Multibody Dynamics study of Subassembly Transfer Flask under Seismic Excitation:

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Abstract

The second stage of Indian Nuclear program is based on design and operation of Liquid metal cooled fast breeder reactors (LMFBRs). Fast breeder reactor (FBR) core typically consist of fuel elements in clad tubes closely packed within a hexagonal sheath called fuel subassembly (FSA). Charging and discharging of these Fuel Sub Assemblies require dedicated operating systems called Fuel handling system; Fuel handling system plays an important role for reliable operation of fast reactors. Design of fuel handling system is very complicated in fast reactors because of specific problems associated with coolant and fuel. Opacity of sodium and high chemical affinity necessitates remote handling of core components in inert atmosphere. Handling of fuel is further complicated by the requirement of decay heat removal and radiation shielding because of high burn up and specific activity of fuel. Charging and discharging of core components to/from the reactor vessel is carried out by ex-vessel transfer machine. In PFBR inclined fuel transfer machine (IFTM) is designed for ex-vessel transfer. Gaining experience from PFBR, many design simplification are carried out for the fuel handling system for future FBRs. Design of ex-vessel transfer machine is changed to flask transfer from the existing design of IFTM in PFBR. Subassembly Transfer Flask (STF) is the ex vessel transfer machine considered for future FBRs. This machine consists of a flask mounted over a self propelled carriage and moves between the fuel transfer port of reactor vessel at one end and fuel transfer port of inert gas filled SA transfer carriage cell (STC cell) at other end.STF transfer / receives transfer pot holding irradiated/ FSA to/from the transfer carriage through the transfer port. The irradiated SA/ fresh SA is further exchanged between the SA transfer carriage and another machine working in fuel building during handling.

Multibody dynamics approach is used to study the dynamic behaviour of the STF under a response spectrum at the support elevation. The present work is a MBD investigation of the performance of STF under seismic events to evaluate the forces experienced by the different components of the machine and the motion study of the Fuel Sub assembly (FSA) when the STF is experiencing seismic excitation. Rigid body dynamic behaviour of the docked STF loaded with FSA forms the paramount portion of the study. Behaviour of contact between STF and rails during seismic excitation is observed. This study verifies the functionality effectiveness of seismic anchors and locking mechanism provided for the machine though MBD investigation using Recurdyn solver for analysis.

The seismic excitation displacement time history is generated by the Response spectrum at 30m elevation in reactor vault at PFBR. This displacement time history is loaded to the rails supporting the STF. The STF is modelled with corresponding degrees of freedom housing a FSA inside. The locking pin latches into a locking hole in the slab constraining translation in two directions. Modelling the total components is not computationally beneficial as their contribution in seismic response is inconsequential. The double wire rope supporting the FSA is modelled with varying stiffness under compression and tension to replicate the actual behaviour of wire during Earthquake excitation which has higher stiffness in tension (during Up motion of STF/down motion of FSA) and almost negligible stiffness under compression (during Down motion of STF/up motion of FSA), the forces extracted from the seismic arrestors and locking pin is further used for design up gradation of respective components.

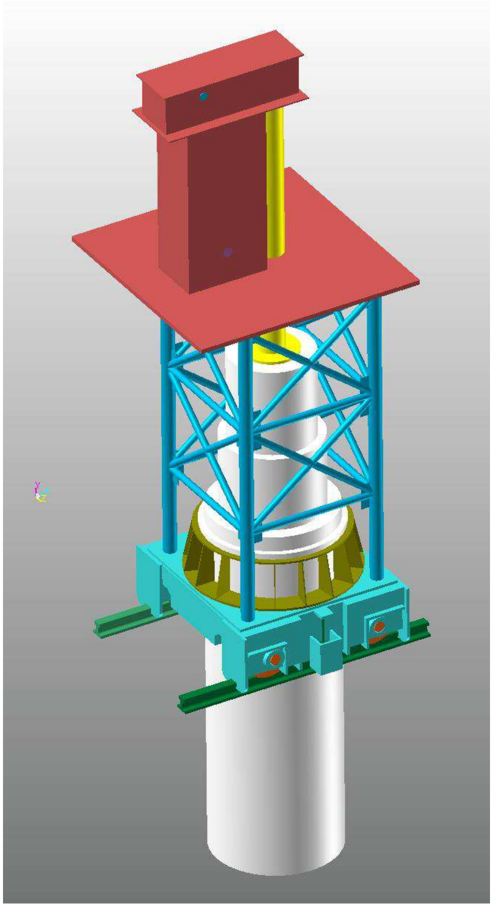

Figure 1: Docked Sub Assembly Transfer Flask

References

[1] Recurdyn documentation - Recurdyn User's manual.