INTRODUCTION

The need to increase the safety and efficiency of different types of nuclear power plants (NPPs) has resulted in special attention being given to the analysis of hypothetical accident situations. In this respect, sodium cooled fast reactor plants are not exceptions. For any reactor, accident situations involve a severe imbalance between heat generation and heat removal in single fuel subassembly or in the core as a whole. Accident conditions may result from a number of causes: (1) local cooling reduction resulting from flow blockages in a single fuel subassembly with the possible failure propagation to adjacent fuel subassemblies; (2) loss of flow (scrammed or unscrammed) in the core; (3) transient overpower (scrammed or unscrammed); (4) loss of heat sink, and (5) possible combinations of these events. Accidents can pass through a number of stages which have common physical characteristics. The physical characteristics can include: (a) temperature profile disturbance; (b) sodium boiling; (c) fuel pin or whole subassembly failures; (d) molten fuel-sodium interaction, and (e) degraded core heat removal due to debris. In this review, results of experiments and analytical methods for analysing such processes are presented.

In the sodium cooled fast reactor, some incidents result from the fact that sodium reacts with water and air. In this review, experimental data and calculated results of the kinetics and thermodynamics of the sodium-water chemical interaction are presented. An analysis of coolant interactions within free volumes, at small and large water-into-sodium leaks in steam generators is given. An analysis of protection systems for various types of sodium-water steam generators, and a brief review of incident situations in those steam generators is also presented. A concise analysis is given of processes that occur when sodium and water come in contact in the steam generator buildings. This review presents information on the features of sodium burning and on the interaction of sodium with concrete that result from sodium leaks. Information on sodium fire extinguishing methods and systems are also presented as well as an analysis of the process in the fire region.

This review does not provide complete coverage of these subjects, but it gives an overview of the current level of understanding processes that occur during an accident or incident in the sodium-cooled fast reactor core and steam generator. This review should be useful to specialists in the field of nuclear power, and, particularly for those concerned with fast reactors.

CONCLUSIONS

Review of experimental and analytical research related to imbalance between reactor core heat generation and heat removal capacities, sodium-water interactions in steam generators and sodium fires produced the following conclusions:

- Reactors transient experiments have determined conditions to fuel pin failure, associated mechanisms and consequences,
- Experimental and calculational studies on core thermohydraulics under flow/power mismatch show that local fuel pin failure does not lead to rapid pin-to-pin propagation,
- In- and out-of-pile experiments on debris bed cooling provide a large amount of information concerning dryout fluxes, and they show that decay heat in a debris bed which is several inches thick can be effectively removed,
- Extensive development and validation of analytical methods and codes has been performed using experimental data,
- Further investigations are aimed at better understanding the postulated accident physical processes in the reactor core taking place under real reactor conditions that would allow improvement of plant economics without reduction in safety,
- Investigations of accident conditions in alternative fuel cores (metal, carbide, nitride, etc) should be intensified,
- Steam generator design are based on single wall tubes and a pressure relief system; SG operating experience has demonstrated that ingress of steam and water into sodium did not result in severe consequences,
- The diversity of SG design and safety systems point to the need for optimization studies which take into account the losses related to operation and maintenance of SG,
- Prevention, detection and mitigation of sodium leaks, improved resistance of nuclear systems to fires and choice of concrete for minimization of interaction with sodium is still an important direction for safety research.