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Pareto Fronts of Machining Parameters for Trade-off among Energy Consumption, Cutting Force and Processing Time

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Abstract

Cutting parameter optimization of machining processes is crucial for green manufacturing and needs to take energy consumption, cutting force and processing time into consideration. This paper presents a method to optimize machining parameters considering the trade-off between environmental concerns and economic objectives. The model for all three objectives of energy consumption, cutting force, processing time and their relationships with machining parameters is established based on theoretical analysis, experiment design, and statistical regression to obtain Pareto fronts. Various algorithms determining strategies, including sharing function approach, VEGA, NSGA-Ⅱ and MOEA/D, are used to study the Pareto front. Examples of a cylindrical turning and a face milling are used to conduct relative validation experiments to evaluate the proposed method and the computational performance of all algorithms. All of the experiments were conducted on a CK6153i lathe and an XHK-714F CNC machining center cutting C45E4 carbon steels. Results demonstrate that the proposed method is effective in finding trade-off among the three objectives and obtaining reasonable application ranges of machining parameters from Pareto fronts.

Keywords：Pareto fronts, cutting parameters optimization, energy conservation, cutting force, processing time

Nomenclature

a_{em}	Cutting width of milling process[mm]
a_{pm}, a_{pt}	Cutting depth of milling and turning processes[mm]
B	Equivalent friction coefficient for the feed torque calculation