CALIBRATION AND COMPENSATION OF DEFLECTIONS AND COMPLIANCES IN REMOTE HANDLING EQUIPMENT CONFIGURATIONS

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Compared to the previous fusion experimental reactors, the size and weight of the remotely handled reactor components are much larger in ITER. This leads to highly demanding remote handling equipment sequences due to the constricted space around the components. The ITER divertor maintenance service tunnels clearances between divertor Cassette and the tunnels ceiling and the floor are approximately 20mm. Moreover, the clearances in the reactor for the installation and removal of reactor components can be even tighter. Therefore, there is a high accuracy demand for every remote handling system configurations. Typical remote handling system configuration for ITER divertor maintenance operations consist of three subsystems which form a kinematic chain. First subsystem is a mover (CMM), second subsystem is an end-effector (SCEE, StCEE, and CCEE) and third subsystem is a payload (Central Cassette, Standard Cassette, and 2nd Cassette). Each of the remote handling system configurations are affected by manufacturing and assembly tolerances, deflections and compliances and these configuration model inaccuracies must be identified and compensated in order to achieve accuracy demands and to be able to perform required tasks safely.

This paper presents a generic method of calibrating and compensating remote handling system configurations subject to manufacturing and assembly tolerances, deflections and compliances. A method consists of kinematic part and non-kinematic part. A kinematic calibration algorithm is presented for finding the values of kinematic model errors by measuring the end-effector Cartesian position. This is a conventional way to calibrate industrial robots. However, in this case the kinematic calibration is not able to compensate flaws fully due to large deflections and compliances caused by a massive Cassette payload (approx. 9tn). Therefore, non-kinematic calibration must be introduced in addition to a kinematic calibration. A kinematic calibration together with a non-kinematic calibration is a demanding task to carry out. The resulting complex compensation function has to be such that it can be implemented in real-time CMM control system software.

This paper presents experimental campaign carried out for calibration and compensation of presented case study which consist of CMM, SCEE and Divertor 2nd Cassette mock-up at DTP2. The measured results show that the positioning accuracy of a remote handling equipment system can be substantially improved using a technique for measuring the Cartesian position of points attached to the end of the system together with a look-up table like corrections. In addition, the results show that the accuracy requirements are achieved and the remote handling system configuration is possible to transfer through the RH maintenance service port. The results also indicate that every remote handling system configuration has to be calibrated in Hot Cell facility before its maintenance operations. This paper describes a Hot Cell calibration procedure to be done prior to sending any divertor remote handling system configuration for a mission.