Energy and Cost Integration for Multi-Objective Optimisation in a Sustainable Turning Process

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Abstract

This paper aims to improve a sustainable cutting process through the integration of energy and cost modeling. The solution is based on the multi-objective optimisation of cutting parameters, including cutting speed, feed rate and cutting depth, based energy, cost and quality processes. The modeling approach has several notable merits, namely direct energy and indirect energy consumption calculation; a machining cost model for all machining tools including energy cost, production operation cost, cutting tool cost, and cutting fluid cost (dry and wet). Quality is represented by surface roughness. The multi-objective optimisation using Response Surface Methodology (RSM) was compared with the Non-Sorted Genetic Algorithm II (NSGA II) before experimental confirmation tests were made. From the multi-objective optimisation it was found that energy saved can be 9.2% and machining cost can be reduced by 4.6% using RSM. Moreover, the second-generation results of optimisation using NSGA II showed an improvement of more than 70% compared to RSM optimisation. A two-confirmation method validated the optimum point and dry cutting showed lower energy and cost with acceptable quality compared to wet conditions. The model proposed in this study is effective in terms of machining energy, cost and environment so as to be integrated with the sustainable machining.

Keywords: energy saving; machining cost; sustainable; multi-objective; turning process parameters.