A mobile robot with parallel kinematics constructed under requirements for assembling and machining of the ITER vacuum vessel. (P2-G-408)

Pekka Pessi(1), Huapeng Wu(1), Heikki Handroos(1), Lawrence Jones(2)

1. Department of Mechanical Engineering Lappeenranta University of Technology FIN-53851 Lappeenranta Finland
2. EFDA Close Support Unit Boltzmannstr. 2 85748 Garching Germany

ITER sectors require more stringent tolerances ±5mm than normally expected for the size of structure involved. The walls of ITER sectors are made of 60mm thick stainless steel and are joined together by high efficiency structural and leak tight welds. In addition to the initial vacuum vessel assembly, sectors may have to be replaced for repair. Since commercially available machines are too heavy for the required machining operations and the lifting of a possible e-beam gun column system, and conventional robots lack the stiffness and accuracy in such machining condition, a new flexible, lightweight and mobile robotic machine is being considered.

For the assembly of the ITER vacuum vessel sector, precise positioning of welding end-effectors, at some distance in a confined space from the available supports, will be required, which is not possible using conventional machines or robots. This paper presents a special robot, able to carry out welding and machining processes from inside the ITER vacuum vessel, consisting of a ten-degree-of-freedom parallel robot mounted on a carriage driven by electric motor/gearbox on a track. The robot consists of a Stewart platform based parallel mechanism. Water hydraulic cylinders are used as actuators to reach six degrees of freedom for parallel construction. Two linear and two rotational motions are used for enlargement the workspace of the manipulator. The robot carries both welding gun such as a TIG, hybrid laser or e-beam welding gun to weld the inner and outer walls of the ITER vacuum vessel sectors and machining tools to cut and milling the walls with necessary accuracy, it can also carry other tools and material to a required position inside the vacuum vessel .

For assembling an on line six degrees of freedom seam finding algorithm has been developed, which enables the robot to find welding seam automatically in a very complex environment. In the machining multi flexible machining processes carried out automatically by the robot have also been investigated, which include edge cutting, smoothing and defect points milling. The kinematic design of the robot has been optimised for ITER access. A virtual prototype of the parallel robot is built. Parts of the robot are studied separately by finite element analysis. Important parts from view of deformation are studied separately by FE-software. The weight and deflections are most important factors in the carriage design. Small deformations of carriage will multiply to the robot's end-effector. A dynamical behaviour of the whole robot is studied by multi-body system simulation. Flexible parts in addition to rigid parts are used in the MBS model. The virtual prototype contains hydraulic components also.