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Schenectady, New York

USE OF A D-C ELECTROMAGNETIC PUMP
AS A
THROTTLING DEVICE IN A SODIUM SYSTEM

by

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SUMMARY

Operation of a d-c pump as a dynamic brake (magnetic drag) in a sodium system proved successful. The sodium flow from the 60 gpm test pump was reduced by 26 percent and the pressure at the inlet of the test pump was lowered from 15 psia to 2.7 psia.

A comparison between the performance of the d-c unit as a pump and as a generator is presented.

INTRODUCTION

The final phase of the operational tests on the sixty gpm electromagnetic sodium pump utilized the existing d-c pump to determine its effectiveness as a dynamic brake. In actuality, it meant running the d-c pump backwards and producing the effect of a generator. The accompanying magnetic drag served to throttle the sodium flow through the d-c pump and decrease the pressure on the inlet side of the test pump.

The layout for these tests is shown on the attached sketch. The test pump had originally been installed in series with the d-c pump to avoid excessive modification to the loop. It had not been operated, however, during the performance runs on the sixty gpm pump. Initially it was planned to use the d-c pump in conjunction with a throttling valve to produce cavitation, but the hazards involved through failure of the valve did not justify its use and subsequent investigations were limited to the braking effectiveness of the d-c pump.

In view of the forthcoming tests that are planned using E.M. throttling devices for the control purposes, it was deemed worthwhile to evaluate the information obtained during the tests on the d-c pump. Pressure drop, flow decrease and current output data were determined as a function of the pump field.

DISCUSSION

The basic principle in the operation of the d-c pump is to force current through the sodium by impressing a voltage across the duct, both perpendicular to direction of flow and to the field set up across the poles. The reaction between the current and the magnetic field forms a force on the sodium similar to the action of a simple d-c motor. To permit the d-c pump to be operated as a dynamic brake, the bus bars of the pump were shorted out and a current was applied to the field coils. The sodium, which was forced through the can by the test pump, would then cut the field set up across the poles and induce a voltage in the bus bar. The magnitude of the resultant current and the corresponding braking effect was proportional to the field applied and to the rate of sodium flow.

In the test set-up, the current was measured on a standard millivolt meter through use of a shunt attached to the bus bar while the inlet pressure was measured by a standard vacuum gage which was tied into the system approximately one foot upstream of the sixty gpm pump.

The results of the tests are shown on the attached graphs. The throttling effect is depicted on figure 1. A flow decrease of approximately 26 percent occurred for the two test pump voltages investigated. Figure 2 shows the inlet pressures that were obtained as the field strength was increased across the d-c pump. The higher flow rate obtained during the 196 volt run, for a given field across the d-c pump, was responsible for the decreased pressures shown. A minimum pressure of 2.7 psia was obtained during the test and this occurred at a test pump voltage of 220 volts and a surge tank pressure of approximately 14.7 psia. Lowering of the surge tank pressure decreased the overall pressure in the loop a corresponding amount. A cross plot of the two curves representing the pressure and flow produced a linear relationship. The smooth curve indicated that no unusual phenomena had taken place during the tests.

Figure 4 is a plot of the d-c current in the shorted bus bars as a function of the current in the field coil. The curves levelled off when the field current approached 1.5 amps. A similar performance occurs during the normal operation of a d-c pump. The flat part of the curve represents the magnetic saturation of the magnetic circuit.

A cross analysis was made between performance curves representing the data for operation of the d-c unit as a pump and as a generator. Through a selection of constant values for the flow, pressure drop and flux density data, it was found that an armature current of approximately 4600 amps was required to produce a given pumping performance. This compares to 625 amps that were generated in the bus bars when the unit was operated as a dynamic brake. The difference between these currents (3975

amps) represents essentially the work done by the pump in transporting the sodium plus the magnetic drag. The 625 amps represents the I^2R losses through the armature, liquid metal and the pump walls.

Cavitation did not occur at the test pump even though the inlet pressure was reduced to approximately 2.7 psia during the successful operation of the d-c pump as a throttling device. Cavitation could be expected to occur at the minimum cross-section of the test pump can when the recorded inlet pressure became equal to or slightly less than the velocity head at this point. A flow of 40 gpm corresponds to a velocity head of 0.88 psia at the point of greatest restriction in the test pump. The pressure obtained by this dynamic throttling was sufficiently above this calculated value of 0.88 psia to prohibit cavitation. This head less the hydraulic losses up to the gauge are the pressure data presented on the curves. Tests were concluded at this point because it was thought unwise to attempt further reduction in pressure by means of the stop valves in the system.

The author wishes to acknowledge the assistance of G. D. Collins, Mrs. J. M. Durgerian, and L. B. Vandenberg during the course of test and the evaluation of the data.

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Figure 1

Figure 2

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60 GPM PUMP
TEST REQUEST #469
USE OF DC PUMP AS DYNAMIC BRAKE
INLET PRESSURE VS FIELD AMPS
7-10-53
580°F TANK
JMD SURGE PRESSURE 3 PSIG
8-5-53

Figure 3

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FLOW (GPM)

60 GPM PUMP
TEST REQUEST #469
USE OF D-C PUMP AS DYNAMIC BRAKE
FLOW VS INLET PRESSURE
196 VOLTS SURGE PRESSURE 3 PSIG
VARIABLE FIELD AMPS
7-10-53
JMD PLOTTED 8-5-53

Figure 4