color >= 19.6
D degree for ash color < 20.4
EN 89
D iii:=2

LE for ash color >= 18.9
 88
D degree for ash color >= 18.9
D degree for ash color < 19.6
EN 89
D iii:=3

IF 84
AND saturation >= 3.35
AND saturation < 3.63
THEN 85
AND eee:=8

RULE for saturation >= 3.63
IF 84
AND saturation >= 3.63
AND saturation < 3.91
THEN 85
AND eee:=9

RULE for saturation >= 3.91
IF 84
AND saturation >= 3.91
THEN 85
AND eee:=10

RULE for getting score
IF 85
THEN sub score is \ ok
AND 86
AND fff:=0.5*eee+ddd

RULE hue error >= 0.40
IF 86
AND hue error > 0.40
THEN 87
AND ggg:=0

RULE hue error >= 0.38
IF 86
AND hue error >= 0.38
AND hue error < 0.40
THEN 87
AND ggg:=1

RULE hue error >= 0.36
IF 86
AND hue error >= 0.36
AND hue error < 0.38
THEN 87
AND ggg:=2

RULE hue error >= 0.34
IF 86
AND hue error >= 0.34
AND hue error < 0.36
THEN 87
AND ggg:=3

RULE hue error >= 0.32
IF 86
AND hue error >= 0.32
AND hue error < 0.34
THEN 87
AND ggg:=4

RULE hue error >= 0.30
IF 86
AND hue error >= 0.30
AND hue error < 0.32
THEN 87
AND ggg:=5

AND solid density >= 1.66
THEN 83
AND ccc:=10

RULE for getting score
IF 83
THEN sub score is \ ok
AND 84
AND ddd:=0.6*ccc*hhh

RULE for saturation < 1.39
IF 84
AND saturation < 1.39
THEN 85
AND eee:=0

RULE for saturation >= 1.39
IF 84
AND saturation >= 1.39
AND saturation < 1.67
THEN 85
AND eee:=1

RULE for saturation >= 1.67
IF 84
AND saturation >= 1.67
AND saturation < 1.95
THEN 85
AND eee:=2

RULE for saturation >= 1.95
IF 84
AND saturation >= 1.95
AND saturation < 2.23
THEN 85
AND eee:=3

RULE for saturation >= 2.23
IF 84
AND saturation >= 2.23
AND saturation < 2.51
THEN 85
AND eee:=4

RULE for saturation >= 2.51
IF 84
AND saturation >= 2.51
AND saturation < 2.79
THEN 85
AND eee:=5

RULE for saturation >= 2.79
IF 84
AND saturation >= 2.79
AND saturation < 3.07
THEN 85
AND eee:=6

RULE for saturation >= 3.07
IF 84
AND saturation >= 3.07
AND saturation < 3.35
THEN 85
AND eee:=7

RULE for saturation >= 3.35

RULE for density >= 1.06
IF 82
AND solid density >=1.06
AND solid density < 1.13
THEN 83
AND ccc:=1

RULE for density >= 1.13
IF 82
AND solid density >= 1.13
AND solid density < 1.19
THEN 83
AND ccc:=2

RULE for density >= 1.19
IF 82
AND solid density >= 1.19
AND solid density < 1.26
THEN 83
AND ccc:=3

RULE for density >= 1.26
IF 82
AND solid density >= 1.26
AND solid density < 1.33
THEN 83
AND ccc:=4

RULE for density >= 1.33
IF 82
AND solid density >= 1.33
AND solid density < 1.39
THEN 83
AND ccc:=5

RULE for density >= 1.39
IF 82
AND solid density >= 1.39
AND solid density < 1.46
THEN 83
AND ccc:=6

RULE for density >= 1.46
IF 82
AND solid density >= 1.46
AND solid density < 1.53
THEN 83
AND ccc:=7

RULE for density >= 1.53
IF 82
AND solid density >= 1.53
AND solid density < 1.59
THEN 83
AND ccc:=8

RULE for density >= 1.59
IF 82
AND solid density >= 1.59
AND solid density < 1.66
THEN 83
AND ccc:=9

RULE for density >= 1.66
IF 82

AND relatively contrast >= 0.25
AND relatively contrast < 0.29
THEN 81
AND aaa:=3

RULE for density >= 0.29
IF have the facts
AND relatively contrast >= 0.29
AND relatively contrast < 0.33
THEN 81
AND aaa:=4

RULE for density >= 0.33
IF have the facts
AND relatively contrast >= 0.33
AND relatively contrast < 0.37
THEN 81
AND aaa:=5

RULE for density >= 0.37
IF have the facts
AND relatively contrast >= 0.37
AND relatively contrast < 0.41
THEN 81
AND aaa:=6

RULE for density >= 0.41
IF have the facts
AND relatively contrast >= 0.41
AND relatively contrast < 0.45
THEN 81
AND aaa:=7

RULE for density >= 0.45
IF have the facts
AND relatively contrast >= 0.45
AND relatively contrast < 0.49
THEN 81
AND aaa:=8

RULE for density >= 0.49
IF have the facts
AND relatively contrast >= 0.49
AND relatively contrast < 0.53
THEN 81
AND aaa:=9

RULE for density >= 0.53
IF have the facts
AND relatively contrast >= 0.53
THEN 81
AND aaa:=10

RULE for getting score
IF 81
THEN sub score is \ ok
AND 82
AND hhh:=1.7*aaa

RULE for density < 1.06
IF 82
AND solid density < 1.06
THEN 83
AND ccc:=0
```

```
RULE for effective density >= 8.86
IF 812
AND effective density >= 8.86
AND effective density < 11.48
THEN 813
AND mmm:=9

RULE for effective density < 8.86
IF 812
AND effective density < 8.86
THEN 813
AND mmm:=10

RULE for getting score
IF 813
THEN sub score is \ ok
AND 814
AND nnn:=0.6*mmm+111

RULE environs scumming >= 30.0
IF 814
AND environs scumming >= 30.0
THEN 815
AND ooo:=0

RULE environs scumming >= 27.0
IF 814
AND environs scumming >= 27.0
AND environs scumming < 30.0
THEN 815
AND ooo:=1

RULE environs scumming >= 24.0
IF 814
AND environs scumming >= 24.0
AND environs scumming < 27.0
THEN 815
AND ooo:=2

RULE environs scumming >= 21.0
IF 814
AND environs scumming >= 21.0
AND environs scumming < 24.0
THEN 815
AND ooo:=3

RULE environs scumming >= 18.0
IF 814
AND environs scumming >= 18.0
AND environs scumming < 21.0
THEN 815
AND ooo:=4

RULE environs scumming >= 15.0
IF 814
AND environs scumming >= 15.0
AND environs scumming < 18.0
THEN 815
AND ooo:=5

RULE environs scumming >= 12.0
IF 814
AND environs scumming >= 12.0
AND environs scumming < 15.0
THEN 815
AND ooo:=6

THEN sub score is \ ok
AND 812
AND lll:=1.0*kkk*jjj

RULE for effective density >= 32.44
IF 812
AND effective density >= 32.44
THEN 813
AND mmm:=0

RULE for effective density >= 29.82
IF 812
AND effective density >= 29.82
AND effective density < 32.44
THEN 813
AND mmm:=1

RULE for effective density >= 27.20
IF 812
AND effective density >= 27.20
AND effective density < 29.82
THEN 813
AND mmm:=2

RULE for effective density >= 24.58
IF 812
AND effective density >= 24.58
AND effective density < 27.20
THEN 813
AND mmm:=3

RULE for effective density >= 21.96
IF 812
AND effective density >= 21.96
AND effective density < 24.58
THEN 813
AND mmm:=4

RULE for effective density >= 19.34
IF 812
AND effective density >= 19.34
AND effective density < 21.96
THEN 813
AND mmm:=5

RULE for effective density >= 16.72
IF 812
AND effective density >= 16.72
AND effective density < 19.34
THEN 813
AND mmm:=6

RULE for effective density >= 14.10
IF 812
AND effective density >= 14.10
AND effective density < 16.72
THEN 813
AND mmm:=7

RULE for effective density >= 11.48
IF 812
AND effective density >= 11.48
AND effective density < 14.10
THEN 813
AND mmm:=8

AND kkk:=1

RULE for color degree >= 0.50
IF 810
AND three piled up color degree >= 0.50
AND three piled up color degree < 0.55
THEN 811
AND kkk:=2

RULE for color degree >= 0.45
IF 810
AND three piled up color degree >= 0.45
AND three piled up color degree < 0.50
THEN 811
AND kkk:=3

RULE for color degree >= 0.40
IF 810
AND three piled up color degree >= 0.40
AND three piled up color degree < 0.45
THEN 811
AND kkk:=4

RULE for color degree >= 0.35
IF 810
AND three piled up color degree >= 0.35
AND three piled up color degree < 0.40
THEN 811
AND kkk:=5

RULE for color degree >= 0.30
IF 810
AND three piled up color degree >= 0.30
AND three piled up color degree < 0.35
THEN 811
AND kkk:=6

RULE for color degree >= 0.25
IF 810
AND three piled up color degree >= 0.25
AND three piled up color degree < 0.30
THEN 811
AND kkk:=7

RULE for color degree >= 0.20
IF 810
AND three piled up color degree >= 0.20
AND three piled up color degree < 0.25
THEN 811
AND kkk:=8

RULE for color degree >= 0.15
IF 810
AND three piled up color degree >= 0.15
AND three piled up color degree < 0.20
THEN 811
AND kkk:=9

RULE for color degree < 0.15
IF 810
AND three piled up color degree < 0.15
THEN 811
AND kkk:=10

RULE for getting score
IF 811

RULE for ash color >= 18.1
IF 88
AND degree for ash color >= 18.1
AND degree for ash color < 18.9
THEN 89
AND iii:=4

RULE for ash color >= 17.4
IF 88
AND degree for ash color >= 17.4
AND degree for ash color < 18.1
THEN 89
AND iii:=5

RULE for ash color >= 16.7
IF 88
AND degree for ash color >= 16.7
AND degree for ash color < 17.4
THEN 89
AND iii:=6

RULE for ash color >= 15.9
IF 88
AND degree for ash color >= 15.9
AND degree for ash color < 16.7
THEN 89
AND iii:=7

RULE for ash color >= 15.2
IF 88
AND degree for ash color >= 15.2
AND degree for ash color < 15.9
THEN 89
AND iii:=8

RULE for ash color >= 14.5
IF 88
AND degree for ash color >= 14.5
AND degree for ash color < 15.2
THEN 89
AND iii:=9

RULE for ash color < 14.5
IF 88
AND degree for ash color < 14.5
THEN 89
AND iii:=10

RULE for getting score
IF 89
THEN sub score is \ ok
AND 810
AND jjj:=0.5*iii*hhh

RULE for color degree >= 0.60
IF 810
AND three piled up color degree >= 0.60
THEN 811
AND kkk:=0

RULE for color degree >= 0.55
IF 810
AND three piled up color degree >= 0.55
AND three piled up color degree < 0.60
THEN 811
```

```
THEN #19
AND sss:=3

RULE for coefficient >= 2.41
IF #18
AND shape coefficient >= 2.41
AND shape coefficient < 2.58
THEN #19
AND sss:=4

RULE for coefficient >= 2.24
IF #18
AND shape coefficient >= 2.24
AND shape coefficient < 2.41
THEN #19
AND sss:=5

RULE for coefficient >= 2.07
IF #18
AND shape coefficient >= 2.07
AND shape coefficient < 2.24
THEN #19
AND sss:=6

RULE for coefficient >= 1.90
IF #18
AND shape coefficient >= 1.90
AND shape coefficient < 2.07
THEN #19
AND sss:=7

RULE for coefficient >= 1.73
IF #18
AND shape coefficient >= 1.73
AND shape coefficient < 1.90
THEN #19
AND sss:=8

RULE for coefficient >= 1.56
IF #18
AND shape coefficient >= 1.56
AND shape coefficient < 1.73
THEN #19
AND sss:=9

RULE for coefficient < 1.56
IF #18
AND shape coefficient < 1.56
THEN #19
AND sss:=10

RULE for getting score
IF #19
THEN The Overall Quality Point for Color Reproduction is \ ok
AND #20
AND ttt:=1.7*sss*rrr
AND DISPLAY data

!=============================================================
!                    EXPERT SYSTEM SUMMARY
!=============================================================

DISPLAY #100
   PLEASE MAKE SURE WHETHER THE VALUE OF EACH ITEM IS CORRECT OR NOT.

   .....................................................................

AND qqq:=4

RULE dot gain >= 12.1
IF #16
AND dot gain >= 12.1
AND dot gain < 15.9
THEN #17
AND qqq:=5

RULE dot gain >= 8.3
IF #16
AND dot gain >= 8.3
AND dot gain < 12.1
THEN #17
AND qqq:=6

RULE dot gain >= 4.5
IF #16
AND dot gain >= 4.5
AND dot gain < 8.3
THEN #17
AND qqq:=7

RULE dot gain >= 0.7
IF #16
AND dot gain >= 0.7
AND dot gain < 4.5
THEN #17
AND qqq:=8

RULE dot gain < 0.7
IF #16
AND dot gain < 0.7
THEN #17
AND qqq:=10

RULE for getting score
IF #17
THEN sub score is \ ok
AND #18
AND rrr:=1.5*qqq*ppp

RULE for coefficient >= 3.09
IF #18
AND shape coefficient >= 3.09
THEN #19
AND sss:=0

RULE for coefficient >= 2.92
IF #18
AND shape coefficient >= 2.92
AND shape coefficient < 3.09
THEN #19
AND sss:=1

RULE for coefficient >= 2.75
IF #18
AND shape coefficient >= 2.75
AND shape coefficient < 2.92
THEN #19
AND sss:=2

RULE for coefficient >= 2.58
IF #18
AND shape coefficient >= 2.58
AND shape coefficient < 2.75

RULE environs scumming >= 9.0
IF #14
AND environs scumming >= 9.0
AND environs scumming < 12.0
THEN #15
AND ooo:=7

RULE environs scumming >= 6.0
IF #14
AND environs scumming >= 6.0
AND environs scumming < 9.0
THEN #15
AND ooo:=8

RULE environs scumming >= 3.0
IF #14
AND environs scumming >= 3.0
AND environs scumming < 6.0
THEN #15
AND ooo:=9

RULE environs scumming < 3.0
IF #14
AND environs scumming < 3.0
THEN #15
AND ooo:=10

RULE for getting score
IF #15
THEN sub score is \ ok
AND #16
AND ppp:=1.6*ooo*nnn

RULE dot gain >= 31.1
IF #16
AND dot gain >= 31.1
THEN #17
AND qqq:=0

RULE dot gain >= 27.3
IF #16
AND dot gain >= 27.3
AND dot gain < 31.1
THEN #17
AND qqq:=1

RULE dot gain >= 23.5
IF #16
AND dot gain >= 23.5
AND dot gain < 27.3
THEN #17
AND qqq:=2

RULE dot gain >= 19.7
IF #16
AND dot gain >= 19.7
AND dot gain < 23.5
THEN #17
AND qqq:=3

RULE dot gain >= 15.9
IF #16
AND dot gain >= 15.9
AND dot gain < 19.7
THEN #17
```

DOT GAIN : [dot gain]

SHAPE COEFFICIENT IN HALFTONE DOT : [shape coefficient]

OVERALL QUAITY POINT

DISPLAY data

OUTPUT AREA

OVERALL QUALITY POINT FOR COLOR REPRODUCTION

The Overall Quality Point for Color Reproduction: [ttt] POINT

IF OVERALL QUALITY POINT IS OVER 70 POINT, THE QUALITY OF PRODUCT IS OK.

IF OVERALL QUAITY POINT IS, ON THE OTHER HAND, LESS THAN 70, THE QUALITY OF PRODUCT IS NOT OK.

• Click <Continue> •

TEXT correct

DID YOU REALLY INPUT THE CORRECT DATA ?

IF YOU INPUT THE CORRECT DATA, CLICK < TRUE > BOTTON AND PROCEED.
IF YOU INPUT THE WRONG DATA, CLICK < FALSE > BOTTON AND TRY AGAIN.

TEXT wrong

THIS TIME, DID YOU INPUT THE CORRECT DATA ?

IF YOU INPUT THE CORRECT DATA THIS TIME, CLICK < TRUE >BOTTON AND PROCEED.
IF YOU INPUT THE WRONG DATA AGAIN, CLICK < FALSE > BOTTON AND CORRECT.

DESCRIPTION OF EACH MEASUREMENT ITEM

TEXT relatively contrast

PLEASE INPUT THE MEASUREMENT VALUE FOR RELATIVELY CONTRAST IN THE BELOW FRAME. (RC)

When the proof sheet and the produced printing product are compared about the density, the ideal is that the completed gradation reproduction is done. RC evaluates how the produced printing product is near the proof sheet.

measurement device: reflection densitometer
measurement position: the gradation scale part (75 % and 100 %) of printing controll gauge (K.C.M.Y 4 color)
method: measure the density at 75 % dot scale part and measure the density at solid place (100%)
The density is measured for 4 color which are black.

RELATIVELY CONTRAST : [relatively contrast]

SOLID DENSITY : [solid density]

SATURATION : [saturation]

HUE ERROR : [hue error]

DEGREE FOR ASH COLOR : [degree for ash color]

THREE PILED UP COLOR DEGREE : [three piled up color degree]

EFFECTIVE DENSITY IN HALFTONE DOT : [effective density]

ENVIRONS SCUMMING OF HALFTONE DOT : [environs scumming]

DOT GAIN : [dot gain]

SHAPE COEFFICIENT IN HALFTONE DOT : [shape coefficient]

DISPLAY 855
PLEASE MAKE SURE WHETHER THE VALUE OF EACH ITEM IS CORRECT OR NOT.

RELATIVELY CONTRAST : [relatively contrast]

SOLID DENSITY : [solid density]

SATURATION : [saturation]

HUE ERROR : [hue error]

DEGREE FOR ASH COLOR : [degree for ash color]

THREE PILED UP COLOR DEGREE : [three piled up color degree]

EFFECTIVE DENSITY IN HALFTONE DOT : [effective density]

ENVIRONS SCUMMING OF HALFTONE DOT : [environs scumming]

DOT GAIN : [dot gain]

SHAPE COEFFICIENT IN HALFTONE DOT : [shape coefficient]

DISPLAY 825
PLEASE MAKE SURE WHETHER THE VALUE OF EACH ITEM IS CORRECT OR NOT.

RELATIVELY CONTRAST : [relatively contrast]

SOLID DENSITY : [solid density]

SATURATION : [saturation]

HUE ERROR : [hue error]

DEGREE FOR ASH COLOR : [degree for ash color]

THREE PILED UP COLOR DEGREE : [three piled up color degree]

EFFECTIVE DENSITY IN HALFTONE DOT : [effective density]

ENVIRONS SCUMMING OF HALFTONE DOT : [environs scumming]

TEXT degree for ash color

PLEASE INPUT THE MEASUREMENT VALUE OF DEGREE FOR ASH COLOR IN THE BELOW FRAME. (G)

As long as concerning about color part, color impurity is a important factor as same as the previous one. In order to evaluate color impurity, it is evaluated by degree for ash color designed by GRETF.

measurement device: reflection densitometer
measurement position: the solid place of three basic printing color(C,M,Y) and three light basic color (R,G,B) at printing control gauge.
method: obtaine the highest density (Hi), and the lowest density (Li) based on the solid density of each six color.

$$\text{Degree for ash color} = (1/6) \sum_{i=C,M,Y,R,G,B} (Li / Hi)$$

TEXT three piled up color degree

PLEASE INPUT THE MEASUREMENT VALUE FOR THREE PILED UP COLOR DEGREE IN THE BELOW FRAME. (I)

Three piled up color degree shows the degree of this inferior part than the prrof one concerning color the same as the saturation.

measurement device: reflection densitometer
measurement position: the solid place of monochromatic (C, M, Y) and light basic color (R, G, B) and three color repeated for three basic printing color(Y+M+C) at printing control gauge.
method: plot the hexagon designed by GRETF based on the solid density of above color.

Three piled up color degree = (the distance between the center of hexagon and three color repeated forthree basic printing color(Y+M+C))/ (hexagon's one side length of saturation 1.0 standard)

TEXT effective density

PLEASE INPUT THE MEASUREMENT VALUE FOR EFFECTIVE DENSITY OF HALFTONE DOT IN THE BELOW FRAME. (DP)

Generally, the halftone dot's density profile is distorted in comparison to the ideal one. Effective density is one of the checking items which evaluate dot's inside density reproduction.

measurement device: picture processing analytical device
measurement position: 50 % halfton dot place of monochromatic (K,C,M,Y) at printing control gauge.
method: make the accumulative area ratio distribution of density according to each color.

Effective density = (effective density of actual printing product) * (area ratio of dot printing part) / (solid density) * (area ratio of dot printing part)

TEXT environs scumming

PLEASE INPUT THE MEASUREMENT VALUE FOR ENVIRONS SCUMMING OF HALFTONE DOT IN THE BELOW FRAME. (SD)

Environs scumming is one of the checking items which evaluate cyan, magenta and yellow, and mean is calculated.

RC = 1.0 - (Dr/Ds)
Dr = density of dot
Ds = solid density

TEXT solid density

PLEASE INPUT THE MEASUREMENT VALUE FOR SOLID DENSITY IN THE BELOW FRAME. (D)

Solid density is a part which is the highest density part in the printing product. Measure solid density of 3 basic printing color that are "yellow" "magenta" "cyan"

measurement device: reflection densitometer
measurement position: the solid place (100%) at gradation scale in the printing control gauge. (C.M.Y 3 color)
method: calculate average for solid density of 3 basic printing color that is "yellow" "magenta" "Cyan"

D = (Dc + Dm + Dy)/3
Dc = solid density for cyan
Dm = solid density for magenta
Dy = solid density for yellow

TEXT saturation

PLEASE INPUT THE MEASUREMENT VALUE FOR SATURATION IN THE BELOW FRAME. (A)

When comparing color between the proof sheet and produced printing product, the color of produced printing product is inferior to the proof sheet. Saturation show the degree of this inferir part than the proof sheet.

measurement device: reflection densitometer
measurement position: the solid place of monochromatic (C, M, Y) and light basic color (R, G, B) and three color repeated for three basic printing color(Y+M+C) at printing control gauge.
method: plot the hexagon designed by GRETF based on the solid density of above color.

Saturation = (actual hexagon's inside area)/ (hexagon's inside area of saturation 1.0 standard)

TEXT hue error

PLEASE INPUT THE MEASUREMENT VALUE FOR HUE ERROR IN THE BELOW FRAME. (I)

Hue error shows the degree of this inferior part than the proof one regarding color the same as the saturation.

measurement device: reflection densitometer
measurement position: the solid place of monochromatic (C, M, Y) and light basic color (R, G, B) and three color repeated for three basic printing color(Y+M+C) at printing control gauge.
method: plot the hexagon designed by GRETF based on the solid density of above color.

Hue error = (standard deviation of each hexagon's side lenght)/ (mean of each hexagon's side length)

TEXT degree for ash color

measurement device: picture processing analytical device
measurement position: 50 % halfton dot place of monochromatic (K,C,M,Y) at printing control gauge.
method: make the accumulative area ratio distribution of density according to each color.

Environs scumming = (environs scumming of actual printing product) / (solid density) * (100 - area ratio of dot printing part)

TEXT dot gain

PLEASE INPUT THE MEASUREMENT VALUE FOR DOT GAIN IN THE BELOW FRAME. (DG)

Dot gain is meant that the area of dot for printing plate does not be agreement in comparison to the area for ink. In general, the area of actual printing product's dot is larger than the proof one.

measurement device: portrait analytical device
measurement position: 50 % halfton dot place of monochromatic (K,C,M,Y) at printing control gauge.
method: calculate dot's area ratio for printing product and dot's area ratio for machine plate or film. (4 color K,C,M,Y) And then, calculate the mean for 4 color.

Dot gain = (dot's area ratio for printing product) - (dot's area ratio for machine plate or film)

TEXT shape coefficient

PLEASE INPUT THE MEASUREMENT VALUE FOR SHAPE COEFFICIENT OF HALFTONE DOT IN THE BELOW FRAME. (SF)

Shape coefficient is one of the checking items which evaluate outline reproduction.

measurement device: picture processing analytical device
measurement position: 50 % halfton dot place of monochromatic (K,C,M,Y) at printing control gauge.
method: measure circumference length and inside area for dot.

Shape coefficient = (the length of circumference)2/ 4 π (dot's inside area)

If the dot is completed circle, shape coefficient is 1.0.

END

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