Development and Validation of a Production Planning Model for Throughput Shortage Recovery Through Process Parameter Adjustment in Manufacturing Industry

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Abstract

Existing production planning models plan throughput to meet customer demand. However, there are limitations, such as a lack of quantitative correlation between process parameters and throughput shortage and emphasis on qualitative exercises in productivity improvements to recover throughput shortage. Most notably, recent developments show little attention is paid to quantitative means of throughput shortage recovery. This will result in jeopardizing the goal of meeting the demand. The study aims at developing and validating a production planning model incorporating throughput shortage recovery using mathematical programming. The literature review identifies opportunities such as the inclusion of process parameters and throughput shortage in the production planning model, which are integrated to develop a feasible production planning model. The study objectives are to perform throughput estimation and recover throughput shortage in a series of processes. The model encompasses three stages. In the first stage, the mathematical model of make span is developed as a function of process parameters for a series of processes. The mathematical model is formulated based on simulation data using statistical software (JMP). In the second stage, the mathematical model of planned throughput is formulated from the mathematical model of make span and validated with simulation-optimization throughput and mathematical programming throughput. In the third stage, a two-stage production planning model utilizes the mathematical model of planned throughput and mathematical programming to search for optimized process parameters to meet both planned throughput and throughput shortage. In the first stage of production planning, the model compares planned throughput with actual throughput for each day to identify actual throughput shortage. If there is a throughput shortage, on the subsequent day at the 2nd stage of production planning, the mathematical programming search for optimized process parameters to estimate attained throughput that can at least meet the projected throughput. The projected throughput is the summation of planned throughput from the current day and the actual throughput shortage from the previous day. If there is a throughput shortage available, the mathematical programming procedure for the next day is repeated. The simulated throughput shortage at 2nd stage of production is further carried forward to the subsequent day for the mathematical programming to estimate the attained throughput that can meet the projected throughput. If there is no simulated throughput shortage, the 2nd stage of production planning is terminated, and the 1st stage of production planning is repeated for the subsequent day. The mathematical programming in this study is to adjust process parameter values within the range of the allowable values when there is a throughput shortage. The model is validated in a manufacturing system for a period. The results show that, compared to existing production planning models with no throughput shortage recovery, the proposed model can reduce accumulated throughput shortage incurred over each period. The study introduces the novelty of formulating multiple processes parameters in mathematical programming to recover throughput shortage at the 2nd stage of production planning. The streamlining of the throughput shortage reduction approach indirectly enables manufacturers to reduce inventory buffers, optimize cycle time, and meet customer due dates.

Keywords
Two-Stage Production Planning Model; Mathematical Programming; Process Parameters; Throughput Shortage Recovery, Throughput Planning; Mathematical Model of Make span; Mathematical Model of Planned Throughput

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Biography

Ho Kok Hoe is a senior lecturer in the School of Engineering (Robotics and Mechatronics Engineering discipline) at Monash University Malaysia. He obtained his PhD in Engineering (Industrial Engineering, Operations Research, and Manufacturing) from UTAR on 21 August 2021. Prior to his PhD, he obtained financial assistance from Mybrain15 (MyPhd) and supervisors grant (UTARRF 6200/J09) and (YUTP-FRG grant – 0153AA-E36). He has more than 6 years of education experience with Wawasan Open University and SEGi College Penang and 17 years of industrial experience in process engineering skills (Polymer and Assembly Semiconductor). In industrial experience, he managed processes such as injection molding, printing, hot stamping, reflow oven, mounting, sawing, die-attach, oven cure, wire bond, gel coating, lid attach, including MEMs product technology operations. He obtained an award as an outstanding performance employee for Carsem (M) Sdn Bhd (April 2017). In education experience, besides lecturing, he is involved as a program leader in school management tasks, including maintaining compliance audit tasks with MQA requirements. His interest areas are manufacturing, industrial engineering, operations research, industrial 4.0 related topics, automation, robotics, modeling, simulation, statistics, mathematics, teaching, and learning pedagogy improvement, including industrial collaboration. He is a graduate member with BEM/IEM, an Associate ASEAN Engineer with AER, and a professional technologist (Ts) with MBOT. Occasionally, he is invited to review papers/articles from the International Journal of Production Research (IJPR), Open Science Journal (OSJ), International Journal of Industrial Engineering: Theory, Applications, and Practice (IJIETAP), and Journal of Industrial and Production Engineering (JIPE).