Foreword

The essence of good engineering practice is to accomplish, within strict restraints of time and cost, the maximum output of excellent work with a minimum of effort. In this particular case, our engineering objective is to design a fission-chain reactor for production of thermal energy. To achieve this objective we must first understand the overall goal of the venture (economic electricity), characteristics of the reactor being designed, capabilities of the tools available, and the materials and systems that interact with, and determine, the optimum design result.

Reactor characteristics discussed in this course are those that relate to the spatial and temporal distribution of heat produced through reaction of neutrons with actinide materials (235U and others) inside the reactor core. These neutrons are, of course, produced by fission reactions. They migrate in the core in a manner similar to that of free gas particles, reacting with and sometimes being absorbed by the various atomic nuclei present. The neutrons lose energy and then continue to migrate until they are either absorbed or escape from the reactor core. Some of the absorption reactions produce fission – the primary goal of the reactor designer is to achieve a continuous, quasi-steady-state chain reaction. The designer's secondary goal is to increase the overall rate of fission reactions until the requisite amount of heat is produced. The designer's tertiary goal is to control the rate of fission reactions and to reduce the rate when and as required. The designer's final goal is to maintain steady heat production over long periods of time, of the order of months or years.

The products of neutron-induced fission play a very important part in reactor dynamic analysis. Aside from their relatively high neutron absorption characteristics, some fission products decay with emission of neutrons – a fact that greatly assists the design of reactor control systems. A few fission products (e.g. 135Xe) with very high absorption cross section tend to dominate the normal-operation dynamics of most thermal reactors.

A free neutron is itself radioactive and decays with a half-life of about 13 minutes. But this "lifetime" is very long compared with a neutron's normal travel time between production and absorption.

Fission-chain reactions are inherently dynamic rather than static. Time scales of interest to the designer range from very short (nanoseconds) to very long (gigaseconds). Spatial scales of interest range from very small (picometres) to medium (metres). Neutron energy scales of interest range from low (centi-electron volts) to high (mega-electron volts). In velocity terms, neutron velocities range from "slow" (kilometers/second) to "fast" (gigametres/second). Reactor dynamic analysis addresses this very broad field.

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