

Finite Element Modeling of the End Milling Process for Cutting and Impulsive-Force Prediction

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Abstract

This study aims to predict the cutting and impulsive forces in an end-milling operation using Finite Element Modeling and Analysis (FEMA). The cutting tool and work piece are modeled using Solid Works software, and the FEM model is developed and simulated in Abaqus software. Specified cutting conditions, including feed rate, spindle speed, axial depth, and radial depth, are considered to simulate and analyze the cutting forces. Two FEM models are examined: one that excludes temperature effects and another that includes them. FEM simulations are performed to investigate how changes in these cutting parameters affect the cutting forces during the operation. Results are presented in graphs and data sets showing the variation of cutting forces over time for both models. The model comparison reveals that temperature reduces cutting forces as it should. The proposed study highlights changes in cutting parameters, such as feed rate and spindle speed, which lead to noticeable variations in cutting forces. The findings reflect the effect of cutting parameters. When radial depth decreases cutting forces will decrease because chip thickness decreases. When we decrease axial depth cutting forces will decrease because chip length will decrease. Also, when we increase the feed rate cutting forces will increase because chip thickness will increase. Finally, when we increase spindle speed Cutting forces will increase rapidly because both chip thickness and chip length rise together. These predictions provide valuable insights for optimizing machining processes, allowing adjustments to cutting parameters to improve efficiency, tool life, and machining quality, and help develop adaptive controls in CNC machines which are not in the scope of this study and hence remain a future work. Finally, the accurate prediction of cutting forces using FEM makes it a reliable tool for process planning and optimization in manufacturing.

Keywords: *FEM, End-Milling, Cutting Forces, SolidWorks, Abaqus.*