MARS Transient Analyzer for Dual Reactor Unit Producing 2000 MWe

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1. Introduction

The reduction of the cost of electricity produced by nuclear power plants (NPP) has become more compelling than ever over the last few years as a way to cope with the rising oil price. One means to achieve this goal has been to look toward increasing the capacity of NPPs, a global trend in nuclear engineering for the 21st century. In particular, to reduce construction and generation cost, the Optimized Power Reactor 1000 MWe (OPR1000) and the Advanced Power Reactor 1400 MWe (APR1400) are designed for larger NPPs. Quite recently the Advanced Power Reactor Plus (APR^+) has evolved from the APR1400 to produce 1500 MWe by increasing the size of the core. However, expanding the NPP capacity comes understandably at the cost of economics and safety. Large and larger NPPs will tend to necessitate redesign, new manufacturing facilities, and, in more cases than not, resolution of would be licensing issues [1, 2].

2. Design Concept

The Dual Unit Optimizer 2000 MWe (DUO2000) is proposed as an engineered solution to these very challenges [3]. The design concept of the DUO2000 is anchored to combine pressurized water reactor (PWR) units, each generating 1000 MWe, in order to produce a total of 2000 MWe.

The DUO2000 comprises two nuclear steam supply systems (NSSSs) of the OPR1000 as reference reactor to double the reactor power. Since DUO2000 has naturally evolved from an existing PWR, it is expected that most of the current design engineering, including the in-vessel retention (IVR), may be straightforwardly extrapolated and maintained.

This approach should not only obviate huge redesign and engineering cost as well as investment risk, but also pave the way to cheaper and safer NPPs than equivalent single units of the same electric output. Specifically, the containment, which occupies a large portion in the construction cost, can be reduced.

Besides, this technology can potentially be extended to coupling modular reactors as dual, triple, or quadruple units to increase their economic efficiencies, thus accelerating the commercialization as well as the customization of small and medium reactors [4].

3. Prototype

The prototype carries a single NSSS composed of two Reactor Pressure Vessels (RPVs) in a single containment building. It has cross piping between RPVs to share the coolant system. The cross piping receives the hot coolant from two reactors and provides the coolant to two steam generators (SGs) by diverging it. Two RPVs share the coolant system and two SGs between the RPVs.

The capacities of the common SGs and of the outside SGs are identical. Although it is true that this prototype aggravates the complexity of piping and augments the hydraulic resistance of the primary coolant system, it unifies the size of SGs. It connects the two OPR1000s that have two hot legs and two loops.

Fig. 1 illustrates the top, side, and front views of prototype with a total of 3 loops, 2 RPVs, 4 SGs, and 8 RCPs along with its bird's-eye view in Fig. 2.

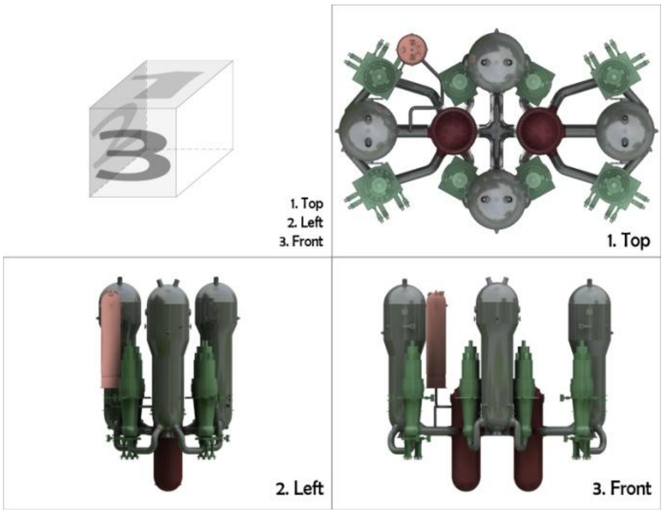

Fig. 1. Top, side and front views of DUO2000 prototype.

Fig. 2. Bird's-eye view of DUO2000 prototype.

4. MARS Model

The MARS code [5] has been selected to develop the NSSS transient analyzer based on best-estimate codes for DUO. MARS is adopted for realistic analysis of small- and large-break loss-of-coolant accidents. It is thus necessary to develop the MARS input model for DUO. Since DUO is designed based on the OPR1000, the MARS input model for DUO is also designed based on that for OPR1000 such as Ulchin Units 3 and 4. The MARS input data is generated from the input model.

The prototype DUO2000 has essentially the same key components as the OPR1000 except the Coolant Unit Branching Apparatus (CUBA). CUBA as shown in Fig. 3 serves the interface between the two hot legs from each reactor. Fig. 4 provides MARS nodalization for CUBA. Components 026, 020, 036 and 080 are the time-dependent volumes for the break boundary.

5. Summary

DUO2000 has been suggested to cope with the need to reduce the construction and maintenance cost of nuclear power plant. Prototypes of DUO2000 have relatively simple design and are based on the OPR1000, which has been proven for a number of reactor years. MARS is adopted to DUO for safety analysis.

The input model is being tested for calculations of a steady state during nominal operation, and of a cold leg and hot leg break loss-of-coolant accidents.

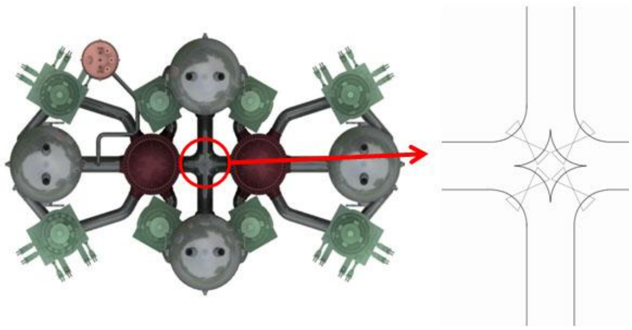

Fig. 3. Location and schematic view of CUBA.

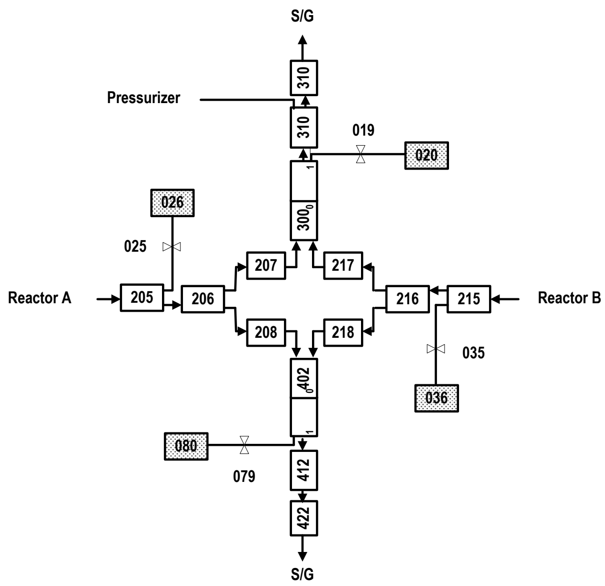

Fig. 4. MARS nodalization for CUBA.

Acknowledgments

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