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SuperCritical Light Water Reactor (SCLWR) with Intermediate Heat Exchanger (IHX)

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Abstract – *All recently proposed SCLWR concepts are once-through designs, based on the BWR concept, where the supercritical water from the reactor directly feeds the turbine. This concept clearly excels in system simplification and cycle efficiency, but the drawback is that the turbine and the Balance Of Plant inevitably become activated. In a BWR, soluble and suspended radioactive products remain in the reactor by the separation of water and steam, but in the SCLWR this process does not occur. In case of an accident, the radioactivity in the supercritical water can easily be transported out of the containment building.*

In this paper, a SCLWR concept with an IHX is proposed. Like the SG in a PWR, the IHX separates the primary loop from the secondary loop. The primary loop can then be completely enclosed within the reactor building. Such a concept will inevitably lead to a higher investment cost. But the advantage is that all primary activity remains within the primary loop and within the reactor building and no contamination of the turbine and BOP occurs. Moreover, this concept allows a separate chemistry for the primary and secondary loops. It also allows the use of a soluble neutron poison for reactivity control.

A conceptual design of the reactor vessel and the IHX is proposed; a RELAP model of the primary and secondary systems has been built and some design base accidents have been analyzed using the RELAP5/mod3.3 code. These analyses were performed to investigate the general behavior of a SCLWR with IHX, to have an idea of the grace time available before fuel damage occurs and to obtain some indication such as which type of safety systems would be needed for this concept. The purpose of the exercise is to determine whether the advantages of this concept with IHX sufficiently outweigh its drawbacks and consequently whether it is worth pursuing the development of this concept with IHX.

I. INTRODUCTION

The very first developments of a supercritical light water reactor (SCLWR) date back to the late 1950's, early 1960's, see historical overview[1,2]. In the late 1960's, there were also some attempts to design a steam cooled fast reactor. But the rapid and spectacular development of the LWR's (both PWR and BWR) on the one hand and the important R&D that was required to develop such a SCLWR on the other hand, stopped their further development and the idea of a SCLWR was abandoned for quite some time. But in fossil fired power plants the development continued and supercritical boilers have been in operation for over 30 years now.

In the late 1980's, the Kurchatov institute took up the idea again and proposed a concept of a small, integral type PWR with the primary loop operating at supercritical conditions[3]. But the concept of a SCLWR was really revived by Prof. Y. Oka at the University of Tokyo in the 1990's[4-9]. The important novelty in the concept of the University of Tokyo was the use of the BWR as starting point for their development. This led to important simplifications and cost savings with respect to current PWR's, while at the same time overall cycle efficiency was increased.

Following the work at the University of Tokyo, several R&D projects were launched:

1. In Canada, the CANDU-X project by AECL to study supercritical versions of the CANDU reactor;
2. In the US, some smaller projects were financed within NERI by the US DOE;
3. In Europe, the HPLWR project[10] was funded by the EC 5th framework program, funding continues in the 6th framework program.