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Taguchi-Based Surface Roughness Optimization for Slotted and Tapered Cylindrical Products in Milling and Turning Operations

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Abstract : The research follows a systematic approach to optimize the parameters for parts machined by turning and milling processes. The quality characteristic chosen is surface roughness since the surface finish plays an important role for parts that require surface contact. A tapered cylindrical surface is designed as a test specimen for the research. The material chosen for machining is aluminum alloy 6061 due to its wide variety of industrial and engineering applications. HAAS VF-2 TR computer numerical control (CNC) vertical machining center is used for milling and HAAS ST-20 CNC machine is used for turning in this research. Taguchi analysis is used to optimize the surface roughness of the machined parts. The L₉ Orthogonal Array is designed for four controllable factors with three different levels each, resulting in 18 experimental runs. Signal to Noise (S/N) Ratio is calculated for achieving the specific target value of 75 ± 15 µin. The controllable parameters chosen for turning process are feed rate, depth of cut, coolant flow and finish cut and for milling process are feed rate, spindle speed, step over and coolant flow. The uncontrollable factors are tool geometry for turning process and tool material for milling process. Hypothesis testing is conducted to study the significance of different uncontrollable factors on the surface roughnesses. The optimal parameter settings were identified from the Taguchi analysis and the process capability C_p and the process capability index C_{pk} were improved from 1.76 and 0.02 to 3.70 and 2.10 respectively for turning process and from 0.87 and 0.19 to 3.85 and 2.70 respectively for the milling process. The surface roughnesses were improved from 60.17 µin to 68.50 µin, reducing the defect rate from 52.39% to 0% for the turning process and from 93.18 µin to 79.49 µin, reducing the defect rate from 71.23% to 0% for the milling process. The purpose of this study is to efficiently utilize the Taguchi design analysis to improve the surface roughness.

Keywords : surface roughness, Taguchi parameter design, CNC turning, CNC milling
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