THESIS

A CONSTANT SPEED GOVERNOR
FOR MOTOR GENERATOR NO. 2

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1922

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For
MOTOR GENERATOR NO.2

A THESIS

Submitted to the Faculty of the

MICHIGAN AGRICULTURAL COLLEGE

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Bachelor of Science.

June, 1922.

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INTRODUCTION

For accuracy in laboratory work it is frequently necessary to have machinery driven at constant speed. There is a demand also in the commercial world for constant speed on current motors.

A shunt wound motor is said to be a constant speed motor but, in reality it is not, for in the case of a variable load and a variable voltage, a regulator of some kind is necessary to maintain a constant speed.

There are a number of devices in the commercial field for the purpose of controlling the speed of a motor, but only a discussion of the type designed and built in this thesis will be given here.

THEORY

The object of this work is to produce a peice of apparatus that will accurately regulate the speed of a compound motor when subjected to variable loads and variable voltages. This is accomplished by varying the field current as the speed requires. The field flux is directly proportional to the field current within small limits.

The field current is varied by inserting and cutting out resistance in the field. Two resistances are used. One is cut in and out of the field circuit by contacts controlled by a coil that is connected across the main line and is operated by slight variations in voltage. This resistance regulates the speed of the motor with respect to the voltage on the source of supply. The other resistance is cut in and out of the circuit by contacts that are operated by a D.C. generator relay coil. This D.C. generator is a small separately excited machine, directly connected to the regulated motor.

As the speed of the motor tends to vary, the relays either insert or cut out resistance and thereby bring the motor back to normal speed because of the dependency of the speed upon the field, as shown in the speed curve graphs.

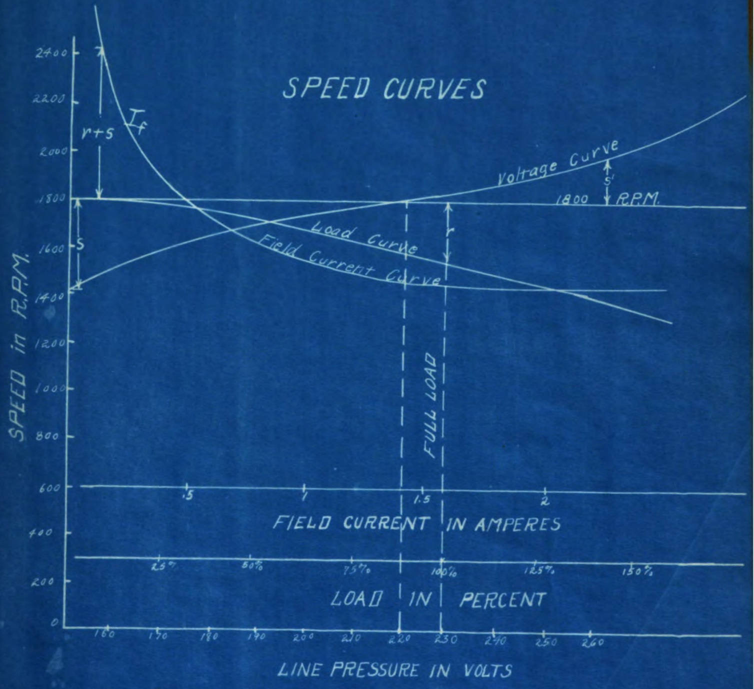
A motor whose field is shunt wound is practically considered to be a constant speed motor, that is, it tends to maintain a constant speed as the load varies.

A series wound motor is a variable speed motor. Its speed varies inversely as the load.

A compound wound motor speed curve may go up or down, depending on whether it is cumulatively or differentially compounded. If it is cumulatively compounded the flux of the series winding will work in conjunction with the flux of the shunt winding, thereby making a stronger flux and lessening the speed as the load increases. If it is differentially compounded the flux of the series winding will act against the shunt winding flux and produce a weaker total field, thereby increasing the speed as the load increases.

The motor to be regulated in this thesis is a cumulative compound motor. The regulator must therefore make correction for a drop in the speed as the load increases.

The purpose of this regulator is to make straight lines of the speed load and the speed voltage curves (shown on speed curve graph) at 1800 R.P.M.

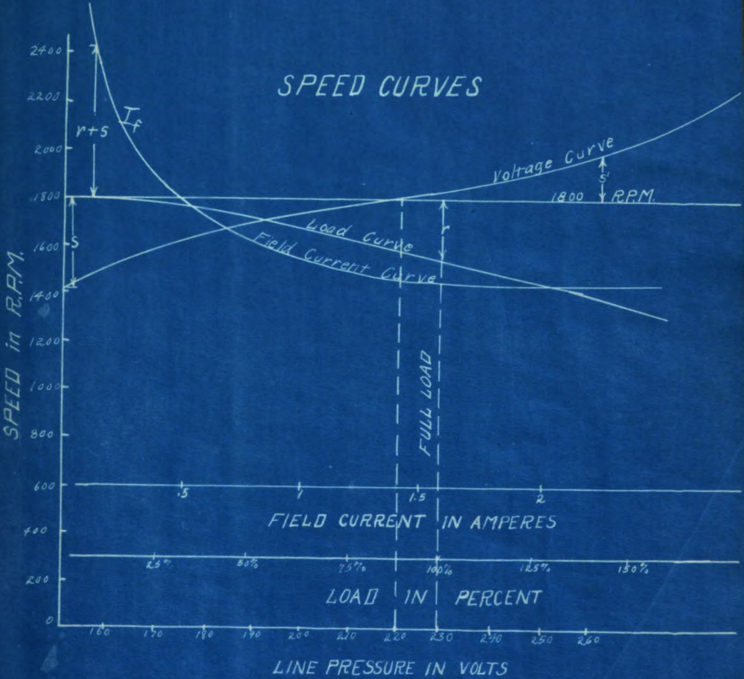


A GRAPH

showing

The Principles of Speed Contrd

The maximum change of speed to be made by I_F is r+s



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THE DESIGN OF A CONSTANT SPEED REGULATOR

For

MOTOR GENERATOR SET NO. 2

A small 110 volt D.C. motor was secured and tested as a generator. It was a series wound motor and would run at about 1200 R.P.M. on 110 volts but when driven at 1200 R.P.M. it would not build up voltage.

It was necessary to rewind the field and separately excite it from storage batteries.

It was excited with .3 amperes and at 1800 R.P.M. it generated 250 milliamps at a pressure of 6 volts.

From this data the Generator Relay Coil was designed.

GENERATOR RELAY COIL DESIGN

Data Given

6 volts

.25 amperes

24 ohms

Assume

Coil 2.5 inches long

2.25 inches diameter

.75 inches thickness of coil.

(1.) $$R = \frac{4p}{L(D^2 - d^2)}$$

All formula from

"The Electro Magnet"

by Wolcott
Kenelly
Vorley

R = Constant for given size wire

p = Resistance of coil

L = Length of coil

D = Outside diameter of coil

d = inside diameter of coil

Substituting these values

$p = 24$

$L = 2.5$

$D = 2.25$

$d = .75$

$$R = \frac{4 \times 24}{2.5((2.25)^2-(.75)^2)} = 8.4$$

For R = 8.4 - # 24 B & S gage wire is necessary (from table in "The Electro Magnet")

Assume No. 22 B & S gage wire.

Then to compute the number of Ampere turns (NI)

$$NI = \frac{2\,E}{K(D \quad d)}$$

NI = Ampere turns

E = Impressed voltage

K = Constant for given size wire

Substituting these values

E = 6

K = .00671 (from table)

D = 2.25

d = .75

$$NI = \frac{12}{.00671\ (2.25 \times .75)} = 1056 \text{ Ampere turns}$$

I = .25 amperes

NI = 1056

$$N = \frac{1056}{.25} = 4224 \text{ turns of wire}$$

Length of wire $L = \frac{D \times N \times \pi}{12}$

D = average diameter

$$L = \frac{1.5 \times 4224 \times 3.1416}{12}$$ = 1662 or 1700 feet of #22 wire required.

DESIGN OF LINE RELAY COIL

Data Given

220 volts

Assume

Coil 2.5 inches long

2.25 inches diameter

.75 inches thickness

Formula

$$R = \frac{4\ E^2}{D\ L^2\ (D^2 - d^2)}$$

R = Constant for given size wire

E = Impressed voltage

D = Outside diameter of coil

d = Inside diameter of coil

L = Length of coil

Substituting these values

E = 220	E^2 = 48400
D = 2.25	D^2 = 5.05
L = 2.5	L^2 = 6.25
d = .75	d^2 = .5625

$$R = \frac{4 \times 48400}{3.1416 \times 2.25 \times 6.25 \times 4.56} = 960$$

When R = 960 the size of the wire corresponding is #35

Assume #32 B & S gage wire.

To compute ampere turns (NI)

$$NI = \frac{2\ E}{K(D\quad d)}$$ (from Electro Magnet)

Substituting these values

E = 220

K = .086 for #32 wire

D = 2.25

d = .75

$$NI = \frac{2 \times 220}{.086 \times 3} = 1703 \text{ Ampere turns}$$

Area of coil = .75 x 2.5 = 1.6885 square inches area

No. 32 wire will wind 9,610 turns per square inch.

1.6885 x 9,610 = 16000 turns of No. 32 B & S gage wire on Line relay coil.

CONSTRUCTION

The Frame, lever arms and springs were made after the coils were wound. A flat piece of cold rolled steel 2½ x ½ was used as a base. The cores also of cold rolled steel were fastened to the base in an upright position by cap screws through the base. Large brass washers were fastened on top of the coils, by a ledge on the end of the cores, to hold the coils in place and protect them. Two brass standards were fastened to the sides of the base midway between the coils to hold the pivot rod of the lever arms in place. The lever arms were first made from twisted pieces of cold rolled steel but they were found to be two heavy. Then they were cut from thin pieces of cold rolled steel. Some difficulty was found in finding suitable contacts, but silver points were finally tried and found to be satisfactory.

Then a support was made from the small D.C.generator at the end of the motor by the use of strap irons fastened to the motor frame and bent into place. The generator was mounted on a flat piece of steel that was held in place by the strap irons. The generator was then coupled to the motor by an ordinary tachometer coupling.

The greatest difficulty was encountered in getting a satisfactory spring action. Flat steel springs were used at first and made adjustable by a set screw. The apparatus was set up and these were tried out but it was found that the magnetism would hold the springs from acting as they should. Then the design of the spring control was changed to use a tension brass coil spring. This required a change in the frame design. A flat piece of brass was fastened to the frame and bent over the lever arms on both sides. The spring adjustments and lever arm stops were fastened to this piece of brass. It was designed so that the spring and stop adjustments could be made by turning small brass nuts on the top of the apparatus.

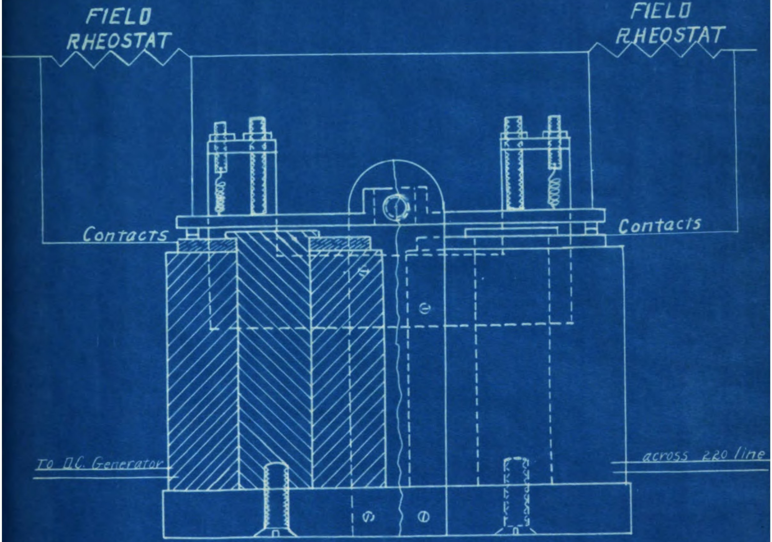

DIAGRAM
of
CONSTANT SPEED CONTROLLER

TESTS AND RESULTS

The first tests were made using flat steel springs. The action of the levers was so slow that no data was taken of the test. This sluggish action was due apparently to the magnetic pull of the core on the spring.

The design was changed and brass coil springs were used in place of the flat steel springs.

This test showed that 30 volts change in the line voltage was required to operate the line relay coil and that a change of 300 R.P.M. was required to furnish enough current to operate the generator relay coil.

CONCLUSION

This Test proved three things.

1. That the theory was correct.
2. That the method of applying the theory was not correct.
3. That the correct method of applying the theory in the design could not be worked out mathematically, but must be experimented with until the desired results are obtained.

This leads to the conclusion that this design is not correct and that it is not correct because it has not great enough sensitiveness. This may be due to a number of faults. The friction and weight of the lever arm, the lack of sufficient winding in the coils to provide operating flux from slight changes of current in the coils, and the saturation of the lever arms above the knee of the saturation curve.

In the origianal design of the coils, a change of 5 volts or of 10 R.P.M. should supply enough flux to operate the contacts regardless of the total amount of flux. This means that the scope of operating ability of the apparatus as built must be narrowed down to these limits,

Altho this design is not correct it provides valuable data from which a successful device may be designed and built.

Any future design should make use of this data: That there should be no oversaturated parts in the magnetic circuit; that the flux should be large enough so that a slight variation in the current will produce enough flux to operate the contacts; That the lever arms should be so designed that the friction and weight would be a minimum and would not materially affect the action of the arms.

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