IFERC Newsletter

IFERC-N-2023-01, 25 January 2023
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Staus of DEMO Design Activity

Highlights on Remote Maintenance

The purpose of task 4 of DDA is to identify and study solutions that have the potential to solve maintenance strategy challenges for the ex-vessel and Active Maintenance Facilities (AMF) of EU DEMO and JA DEMO. The following major design items were conducted in EU and JA based on the 2022 task work plan.

(i) Application of Condition Monitoring on DEMO Remote Maintenance System (RMS)

The process for estimating the health of equipment based on observations of certain equipment parameters and dedicated sensor measurements is called Condition Monitoring (CM) and is part of preventive-predictive maintenance. The benefits of using CM are usually hard to quantify because a cost must be assigned to the risk mitigation factor that the CM system provide. For estimating the potential benefit of application of CM on DEMO RMS, a Cost-Benefit Analysis (CBA) has been used to quantify the potential savings in downtime. CBA is a systematic technique used to compare the costs and benefits of a project using a single common metric. In the industries with a critical downtime cost (oil and gas, nuclear, fusion, etc.), CBA is mainly used for comparing a cost of investment against the benefits of reduced equipment downtime as follows:

$Cbnet=(Cost_{CM}-Cost_{noCM})-(Benefit_{CM}-Benefit_{noCM})$

The Blanket Transporter (BT) maintenance operation with 4 BT working in parallel has been used as a main use case. A reliability block diagram has been created from the Failure Mode Effect and Criticality Analysis (FMECA) of this process, and Discrete Event Simulation has been used for estimating the average downtime savings the CM offers when the occurrence rate of the monitored failure modes (FM) has been reduced. A sensitivity analysis has been performed of the amount of downtime change to the occurrence rate factor of the monitored FM. The results show that there could be significant savings in mitigated downtime (~€45M) when CM is used during 1000 days of operation of the BTs.

(ii) Clarification of system requirements for remote maintenance related to AMF and Ex-vessel

Cask-based maintenance, such as ITER, is used for in-vessel components, such as blanket segments and divertors, to prevent the spreading of radioactive dust. The casks, with enveloped and double seal doors, are shuttled between the AMF and tokamak complex building to replace the in-vessel components (see Fig-1). Based on the current maintenance plan, blanket segments (BSs) consisting of breeding blanket modules (BBMs) and back plates (BPs) require replacement approximately every three years; divertor target plates (DTPs) require replacement annually. According to the estimated maintenance time required to replace in-vessel components, four parallel works need to be conducted to meet the target maintenance availability of ~70%. Since it is difficult to deploy four casks to the upper maintenance cell, two parallel works using a cask for replacement were selected. In order to mitigate the impact of target availability regarding reduction to two parallel works using by cask, four parallel works are conducted on cooling pipe welding/inspection work as this severely impacts maintenance time, whereas a single line is required for the accessway between AMF and tokamak complex building, based on a logistics study. The AMFs comprise facilities for decontaminating radiation dust; storage for radiation dose rate reduction and heat cooling; replacement of BBMs and DTPs; and a subassembly for reinstallation to vacuum vessel. Maintenance requirements in AMF are to reduce low-level radioactive waste and to downsize AMF. To meet these requirements, specifications of AMF were updated as follows: a) storage ability of 80 BSs and 54 diverter cassettes, b) BSs storage period of 2 -3 years to reduction of dose rate, c) BBMs replacement period of 2 years by using parallel works and d) reuse of BPs and divertor cassette bodies.

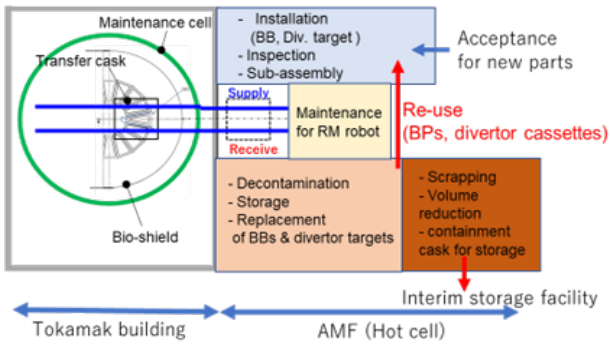

Fig-1: Schematic view for AMF layout

(DEMO Design Task-4 TROs)