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Adaptive Machining for Curved Contour on Deformed Large Skin Based on On-Machine Measurement and Isometric Mapping

Qingzhen Bi[a,*], Nuodi Huang[b], Shaokun Zhang[a], Chaolin Shuai[c], Yuhan Wang[a]

[a] *State Key Laboratory of Mechanical System and Vibration, School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai 200240, P.R. China.*
[b] *Hubei Key Laboratory of Waterjet Theory and New Technology, School of Power and Mechanical Engineering, Wuhan University, Wuhan 430072, P.R. China.*
[c] *AVIC Chengdu Aircraft Industrial Co. Ltd.*

Abstract

Curved contour on large thin-walled skin is difficult to be machined since severe deformations usually occur on real skin. It is critical to determine the real geometry of the deformed contour. Under the assumption that only the normal deformation of the large thin-walled skin occurs and the shear deformation is ignored, a novel isometric mapping based adaptive machining method is developed. While straightness distance or local angle is preserved in traditional surface mapping methods, arc-length is preserved in proposed isometric mapping to improve the contour cutting accuracy. The proposed method consists of three steps. (1) The real geometry of the deformed surface is obtained by using a laser scanner based on-machine measurement (OMM) system. The measured point cloud is then transformed into triangular mesh to represent the deformed surface. Some points on the nominal surface are sampled based on uniform sampling strategy, and the corresponding sampling points in the deformed surface are also allocated. (2) Isometric mapping between the two groups of points is constructed. Matching accuracy between nominal surface and real surface is defined based on the deviation of the geodesic distances of the two groups of points. A surface matching optimization model is developed to adjust the mapping point location in the triangular mesh and achieve a minimum surface mismatch error. (3) The toolpath is adaptively adjusted to compensate the deformation error based on the isometric surface mapping results. Both simulation and machining experiments are conducted to demonstrate the feasibility and validity of the proposed method. The experiment results show that accuracy of the machined curved contour on the deformed skin has been significantly improved.

*Corresponding author
Email address: biqz@sjtu.edu.cn (Qingzhen Bi)