EXPERIMENT NO. 2

SATURATION CURVE OF A GENERATOR

PURPOSE:

To discover the meaning of the term saturation and the effect saturation has on the output of a generator.

PERFORMANCE OBJECTIVES:

Upon successful completion of this experiment, the student will be able to:

1. Take necessary data and plot a saturation curve.
2. Explain the effects of saturation.

BRIEFING:

The field coils are wound on pole pieces. Pole pieces are specially shaped pieces of soft-iron which are easily magnetized. The magnetomotive force created by the current passing through the field coils magnetizes the pole pieces. You can think of magnetization as the lining up of the tiny internal magnets of the iron. As you start out, the number of these internal magnets that get lined up is directly proportional to the field current. This means that the magnetic field strength is directly proportional to field current. But then you reach a point called SATURATION. That's when most of the internal magnets of the pole pieces have become lined up. It becomes increasingly harder to line up any more. If you keep on increasing the field current beyond saturation, you get very little increase in field strength.

In the Hampden DC Machine, we can't measure the field strength directly but we can measure it indirectly. The amount of voltage generated by a generator depends on two things: (1) the speed of the armature and (2) the field strength. Therefore if we run the generator at a constant speed, the terminal voltage will be directly proportional to the strength of the magnetic field. As we increase the field current we will see the generator terminal voltage go up in a straight line and then level off, when the iron becomes saturated.

Then, if we start decreasing the current through the field coil, a curious thing happens. We can decrease the field current to the same values we did when increasing it, but we get a different terminal voltage. It would be slightly higher for, say 0.3 amps coming down than it
was for 0.3 amps going up. The reason is that it takes some effort to line up the internal magnets of the pole piece. But, once they are lined up, they don’t readily snap back to their original positions when you decrease the magnetizing current. This lag in response is known as hysteresis. It is like internal friction.

MACHINES REQUIRED:

DM-100A DC Machine operating as a generator
MFM-100 Single-phase motor as the prime mover

POWER REQUIRED:

120 volt AC, single-phase
0-150 volt variable DC, 1 amp

METERS REQUIRED:

0-150 volt DC Voltmeter
0-0.5 amp DC ammeter

ADDITIONAL MATERIAL REQUIRED:

MGB-100-DG Bedplate

PROGRAM PLAN:

Step 1. Place the two machines on the bedplate with the motor on the left and the generator on the right.

Step 2. Couple the machines tightly using the rubber coupling. Be sure the rubber coupling fits snugly inside both flanges.

Step 3. Clamp the machines tightly. Place the coupling guard over the coupling and the shaft guards over the shafts at each end.

Step 4. Connect the single-phase motor to the 120 volt AC supply as shown in Figure 2-1. Do not turn the power ON yet.

Step 5. Connect the shunt field of the DC generator to the 0-150 volt excitation supply, as shown in Figure 2-1.
Step 6. Turn the power supply knob to zero. Do not turn the power on yet.

![Diagram](image)

**Figure 2-1**

Step 7. Have the instructor check your connections to be sure they are correct.

Step 8. Turn ON the main AC circuit breaker; turn ON the 0-150 volt DC supply circuit breaker; and turn ON the circuit breaker switch that starts the motor.

Step 9. At this point there is no current in the field coil. However if the field pole pieces have been magnetized before, they will have enough residual magnetism in them to produce a voltage at the generator's terminals. Record this voltage in Table 2-1 of TEST RESULTS.

Step 10. Slowly turn the knob of the 0-150 volt excitation supply until the ammeter reads approximately 0.1 amps of field current.

**NOTE:** It is not important that the field current be exactly 0.1 amps. If you overshoot, stop and take your reading there. If you decrease the current you will not be able to see how the voltage changes as the current goes up.

Step 11. Record the exact value of field current and generated voltage and record the readings in Table 2-1 of TEST RESULTS.

Step 12. Slowly turn the knob of the 0-150 volt excitation supply until the ammeter reads approximately 0.2 amps of field current. Record the actual field current and generated voltage in Table 2-1 of TEST RESULTS.
Step 13. Repeat Step 12 for the following approximate values of field current: 0.3 amps; 0.4 amps; and 0.5 amps.

Step 14. Slowly decrease the excitation voltage until the ammeter reads approximately 0.4 amps of field current. Record the actual field current and generated voltage in Table 2-1 of TEST RESULTS.

Step 15. Repeat Step 14 for the following approximate values of field current: 0.3 amps; 0.2 amps; 0.1 amps; and 0 amps.

Step 16. Turn OFF all circuit breaker switches. Disconnect all leads.

**TEST RESULTS:**

<table>
<thead>
<tr>
<th>FIELD CURRENT</th>
<th>0</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN. VOLTAGE</td>
<td></td>
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<td>GEN. VOLTAGE</td>
</tr>
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</table>

**TABLE 2-1**

**DE-BRIEFING:**

1. Using the data you recorded in Table 2-1, plot a curve of GENERATED VOLTS versus FIELD AMPERES on the graph provided. Label this curve INCREASING.

2. Using the data you recorded in Table 2-1, plot a curve of GENERATED VOLTS versus FIELD AMPERES on the graph provided. Label this curve DECREASING. NOTE: The reading taken at approximately 0.5 amperes is a plotting point on both curves.

3. From your curves, would say that saturation occurs all at once or gradually? Explain how you reached the conclusion you did.
4. Explain why the DECREASING Curve is different from the INCREASING curve, if it is.


5. Under what condition would the generator produce zero terminal volts while its armature is being driven at normal speed?


Name one of the possible causes for this condition.


QUICK QUIZ:

1. Current flowing through the field coils:
   a. Magnetizes the pole pieces.
   b. Makes the generator armature turn.
   c. Has no effect on the generator's magnetic field.

2. The process of magnetizing the pole pieces involves:
   a. Passing a magnetic field through them without change.
   b. Lining up the internal magnets of the pole pieces.
   c. Trying to get the tiny internal magnets of the pole pieces into random, helter-skelter positions so their fields cancel.

3. The terminal voltage of a given generator depends on these two things:
   a. The magnetic field strength and armature speed.
   b. The field current and armature speed.
   c. Resistance of the field coil and armature speed.
4. A field pole piece is said to be saturated when:

a. A small increase in field current produces a large jump in magnetic field strength.

b. Magnetic field strength increases when there is no increase in field current.

c. Increases in field current produce proportionately smaller increases in magnetic field strength.

5. Hysteresis is the term used to describe:

a. The way iron can become magnetized

b. The way iron can become saturated.

c. The way a decrease in magnetic field strength lags behind a decrease in field current.

![Graph](image-url)