Development of a finite element model for prediction of cutting forces in turning of AISI 1040 alloy

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Abstract

The cutting forces during the machining of steels cause tool wear, increased power consumption, excessive deflection, and residual stress in turning operations. This study used Analysis Systems (ANSYS) software to create a 3D finite element simulation of AISI 1040 alloy turning. Johnson-Cook equation modelled the work material. The piezoelectric dynamometer was used to measure the cutting forces to validate the simulation results. Feed rate (f), speed (v), and depth of cut (d) were taken as input variables. Taguchi L27 design of experiment was applied, and results were treated using Minitab 18 software. The analysis of variance (ANOVA) was also employed to analyze the cutting parameters' effects and interactions on the machined parts' performance. From the analysis of variance, speed had the highest contribution (94.96%), followed by feed rate (0.77%), and lastly, depth of cut (0.19%). The simulation results for each combination of input variables correlated closely with empirically measured outcomes (error of $< 4\%$). Empirical model equations and their coded coefficients were significant, with a probability value of < 0.05. The correlation coefficients R were 99.75% for simulation and 99.81% for experiment results, validating the finite model predictions.

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