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USE OF POISON SPLINES TO REDUCE NON-EQUILIBRIUM
LOSSES - KE REACTOR

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February 5, 1960

USE OF POISON SPLINES TO REDUCE NON-EQUILIBRIUM LOSSES KE REACTOR

INTRODUCTION

A significant reduction in non-equilibrium losses is possible through the use of poison splines for reactivity and heat distribution control during reactor startups. The curves presented show the results of an analysis of recent KE Reactor poison spline startup usage.

These curves demonstrate the magnitude of gains possible at other reactors through the use of poison splines for turnaround control.

SUMMARY AND CONCLUSIONS

Limited use of poison splines for supplementary startup control has resulted in an efficiency improvement of 1000 to 1500 MWD (.3 to .4 effective day's full production) per startup for the last ten startups of the KE Reactor. During the last minimum startup when a larger number of splines was used, the startup loss was about 1400 MWD, approximately 2600 MWD less (.7 effective day) than would have occurred without splines for supplemental control. It is believed that these gains can be increased as further experience with this newly adopted supplementary control system justifies usage of larger

SUMMARY AND CONCLUSIONS (Continued)

numbers of splines and bolder startup techniques. It should be pointed out, however, that there has been insufficient experience with these techniques to be certain that unforeseen operating problems will not occur in the future which could limit these gains.

DISCUSSION

The number of poison splines used per startup at KE Reactor has been progressively increased. The result has been either a decrease in the non-equilibrium loss on successive startups or essentially no increase in the non-equilibrium loss when the outage length was increased. The above results were possible because the turnaround level for a particular outage length can be increased as the number of poison splines used is increased.

A. Spline Startups Without Temporary Poison

Figure 1 shows the relationship between the non-equilibrium loss and the difference between the equilibrium power level and the turnaround power level. Obviously the idea is to approach full level at startup in order to minimize non-equilibrium losses. (The non-equilibrium loss is not quite zero if the difference between the equilibrium level and the turnaround level is zero because the power rise to turnaround level is not instantaneous. The curve must approach infinity when the difference between the equilibrium and turnaround levels is equal to the equilibrium level - meaning the pile takes forever to climb to full level.)

Figure 2 shows the poison spline requirements for different turnaround levels and outage lengths (shown as time from minimum down time to time one-half up to turnaround level). The family of curves shown are approximations based on turnaround reactivity transient calculations and estimates of the heat distribution in the reactor at turnaround. Actual cases are shown on the graph as data points. When the number of splines used is small, the turnaround level is often more dependent on the heat distribution than on the turnaround reactivity, but these two parameters are not independent of each other. The number of splines required will vary somewhat from time to time for the same turnaround level and down-time because the turnaround reactivity transient and heat distribution are dependent on other variables such as the reactor loading and the size of the temperature coefficients.

B. Startups Without Splines

Without splines at present power levels the equilibrium level minus the turnaround level would be about 2400 MW for a minimum time startup. The total startup losses probably would be about 3800-4200 MWD (1 to 1.1 effective day) for all temporary poison startups - about the same as for a minimum time startup without temporary poison.

C. Temporary Poison Startups Supplemented with Splines

The normal non-equilibrium loss for startups during which splines were used to accelerate the rise to equilibrium power following the temporary poison discharge has been 2500-2600 at present equilibrium operating levels, a gain of 1300-1600 MWD over splineless secondary startups. (About 20 splines were used for each of two such startups in January.)

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FIGURE 1 - NON-EQUILIBRIUM LOSS VS. DIFFERENCE BETWEEN EQUILIBRIUM LEVEL AND TURNAROUND LEVEL - KE

FIGURE 2 - TURNAROUND SPLINE REQUIREMENTS - NO TEMPORARY POISON

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