

Public Abstract

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Title: Effects of Machining System Parameters and Dynamics on Quality of High-Speed Milling

This dissertation outlines research on studying the effects of machining parameters such that cutting speed, feed rate, axial depth of cut, radial depth of cut and helix angle on system dynamic stability and the surface quality of high-speed milling. With the use of structural tool modal parameters, the material cutting force coefficients and the axial depth of cut, the system can avoid the chatter phenomenon of the tool at high cutting speeds. The surface roughness finish in the milling process is determined by the machining parameters and tool structure dynamics. To perform high-speed milling, the chance of tool vibration (chatter phenomenon) which affects the cutting tool, must be minimized or eliminated.

In this research, the linear and nonlinear mathematical force models including the effect of the helix angle are presented for an end-milling process. The linear force model includes cutting-edge coefficients. The cutting force coefficients are determined for an end-milling process using two methods, the average force method and the optimization technique method. The second method is developed to identify the cutting force coefficients in the milling process by forming the objective functions using the optimization technique to minimize the error between the experimental and the analytical forces. Moreover, this method produced a good force model that approximates the experimental force results, which compared with the average force method.

The stability lobe diagrams are created using the analytical method to determine whether the cut is stable or unstable. In addition, simulations are performed to predict stability of the milling process. By comparing simulated and experimental results, the dynamics and stability of the milling operation can be easily identified before performing any cutting operation. The slot milling experiments show that while the system in the chatter region close to the stability limits and the axial depth of cut increased, the system changes from stable chatter to chaotic chatter. Furthermore, the nature of bifurcation in milling is investigated by performing experiments and simulations. The linear and nonlinear mathematical force models are used for simulating end-milling process. Simulated bifurcation diagrams are generated using both models and compared to experimental results. In addition, the effect of the feed rate on the location of the bifurcation point (start and end of bifurcation) is studied. By comparing simulated and experimental results, the simulation using a nonlinear force model is found more accurate in predicting the dynamics and stability of the milling operation.

The applications of Taguchi and response surface methodologies (**RSM**) are used to minimize the surface roughness in the end milling process. Taguchi's method for optimum selection of the milling process parameters is applied based on the signal to noise ratio and ANOVA analysis of the surface finish. A second-order model contains quadratic terms that have been created between the cutting parameters and surface roughness using response surface methodology (**RSM**). Surface roughness of the machined surfaces are measured and used to identify the optimum levels of the milling parameters. Based on Taguchi, ANOVA, and RSM analyses, the end milling process can be optimized to improve surface finish quality and machining productivity