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Multi-objective optimization of chip-tool interaction parameters using Grey-Taguchi method in MQL-assisted turning

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Abstract: The chip shearing process is afflicted by the friction which gives rise of temperature and produces varied chip forms. For effective controlling of machining process, it is imperative to measure and optimize the chip-tool interaction parameters. In that respect, this paper presents the multi-objective optimization of some of the representative indices of chip-tool interaction in turning process using Grey relation based Taguchi method. The optimized responses are chip compression ratio (K_h), effective shear angle (β_{eff}), friction coefficient (μ) at the tool rake surface and the chip-tool interface temperature (θ). The optimization is performed with respect to the cutting speed (v_c), feed rate (f), depth of cut (a_p) and cutting conditions. Two sustainable cutting conditions i.e. dry and minimum quantity lubrication (MQL) are used in the experimental runs. The objectives of this system optimization were to minimize K_h, μ, θ and maximize β_{eff}. After optimization it was found that v_c = 90 m/min, f = 0.1 mm/rev, a_p = 1.5 mm and MQL cutting environment simultaneously optimized this turning system. Furthermore, Grey-Taguchi analysis revealed that the cutting speed exerts the most dominant effect, followed by feed rate, on combined grey relational grade; in other words, on the aforementioned responses. It is expected that the found optimized parameters can contribute to machining end-outcomes such as an improved surface finish, reduced tool wear and cutting force.

Keywords: Turning; MQL; Chip-tool interaction; Chip compression ratio; Frictional coefficient; Shear angle.