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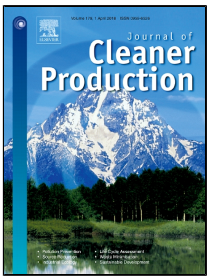

A Novel Energy Consumption Model for Milling Process Considering Tool Wear Progression

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A Novel Energy Consumption Model for Milling Process Considering Tool Wear Progression

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Abstract

Energy crisis, climate change, and stringent legislations are imposing great pressure on enterprises, especially manufacturing sectors, to improve their energy efficiency. To achieve higher energy efficiency in manufacturing, reliable energy consumption modelling is the prerequisite since it offers fundamental basis for any energy efficiency-related optimization. Although tool wear is inevitable, traditional energy consumption models fail to take tool wear effects into consideration. To address this issue, this study proposes an energy consumption model with tool wear progression for 3-axis milling process. Based on modern machining theory and recent achievements in energy consumption modelling, the proposed model is firstly derived as an expression with unknown coefficients. Subsequently, the involved coefficients are calibrated based on cutting experiments. With the explicit energy consumption model, power consumption with a given tool wear under new cutting conditions can be predicted with a high accuracy. In addition, as the model reveals a one-to-one correspondence between the power consumption and tool wear, the tool wear can also be effectively estimated from the measured power consumption. Compared with other tool wear monitoring methods such as acoustic emission and vibration, this power consumption-based tool wear estimation method is not only straightforward but also cost-effective. To the best of the authors' knowledge, the proposed energy consumption model with tool wear progression is the first model that was experimentally validated in terms of total power prediction and tool wear prediction, respectively. As such, the proposed model can be a significant supplement to existing energy consumption modelling in machining process, and may provide a more accurate and comprehensive platform for energy efficiency optimization.

Keywords: Energy efficiency; Energy consumption modelling; Tool wear; Milling process; Cutting power