A STUDY OF THE CAUSES OF VARIATIONS IN THE PHYSICAL PROPERTIES OF CARBON STEELS FOR CRANKSHAFTS

THESIS FOR THE DEGREE OF M. S.

Robert Guthrie

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THESIS

Steel - Testing

A STUDY OF THE CAUSES OF VARIATION IN THE PHYSICAL PROPERTIES OF CARBON STEELS FOR CRANKSHAFTS.

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THESIS

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INTRODUCTION.

With increasing power and speed in automobile engines there has developed greater and greater demands on the steel of the crankshafts and connecting rods. These parts have had to meet higher physical ~~physical~~ property requirements, making it essential that the manufacturer study all the possible factors which affect the strength and toughness.

Strength, or hardness, which is the ability of the steel to resist deformation from external forces, may be measured by the normality of the steel and indicated by the expansion. The normality is a measure of the ability of the steel to harden. A normal steel being defined as one which will harden all the way through from the surface to the center.[1] The expansion of the steel during hardening and tempering is proportional to its hardenability; a steel with the maximum hardenability will show the maximum expansion.[2]

Toughness, which may be defined as resistance to fracture after deformation has begun, may be determined in two ways: by the grain size by the McQuaid-Ehn test and by the value obtained on the impact tester. The McQuaid-Ehn test consists of classifying specimens which have been carburized at 1700 deg. Fahr. for eight hours and allowed to cool in the furnace.[3] The classification is carried out at a magnification of 100 diameters. The chart consists of eight grain size numbers running from number one with one and one-half grains per square inch up to number eight with ninety-six.

grains per square inch. It has been found by Grossman, McQuaid, and others that a coarse grained structure based on this classification is usually an indication of brittle steel while a fine grained structure suggests toughness.[4] The impact value is a measure of the toughness in that it gives the amount of energy required to fracture a standard test bar. The tougher the steel the higher is this value.[5]

OBJECT.

The purpose of this paper is to study the relationship existing between normality, dimension changes, grain size under the McQuaid-Ehn classification, and Izod impact values of plain carbon crankshaft steels.

APPARATUS.

The instrument used to measure the dimensional changes of the bars was a Gaertner Comparator (Fig.1) which had a range of 200 millimeters.

The micrometer head is about eighteen centimeters in diameter and is divided into one thousand parts, every ten of which is marked so that readings of one micron (.0001 cm.) can be made directly and fractions can easily be estimated.

The instrument used for breaking the bars was a standard Izod Impact Tester with a range of 120 foot- pounds. The scale of this instrument could be read accurately to one-half of a foot pound.

Gaertner Comparator.

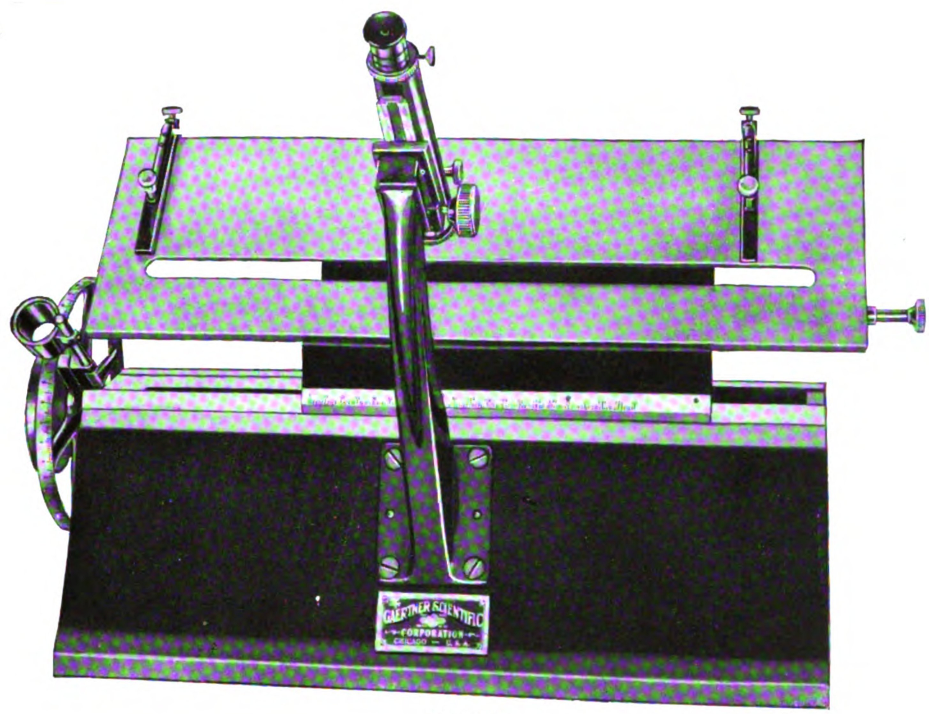

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Fig. 1

A standard metallurgical microscope was used to determine the grain size and the normality, using a magnification of 100 and 500 diameters respectively.

PROCEDURE.

Standard S.A.E. 1045 steels used in crankshafts were obtained from various manufacturers in order to introduce variables of manufacture as much as possible. Specimens cut from the center of each bar were then carburized in the furnace at 1700 deg. Fahr. (927 deg. Cent.) for eight hours, polished, etched, and rated according to the McQuaid-Ehn Test. The specimens were also examined for abnormality. In both of these classifications the listings accepted were the check results of two independent observers.

The remainder of the bars were then cut into specimens six inches long and turned to a diameter of .500 in. with an allowance of plus or minus .002 in. These limits were chosen inorder to have the minimum variation in the rate of heat absorption due to variations in the dimensions of the piece. Grooves were cut about four inches apart around each bar while the work was revolving in the lathe.

The distance between the inner edges of the grooves was measured accurately with the Gaertner Comparator.

The bars were then heated to the proper hardening temperature in an electric muffle furnace, held at heat for thirty minutes, and quenched in water. After being allowed to stand overnight they were tempered to a Rockwell Hardness of 20-25 on the C-scale

TABLE No. I

HEAT TREATMENT

Sample No.	S.A.E. No.	Hardening Treatment Deg. Fahr.	Tempering Treatment Deg. Fahr.
1	1045	1500 water	1000 air
2	1045	1500 water	1000 air
3	1045	1500 water	1000 air
4	1045	1500 water	1000 air
5	1045	1500 water	1000 air
6	1045	1500 water	1000 air
7	1045	1500 water	1000 air
8	1045	1500 water	1000 air
9	1045	1500 water	1000 air
10	1040	1525 water	1000 air
15	1045	1500 water	1000 air
23	1040	1525 water	1000 air
24	1050	1500 water	1000 air
25	1040	1525 water	1000 air
26	1040	1525 water	1000 air.

These specimens were held at heat for thirty minutes in all cases.

which required a reheating temperature of 1000 deg. Fahr. (537 deg.C) Care was taken at all times that the bars were placed on an even surface of the furnace floor in order to maintain a minimum distortion.

After the tempering treatment the length of the bars was measured at four different positions around the bar, each position being approximately ninety degrees from the preceding reading. The per cent change in length as compared to the original measured length was determined. Each length change value, given in Table II was the average of twenty four readings.

The bars were then machined to the standard Izod Impact round test bars and broken on the Izod Tester. The values obtained are the average of twelve results for each type of bar indicated in Table II.

DISCUSSION.

From columns two and four of Table II it will be seen that the grain size as classified by the McQuaid-Ehn test decreases in almost the same proportions as the Izod impact value increases. 2

Columns six and eight of Table II show the relation between the normality and the dimensional changes. Those steels which showed a decrease in length after heat treatment are marked negative while those which increased in length are marked positive. The degree of abnormality of each steel was determined by its tendency to divorce cementite in the case of the McQuaid-Ehn test pieces. Those steels showing no divorced cementite being normal. In the case of samples 2 and 26 there was a question as

TABLE NO. 2

Column No.

1	2	3	4	5	6	7	8
Sample No.	Izod Impact Ft-Lbs.	Sample No.	Grain Size No.	Sample No.	Normality	Sample No.	Expansion Per cent
25	62.75	24	8	24	Ideally Normal	6	* .537
15	58.0	7	7-8	25	Normal	24	.451
24	55.9	6	6	23	Normal	4	.406
2	51.0	26	5	5	Normal	5	.274
10	50.5	25	4	1	Normal	3	.246
9	48.8	10	4	2	Normal to Slight Ab.	2	.240
7	44.6	15	4	26	Normal-Ab.	23	.096
6	43.75	8	4	3	Very Slightly Ab.	8	.082
8	40.8	2	4	8	Slightly Ab.	1	.072
4	40.3	4	4	9	Slightly Ab.	9	.028
1	40.25	1	4	4	Slightly Ab.	26	-.149
23	37.95	3	4	6	Slightly Ab.	25	-.468
3	37.75	23	3	10	Abnormal	10	-.491
5	37.6	5	3	15	Abnormal	15	-1.966
26	34.25	9	3	7	Very Abnormal	7	-2.236

Footnote

* Positive readings indicate expansion; negative readings indicate contraction.

to just how they should be classified. These two specimens seemed to be normal but at the same time, showed traces of abnormal cementite. If the value of the length changes is taken into consideration, however, specimen two seems to be listed correctly while specimen twenty-six should be regarded as abnormal.

CONCLUSIONS.

The following conclusions may be drawn from the work of this investigation upon the causes of variations in the physical properties of S.A.E. 1045 steels:

1. The greater the expansion during heat treatment, the greater is the hardening ability. The normality, or hardenability, is definitely related to the length changes due to hardening and tempering.
2. The grain size does not seem to bear any definite relation to the normality, or hardenability, of the S.A.E. 1045 steels discussed in this paper. A comparison of the results will show that the most normal specimen had a fine grain size while the most abnormal specimen had a coarse grain size.
3. Variations in the toughness of S.A.E.1045 steels are caused by variations in the grain size.

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