Dynamic Modeling and Eigenvalue Evaluation of a 3-DOF PKM Module

ZHANG Jun[1], LI Yonggang[1,2], HUANG Tian[1,*]

1 School of Mechanical Engineering, Tianjin University, Tianjin 300072, China

2 Tianjin University of Technology and Education, Tianjin 300222, China

Received May 26, 2009; revised February 27, 2010; accepted March 6, 2010; published electronically March 16, 2010

Abstract: Due to the structural complexity, the dynamic modeling and quick performance evaluation for the parallel kinematic machines (PKMs) are still to be remained as two challenges in the stage of conceptual design. By using the finite element method and substructure synthesis, this paper mainly deals with the dynamic modeling and eigenvalue evaluation of a novel 3-DOF spindle head named the A3 head. The topological architecture behind the proposed A3 head is a 3-RPS parallel mechanism, which possesses one translational and two rotational capabilities. The mechanical features of the A3 head are briefly addressed in the first place followed by inverse position analysis. In the dynamic modeling, the platform is treated as a rigid body, the RPS limbs as the continuous uniform beams and the joints as lumped virtual springs. With the combination of substructure synthesis and finite element method, an analytical approach is then proposed to formulate the governing equations of motion of system using the compatibility conditions at interface between the limbs and the platform. Consequently, by solving the eigenvalue problem of the governing equations of motion, the distribution of lower natural frequencies of the A3 head throughout the entire workspace can be predicted in a quick manner. Modal analysis for the A3 head reveals that the distributions of lower natural frequencies are strongly related to the mechanism configuration and are axially symmetric due to system kinematic and structural features. The sensitivity analysis of the system indicates that the dimensional parameters of the 3-RPS mechanism have a slight effect on system lower natural frequencies while the joint compliances affect the distributions of lower natural frequencies significantly. The proposed dynamic modeling method can also be applied to other PKMs and can effectively evaluate the PKM's dynamic performance throughout the entire workspace.

Key words: dynamic modeling, parallel kinematic machine, natural frequency

*Corresponding author. E-mail: htiantju@public.tpt.tj.cn

This project is supported by National Natural Science Foundation of China (Grant No. 50535010 and No. 50775158) and National Science and Technology Supporting Plan of China (Grant No. 2006BAF01B00)

地址: 中国北京百万庄大街22号 **邮编:** 100037 **电话:** 8610-88379907 **传真:** 8610-68994557
E-mail: cjme@mail.machineinfo.gov.cn **http:** // www.cjmenet.com.cn