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Effects of Machining Parameters on the Surface Roughness and Vibration of the Milling Tool

Authors : Yung C. Lin, Kung D. Wu, Wei C. Shih, Jui P. Hung

Abstract : High speed and high precision machining have become the most important technology in manufacturing industry. The surface roughness of high precision components is regarded as the important characteristics of the product quality. However, machining chatter could damage the machined surface and restricts the process efficiency. Therefore, selection of the appropriate cutting conditions is of importance to prevent the occurrence of chatter. In addition, vibration of the spindle tool also affects the surface quality, which implies the surface precision can be controlled by monitoring the vibration of the spindle tool. Based on this concept, this study was aimed to investigate the influence of the machining conditions on the surface roughness and the vibration of the spindle tool. To this end, a series of machining tests were conducted on aluminum alloy. In tests, the vibration of the spindle tool was measured by using the acceleration sensors. The surface roughness of the machined parts was examined using white light interferometer. The response surface methodology (RSM) was employed to establish the mathematical models for predicting surface finish and tool vibration, respectively. The correlation between the surface roughness and spindle tool vibration was also analyzed by ANOVA analysis. According to the machining tests, machined surface with or without chattering was marked on the lobes diagram as the verification of the machining conditions. Using multivariable regression analysis, the mathematical models for predicting the surface roughness and tool vibrations were developed based on the machining parameters, cutting depth (a), feed rate (f) and spindle speed (s). The predicted roughness is shown to agree well with the measured roughness, an average percentage of errors of 10%. The average percentage of errors of the tool vibrations between the measurements and the predictions of mathematical model is about 7.39%. In addition, the tool vibration under various machining conditions has been found to have a positive influence on the surface roughness (r=0.78). As a conclusion from current results, the mathematical models were successfully developed for the predictions of the surface roughness and vibration level of the spindle tool under different cutting condition, which can help to select appropriate cutting parameters and to monitor the machining conditions to achieve high surface quality in milling operation.

Keywords : machining parameters, machining stability, regression analysis, surface roughness
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