CONF-830609--66 Conf-830609--66
DE84 003198

DR-0488-X

NUCLEAR ENGINEERING LABORATORY SELF REGULATED POWER OSCILLATION EXPERIMENTS AT THE HEALTH PHYSICS RESEARCH REACTOR

Self regulated power oscillation experiments with a variety of initial conditions have been performed with the ORNL Health Physics Research Reactor[1] (HPRR) by undergraduate nuclear engineering students from The University of Tennessee for several years. These experiments demonstrate the coupling between reactor kinetics and heat transfer and show how the temperature coefficient of reactivity affects reactor behavior. A model that consists of several coupled first order nonlinear differential equations is used to calculate the temperature of the core center and surface and power as a function of time which are compared with the experimental data; also, the model is also used to study the effects of various model parameters and initial conditions on the amplitude, frequency and damping of the power and temperature oscillations. A previous paper[2] presented some limited experimental results and demonstrated the correspondence between a simple point model and the experimental data. This paper presents the results of experiments for: 1) the initial power fixed at 9 KW with central core temperatures of 300°F and 500°F, and 2) the initial central core temperature fixed at 500°F with initial powers of 6 and 8 KW.

The power oscillation experiments are initiated by maintaining the reactor power at a preselected level by adding reactivity with uranium control rods until the core temperature increases to a preselected value. Once the selected temperature is achieved, no further reactivity changes by control rods are made. The effective average core temperature continues to increase and to add negative reactivity until the energy loss from cooling becomes greater than the delayed fission power. The core power begins to decrease immediately and continues to decrease until the effective average core temperature drops below its initial value. Then it increases rapidly as the additional cooling adds positive reactivity. The temperature again increases when the fission energy input rate becomes greater than the cooling rate and thus the temperature and power oscillations are initiated. The time dependence of core temperature and reactor power (Figure 1) are for an initial power of 9 KW with initial core temperatures of 500°F and 400°F. The reactor power, core temperature and surface temperature for an initial core temperature 500°F with initial powers of 8 KW and 6 KW are shown in Figure 2. The data shown in both figures clearly illustrate that the core temperature distribution is strongly centrally peaked at the beginning of the transient relative to the equilibrium temperature distribution. This is especially apparent from Figure 2 for the case with an initial core power 8 KW since the initial temperature difference between the core and surface thermocouples is 300°F and since the equilibrium temperature difference is approximately 100°F. Note that the equilibrium temperatures can be determined at the times when the time derivative of the power is zero. Thus, the nonequilibrium initial temperature distribution is apparently the forcing function for the temperature and power oscillations; hence, a model that incorporates spatial effects is required to accurately calculate the core and surface temperature oscillations. The data show that the system response is nonlinear since in Figure 1 the frequency of oscillation is increased when the initial core temperature is increased. A similar nonlinear effect is illustrated by Figure 2 since the frequency of oscillation is increased when the initial power is decreased. On the other hand, the general correspondence between initial conditions and amplitude responses are consistent with what would be illustrated by a underdamped second order linear system.

The data from the HPRR power oscillation experiments with various initial conditions illustrate to the students some interesting characteristics of a coupled reactor kinetics and heat transfer system. Model results are very useful for illustrating the effects of reactor kinetics and heat transfer model parameters on the amplitude, frequency and damping of the temperature and power oscillations.

REFERENCES

1. M. J. Lundin, Health Physics Research Reactor Hazards Summary, ORNL-3248, Oak Ridge National Laboratory (1962).

2. J. T. Mihalczo and Donald R. Ward, "Self-Regulated Damped Power Oscillations of the Health Physics Research Reactor," Transaction of the ANS, pp. 895-896 (1972).

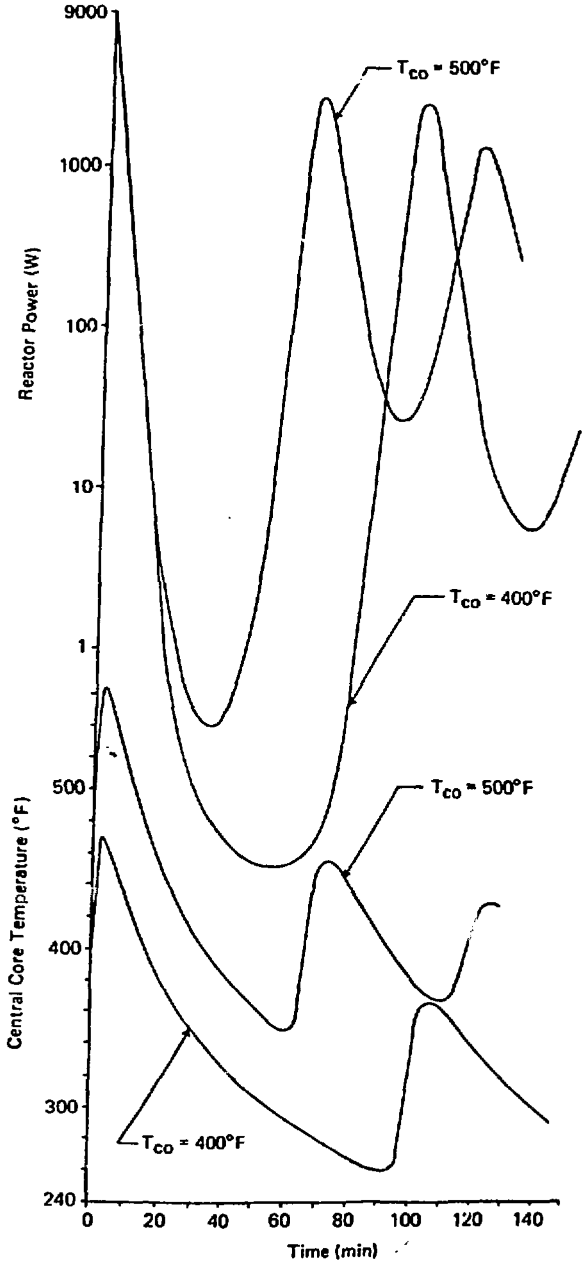

Fig. 1. Reactor power and central core temperature time responses of experimental data for initial central core temperatures of 500 and 400°F with an initial power of 9 kW.

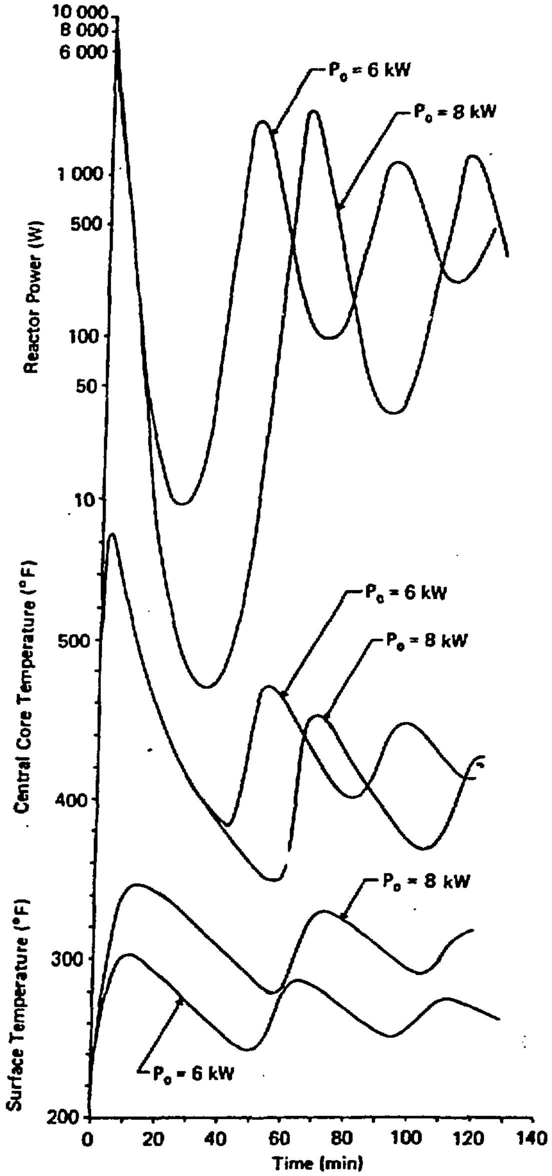

Fig. 2. Reactor power, central core temperature, and surface temperature time-dependent responses of experimental data for initial powers of 6 and 8 kW with an initial central core temperature of 500°F.

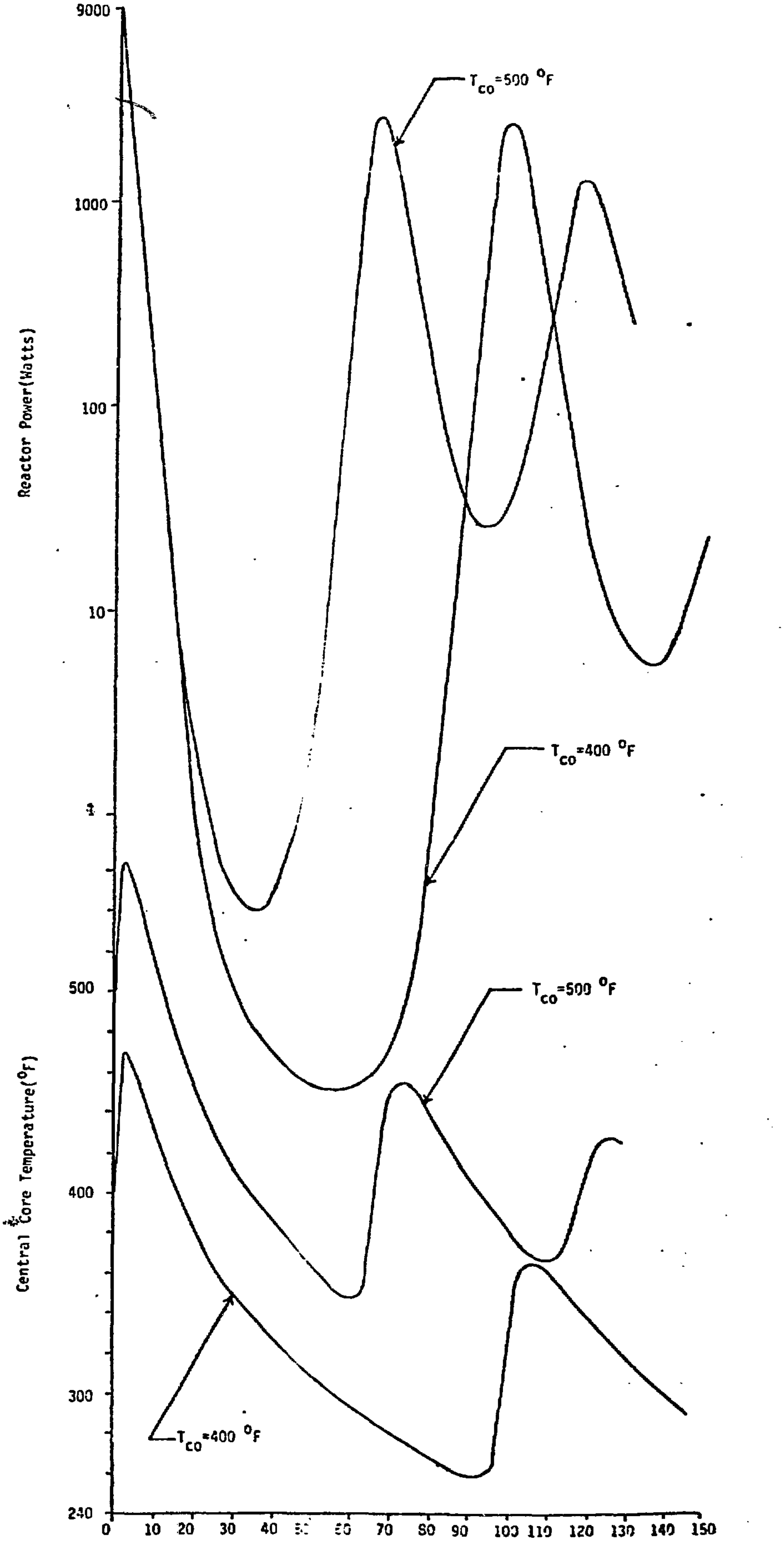

Figure 1. Reactor Power and Central Core Temperature Time Responses of Experimental Data for Initial Central Core Temperatures of 500°F and 400°F with an Initial Power of [illegible].

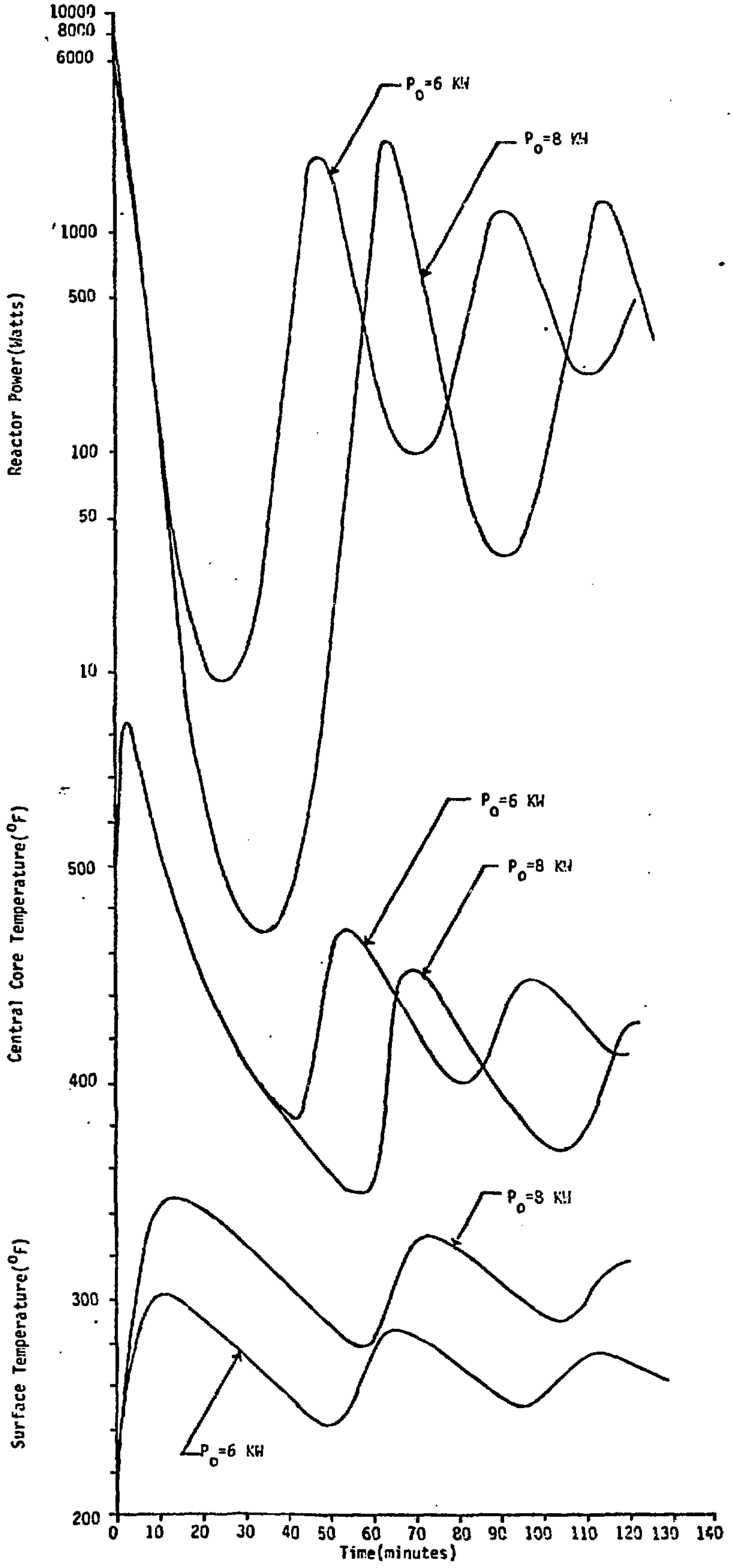

Figure 2. Reactor Power, Central Core Temperature and Surface Temperature Time Dependent Responses of Experimental Data for Initial Powers of 6 KW and 8 KW with an Initial Central Core Temperature of 500^{o}F.