Sliding Pressure Evaluation with PEPSE®

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ABSTRACT

Varying throttle pressure to control load is one method of improving operating heatrate of cycling units. PEPSE can be used to simulate this method of load control. The results of these simulations can be used to determine the economic impact of sliding pressure operation without expensive testing. Then benefit/cost studies can be performed to justify the cost of control retrofits.

INTRODUCTION

Oklahoma Gas and Electric Company is presently studying methods of lowering the company operating heatrate. One method being considered is to use sliding pressure control on some cycling units for low load heatrate improvement. To determine the benefit to operating heatrate a study was performed using the PEPSE program. The purpose of this paper is to outline the technique used to simulate turbine performance with sliding pressure control and also to discuss the results of the study.

EXPECTED RESULTS

There are four main beneficial results of sliding pressure operation that affect low load heatrate improvement. One is extended temperature control. Units are better able to maintain reheat and throttle temperatures at lower loads with sliding pressure operation.[1,2] A second result is lower boiler feed pump work. Lower pressures in the drum mean less work needed by the pump.[3] The third result is reduced throttle losses. By sliding pressure rather than throttling, the HP turbine efficiency should remain relatively constant.[2,3] The fourth result is higher governing stage exit temperatures. Turbine manufacturers recommend sliding pressure to reduce thermal stresses across the HP turbine during load changes.[2,3,4] Results of the PEPSE simulation showed these four results.

HYBRID MODES

The basic concept of sliding pressure operation is to lower load by lowering throttle pressure at valves wide open rather than throttling the main steam. A hybrid mode of operation is possible by throttling the steam to a valve point with one or more of the throttle valves and then sliding pressure.[3,5] This allows some throttling control if needed.

MODEL PREPARATION

To simulate operation at a set valve point, Special Option One was used. The throttle valve card and throttle valve first admission card (70XXX9) were used to establish the throttle valve flow passing characteristics. To determine the inputs, PEPSE runs were made at the flows corresponding to the desired valve points. These flows were determined from design information. The throttle valve cards were set as follows:

1. PDRPF was set at VWO design pressure drop.
2. TFR1ST was set at the ratio of valve point flow to VWO flow.
3. PREF, HREF and WREF were added and established at the valve point conditions.
4. The throttle valve first admission card was added with the HP exhaust pressure from the valve point flow PEPSE run input as PPXFST.

These steps established the throttle valve position. Schedules of throttle and reheat temperatures versus throttle flow were inserted into the model. The data for the schedules was taken from a graph of temperature versus percent evaporation on page 7 of <u>Steam Generator Design Features for Variable Load Operation</u> by Burbach, Fox and Hamilton. The temperatures from the thermal kit closely matched the throttled operation line of this graph. The boiler feed pump discharge pressures were set at 119% of the throttle pressures and the throttle valve leakages were set at the flows corresponding to the valve points. Stack cases were then run at different throttle pressures.

To simulate throttled operation after the unit throttle pressure had been lowered to the minimum pressure the following steps were taken:

1. Special Option One was changed to Special Option Three.
2. A replacement generator card (011010) was input with POWER set at the desired load.

Stacked cases were then run with POWER changed for each load to be considered.

RESULTS

A study was performed with this method for a 430 MW, eight valve Westinghouse turbine at OG&E. The machine loads by raising four valves together, then raising the next four valves independently. The study looked at operation with pure sliding pressure, one valve hybrid, two valve hybrid, three valve hybrid and four valve hybrid. The minimum operating pressure for the study was determined by engineering personnel as 1800 psi. Pressures during the study were lowered to 1800 psi then held at that pressure while throttling was resumed until minimum load was reached.

Equations of polynomial curve fits of the data from the sliding pressure runs and the run matching the thermal kit were placed into a computer spreadsheet so the results could be plotted. A plot of heatrate versus load for the five operating modes is shown in figure 1. The plot shows that the heatrate for sliding pressure operations are initially higher than throttled operation. At lower loads, however, the sliding pressure has a lower heatrate. This is easier to see in figure 2 which plots the delta heatrate

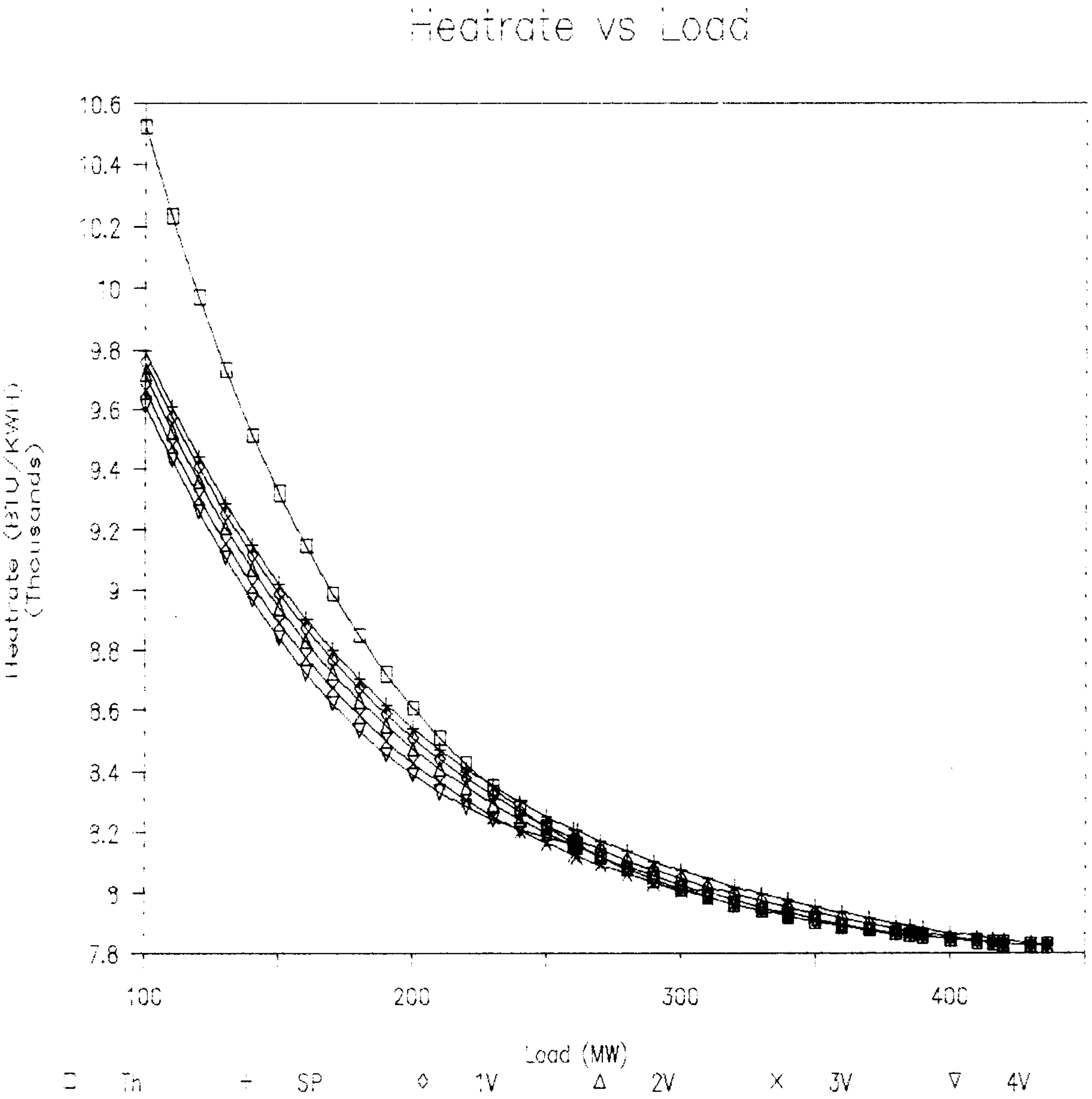

Figure 1

Gross Turbine Heatrate versus Load

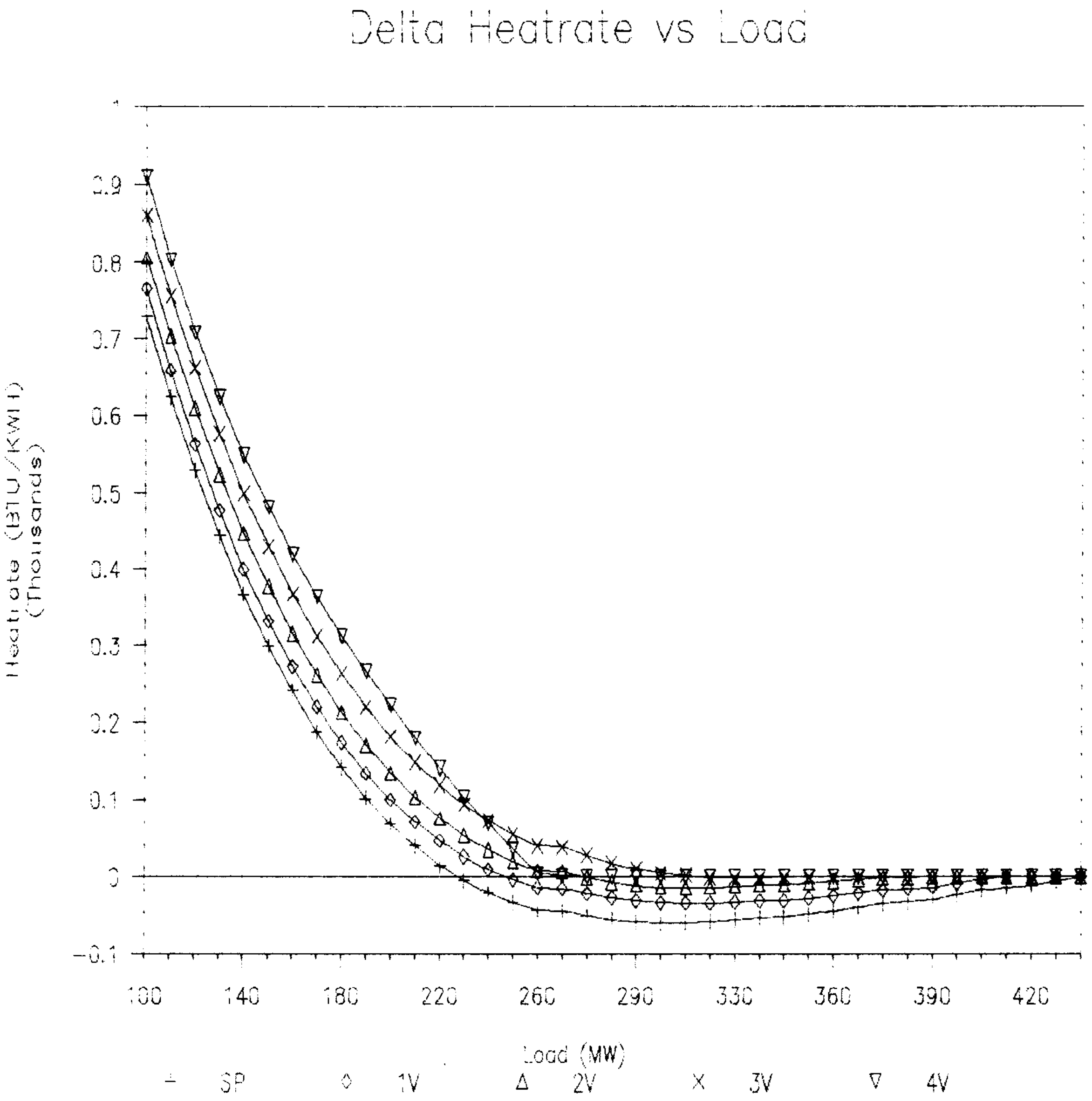

Figure 2

Delta Heatrate versus Load

Thermal Kit Match minus Sliding Pressure Operations between throttled operation and the sliding operation modes versus load. An exception is the four valve hybrid which has a lower heatrate from the beginning of sliding pressure operation. The three valve hybrid operation has a lower heatrate than any mode of operation from approximately 235 megawatts to 315 megawatts. At all other loads the four valve hybrid appears to be the more efficient mode of operation.

Figure 3 is a plot of the power used by the boiler feed pumps in the model. The plot shows the expected drop in power usage caused by the lower discharge head during sliding pressure operation.

The plot of HP section efficiency at the throttle valve inlet versus load in figure 4 shows the expected leveling of HP efficiency during sliding pressure operation. After reaching the minimum pressure and throttling resumes, the HP efficiency begins to drop again.

Governing stage exit temperature is plotted in figure 5. The temperature drops steadily during throttled operation, but the trend reverses when sliding pressure operation begins. When the assigned minimum pressure was reached and throttling was resumed, the temperature once again started a downward trend.

CONCLUSION

The difference in heatrate for the four valve hybrid was applied to an actual month of operating data. It showed a savings of $20000 in fuel for one months operation with sliding pressure operation. Because the study produced the results that were expected and correlates with other sliding pressure studies [3], the data was used to justify the expense to convert controls for sliding pressure operation.

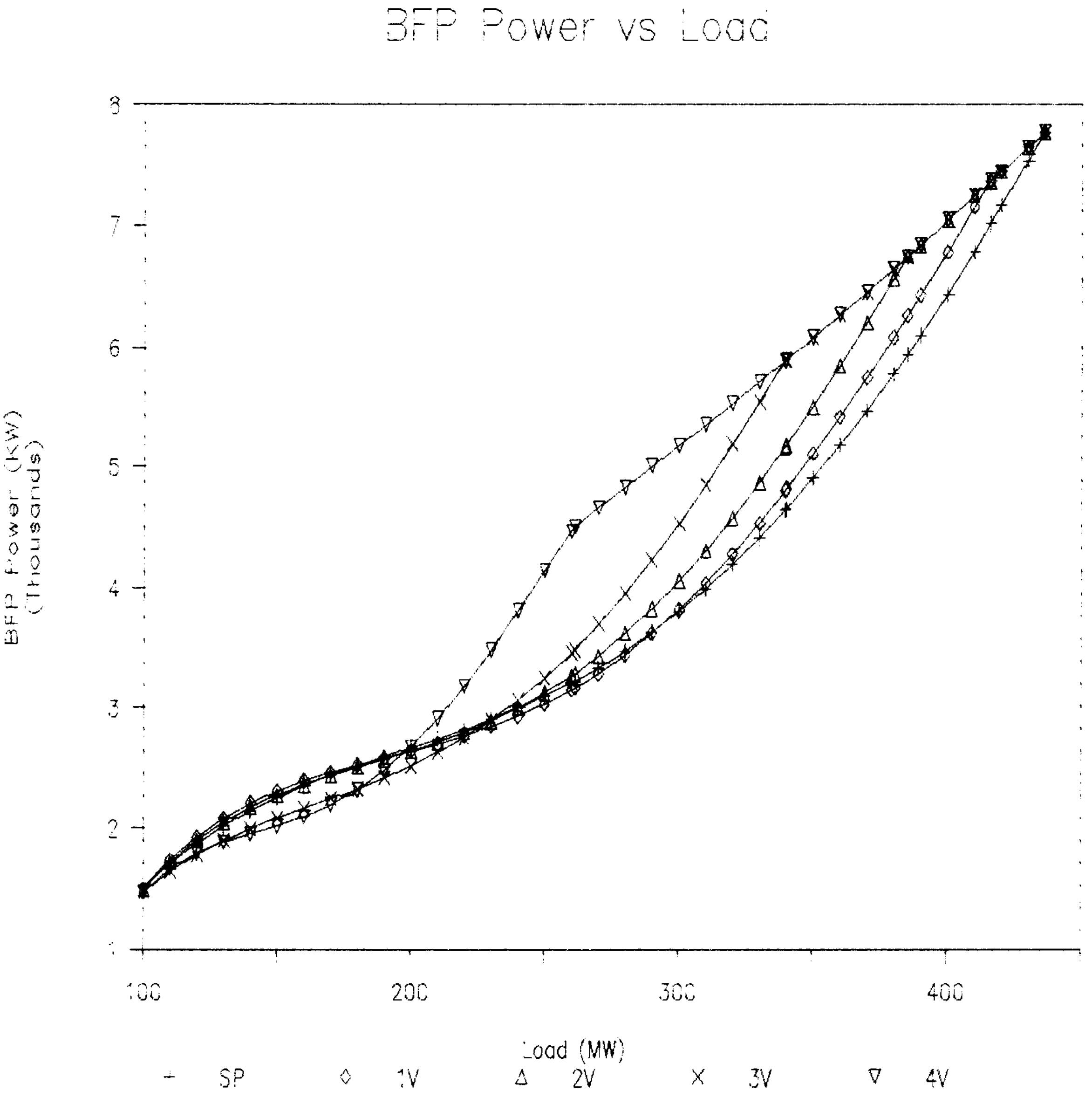

Figure 3

Boiler Feed Pumps Power versus Load

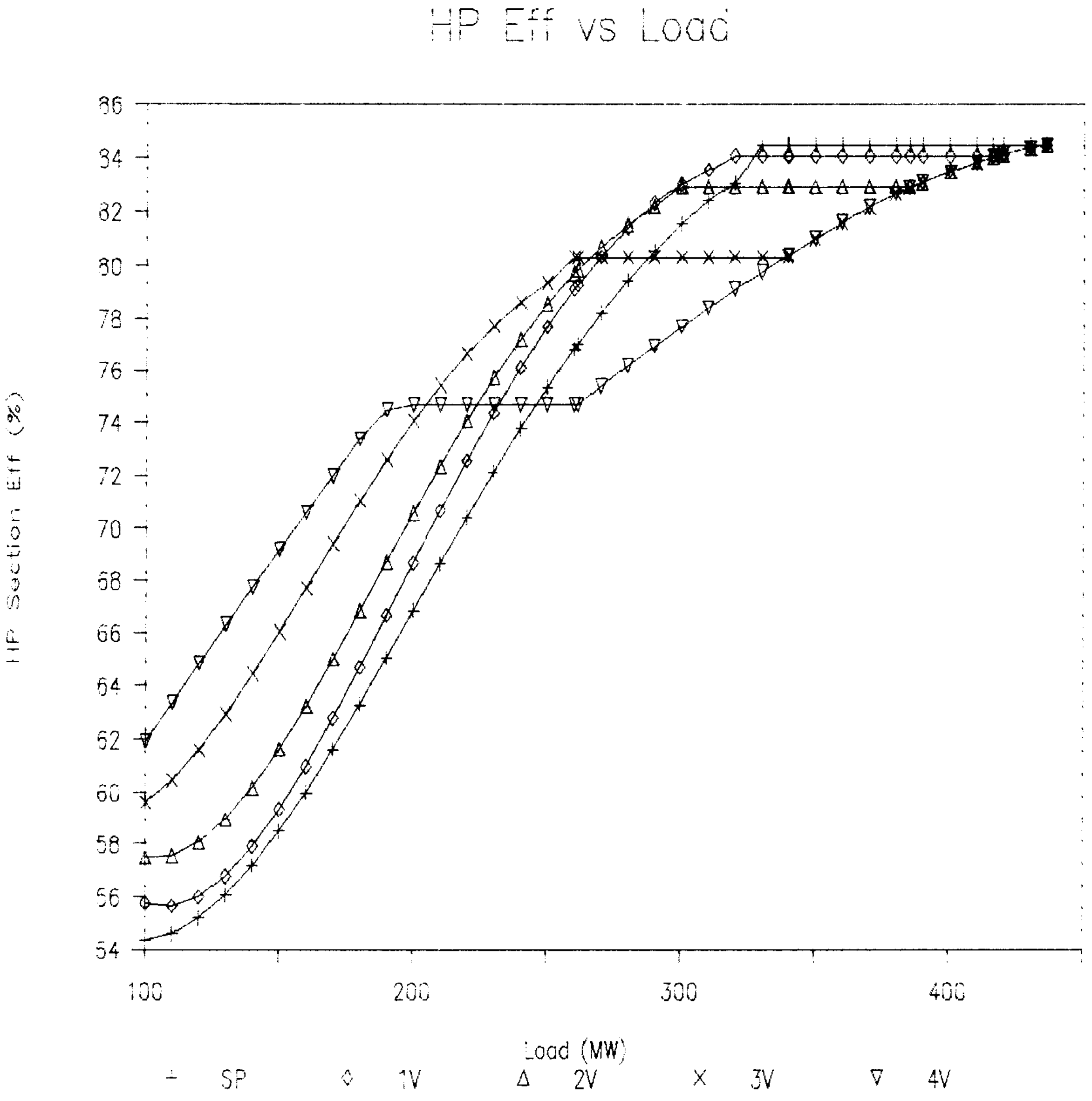

Figure 4

HP Turbine Section Efficiency versus Load

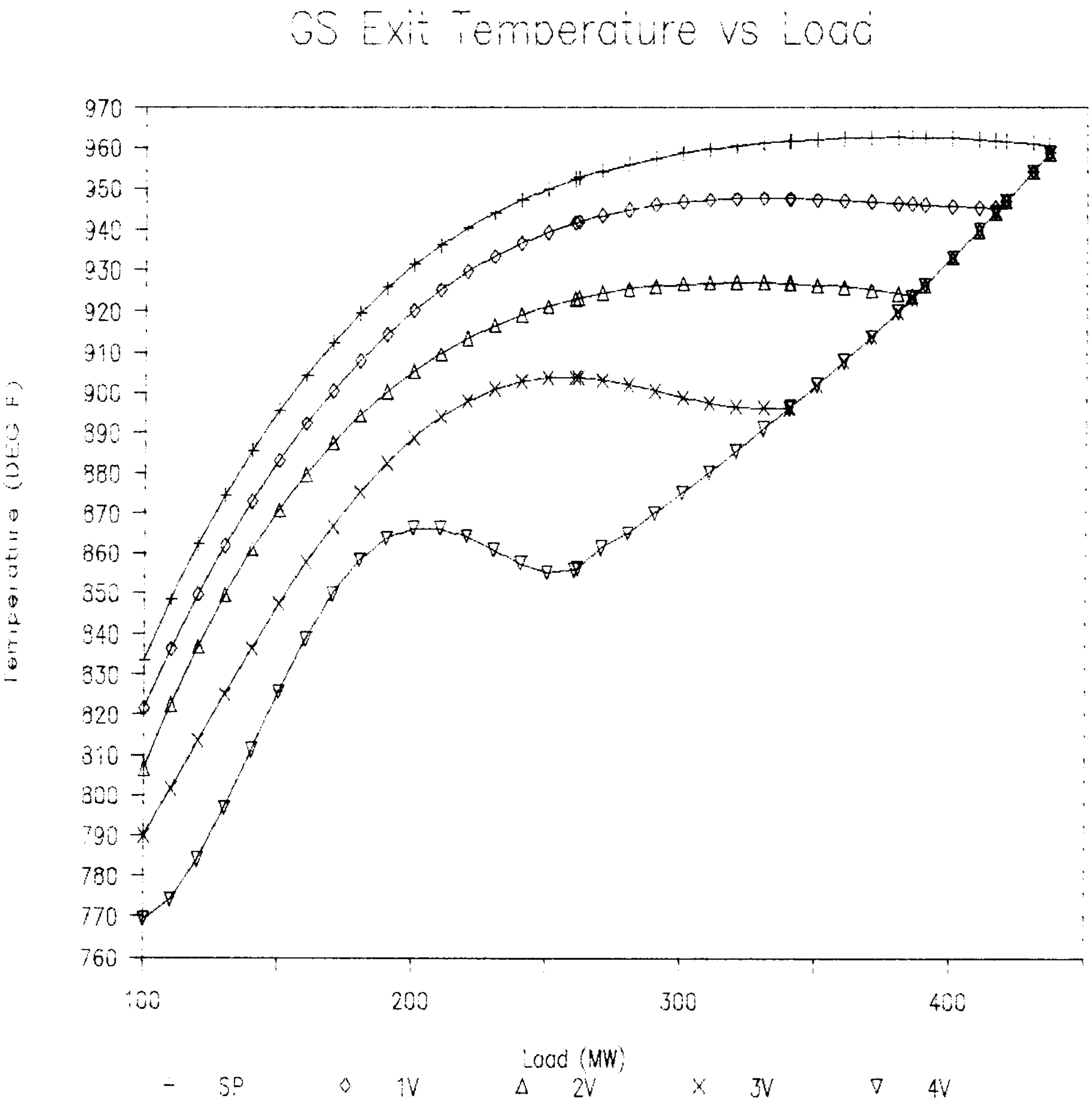

Figure 5

Governing Section Exit Temperature versus Load

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