STATIC STIFFNESS MODELING OF A NOVEL HYBRID REDUNDANT ROBOT MACHINE

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The purpose of this work is to build up a static stiffness model which is used to optimize the configuration of the redundant hybrid parallel robot machine when the robot carries out welding, machining, and remote handing for the assembly of vacuum vessel of the ITER reactor. This robot machine merges the advantages of both the serial and parallel mechanisms, and it has ten degrees of freedom. Among the ten degrees, six are contributed by the parallel mechanism and the rest by the serial mechanism. Due to the redundant freedom, when a particular position and orientation of the end-effector in the robot are given, there are infinite configurations theoretically, so it provides an optimization space in which the stiffest posture of the robot is considered as the objective function. To build up stiffness model multi algorithms have been involved, e.g. the matrix structure analysis (MSA), virtual joint method (VJM) and virtual work principle (VWP). In this paper, the VJM method is also improved based on the model of Gosselin's which is firstly proposed in the year of 2000.

Firstly, the stiffness model of the parallel mechanism is studied. The parallel structure is decomposed into up u-joints, limbs, foot u-joints, and bearing housings on the basement. The MSA method is applied for calculating the stiffness of the U-joint and the bearing housing, the stiffness of foot u-joints is built up by using the method of VJM and VMP because of their special structure, and the stiffness of the cylinder is constructed by taking account of hydraulic stiffness. Consequently, the stiffness model of the parallel mechanism is obtained by integrating the stiffness of up u-joints, limbs and feet on the basement under the combining methods of VJM and VWP.

Secondly, the stiffness model of serial part of the robot machine is investigated by decomposing serial part into frame, elevating part and a movable basement. The frame is considered as a rigid strut. The stiffness of the elevating part is mainly contributed by the joints and a hydraulic limb, and its stiffness model is calculated by integrating the joint and limb stiffness by the methods of VJM and VWP. The stiffness model of the movable basement is obtained by calculating the stiffness of two vertical linear motors and a pair of gears.

Finally, by combining the stiffness of parallel structure and components of serial part, the stiffness model of the hybrid redundant robot is then obtained. The simulation results show that the final model of the robot can be used as an objective function for solving the redundant problem in trajectory planning.