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Using Solver Interfaced Virtual Reality in PEACER Design Process

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1. Introduction

The recent research progress in the area of plant design and simulation highlighted the importance of integrating design and analysis models on a unified environment. For currently developed advanced reactors, either for power production or research, this effort has embraced impressive state-of-the-art information and automation technology [1].

The PEACER (Proliferation-resistant, Environment-friendly, Accident-tolerant, Continual and Economical Reactor) [2] is one of the conceptual fast reactor system cooled by LBE (Lead Bismuth Eutectic) for nuclear waste transmutation. This reactor system is composed of innovative combination between design process and analysis. To establish an integrated design process by coupling design, analysis, and post-processing technology while minimizing the repetitive and costly manual interactions for design changes, a solver-interfaced virtual reality simulation system (SIVR) has been developed for a nuclear transmutation energy system as PEACER. The SIVR was developed using Virtual Reality Modeling Language (VRML) [3] in order to interface a commercial 3D CAD tool with various engineering solvers and to implement virtual reality presentation of results in a neutral format. In this paper, we have shown the SIVR approach viable and effective in the life-cycle management of complex nuclear energy systems, including design, construction and operation. For instance, The HELIOS [4] is a down scaled model of the PEACER prototype to demonstrate the operability and safety as well as preliminary test of PEACER PLM (Product Life-cycle Management) with SIVR (Solver Interfaced Virtual Reality) concepts. Most components are designed by CATIA [5], which is 3D CAD tool. During the construction, 3D drawing by CATIA was effective to handle and arrange the loop configuration, especially when we changed the design.

Most of all, This system shows the transparency of design and operational status of an energy complex to operators and inspectors can help ensure accident-tolerance and proliferation-resistance of sensitive processes such as spent nuclear fuel partitioning operations.

2. Solver-Interfaced Virtual Reality System

The CAD approach for PEACER is intended to cover not only digital drawing function but also to demonstrate its functional performances including proliferation-resistance, environment-friendliness, accident-tolerance and economy. For this purpose, combining CAD geometry data with the results of design analysis solvers can make a 3D visualization in Figure 1 of functional performance characteristics. Nuclear engineering solvers employed in PEACER design include REFIN [6], ANSYS [7], MCNP [9], REBUS [10], DSNP [11], MATRA [12], CFX [13], RODSIS [14], GEN II [15] and RESRAD [16]. At the first step, 3D snapshot images are pursued in this work in order to demonstrate detailed functional performances to levels that can be adequate for thorough scrutiny of experts as well as the public. In the future, dynamic visualization with virtual reality

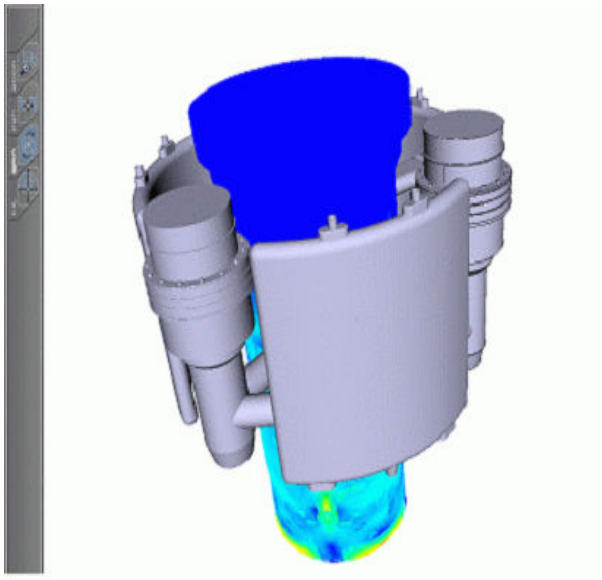

Figure 1. Combing original 3D CAD geometry with analysis data

capability is to be included.

PEACER-SIVR application for the design process is summarized in Figure 2. The benefit of the approach is found in providing design groups with both big picture and detail information that significantly help minimize data transfer errors and accelerate the design evolution process. CATIA coupled with nuclear, thermal-hydraulic, and structural analysis codes helps minimize the repetitive manual changes of input and output process. The manual process is prone to introducing errors that are often difficult to trace, causing delays. This aspect highlighted advantage of PEACER-SIVR.

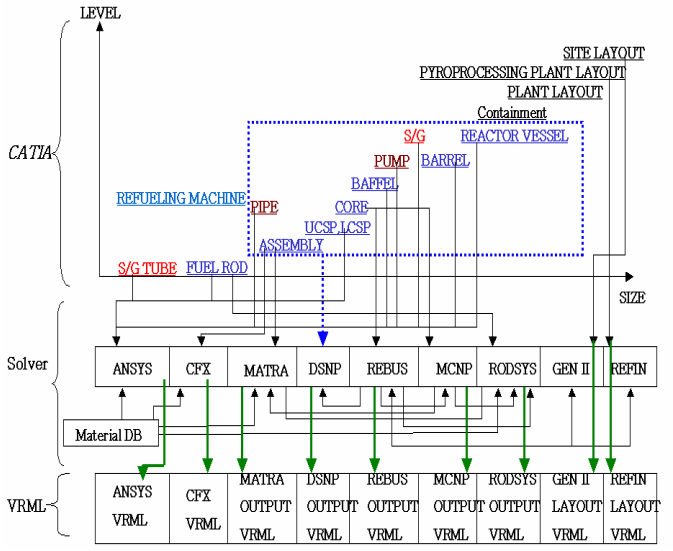

Figure 2. PEACER-SIVR system on design process

3. Conclusion

Interfacing a commercial CAD tool with nuclear solver codes using Virtual Reality Modeling Language (VRML) has developed solver-interfaced virtual reality (SIVR), a 3D visualization system. CAD geometry data are directly utilized to prepare input data for solver codes having 3D analysis capability while manual preparations were made for other codes. Analysis results from solvers are translated by developing processors using VRML into a format that is suitable for 3D visualization. Significant saving in time is realized in the design modifications and major shakedowns of a nuclear transmutation energy system named as PEACER (Proliferation-resistant, Environment-friendly, Accident-tolerant, Continual and Economical Reactor). To date, static 3D images are generated for a given time during system transient events to examine potential benefits of such a full SIVR capability. The full automation of input and out process is under the development. The viability of SIVR approach is demonstrated in time and cost reduction by applying it to the design and construction of a non-radioactive PEACER mockup designated as HELIOS. Upon the completion of the full automation of interfacing and testing in HELIOS, the SIVR is expected to be useful in the life-cycle management of energy complexes, including design, construction and operation.

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