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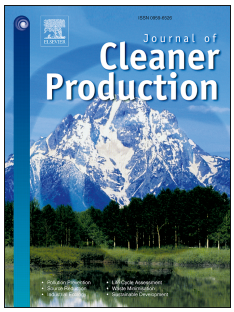

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Cyber Physical System and Big Data Enabled Energy Efficient Machining Optimisation

Y.C. Liang [1], X. Lu [1], W.D. Li [2,1]†, S. Wang [1]

[1] Faculty of Engineering, Environment and Computing, Coventry University, CV1 5FB, U.K.

[2] School of Logistics Engineering, Wuhan University of Technology, 430070, China

† Email: weidong.li@coventry.ac.uk, weidongli@whut.edu.cn

Abstract

Due to increasingly customised manufacturing, unpredictable ambient working conditions in shop floors and stricter requirements on sustainability, it is challenging to achieve energy efficient optimisation for machining processes. This paper presents a novel Cyber Physical System (CPS) and Big Data enabled machining optimisation system to address the above challenge. The innovations and characteristics of the system include the following four aspects: (1) a novel process of "scheduling, monitoring/learning, rescheduling" is designed to enhance system adaptability during manufacturing lifecycles; (2) an innovative energy model to support energy efficient optimisation over manufacturing lifecycles is developed. The energy model, which is enabled by CPS, Big Data analytics and intelligent learning algorithms, considers dynamic and aging conditions of machine tool systems during manufacturing lifecycles; (3) an effective evolutional algorithm based on Fruit Fly Optimisation (FFO), is applied to generate an adaptive energy efficient schedule, and improve schedule when there are significantly varying working conditions and adjustments on the schedule are necessary (that is rescheduling); (4) the system has been successfully deployed into European machining companies to verify capabilities. According to the results, around 40% energy saving and 30% productivity improvement have been achieved in the companies. A practical case study presented in this paper demonstrates the effectiveness and great potential of applicability of the system in practice.

Keywords: Cyber Physical System, Big Data, Energy efficient machining, Scheduling optimisation

1. Introduction

Manufacturing such as Computer Numerical Control (CNC) machining is characterised by increasingly customised and low-volume orders as well as stricter energy saving and faster delivery requirements for products. That is, in a manufacturing shop floor, there could be various changes on order priorities, unexpected delays and ambient working conditions, requiring companies to rapidly adjust their manufacturing processes timely to fit the current conditions. Meanwhile, manufacturing