Journal of Manufacturing Systems 43 (2017) 100–116

Contents lists available at ScienceDirect

Journal of Manufacturing Systems

journal homepage: www.elsevier.com/locate/jmansys

Customer centric production planning and control in job shops: A simulation optimization approach☆

Hülya Güçdemir[a,c,*], Hasan Selim[b]

[a] Manisa Celal Bayar University, Department of Industrial Engineering, Muradiye Campus, 45140 Manisa, Turkey
[b] Dokuz Eylul University, Department of Industrial Engineering, Tınaztepe Campus, 35397 Izmir, Turkey
[c] Dokuz Eylul University, The Graduate School of Natural and Applied Sciences, Izmir, Turkey

ARTICLE INFO

Article history:
Received 10 February 2016
Received in revised form 25 June 2016
Accepted 6 February 2017

Keywords:
Customer relationship management
Production planning and control
Job shop scheduling
Lot streaming
Simulation optimization

ABSTRACT

Today, customer centricity becomes the key success factor for the manufacturing companies in gaining sustainable competitive advantage. In this regard, they need advanced production planning and control (PPC) techniques to be more customer focused. This study aims to integrate customer relationship management (CRM) and PPC approaches in order to use manufacturing resources of job shops more effectively in satisfying customers. To this aim, a simulated annealing based simulation optimization approach is proposed. To confirm the viability of the proposed approach, it is applied to a realistic job shop system. In order to accelerate the flow of production, product type based lot splitting is applied. In the scheduling phase, dynamic scheduling is implemented by machine-based dispatching rules. Multiple customer segments with different importance weights, and their expectations and penalties on order completion rate on due date, tardiness and earliness are considered. The aim of the proposed approach is to make near optimal policy decisions regarding the machine-based dispatching rules and number of equal sublots for the products. In this regard, four well-known dispatching rules and five modified versions of these rules which are proposed in this study are employed. Computational experiments are performed by using different dominance relationships between the customer segments, inter-arrival times and level of due date allowance factor. Results of the experiments reveal that integration of CRM and PPC approaches in job shop systems provides more effective use of resources in satisfying customers, and that the proposed approach can easily be implemented in practice.

1. Introduction

Today, business customers are quite demanding and they expect on time delivery, short lead times, high quality and affordable prices. In addition, they have many options and can rapidly switch to other companies. Furthermore, they have different expectations, preferences, and tolerances on various issues. On the other hand, manufacturing companies have limited resources and production capacity, and they are confronted with many complex production planning and control (PPC) decisions such as order acceptance, order scheduling, lot sizing, due date setting, capacity allocation etc.

In the past, manufacturing companies focused heavily on engineering and production processes in order to gain market power. However, today, they face tougher competition and have realized that customers are the main reason for a company's existence. Therefore, customer centricity becomes an important strategy for manufacturing companies in gaining sustainable competitive advantage. In this challenging environment, managing customer demand by considering various issues and satisfying customers are difficult tasks. In this concern, integrating customer relationship management (CRM) issues such as customer segmentation, customer value analysis, customer expectation-satisfaction analysis and PPC issues such as order acceptance, production scheduling, capacity planning, due date setting and lot sizing helps companies to build production plans or strategies around the customers, focus on key customers, offer more customized solutions and obtain long term business relationships.

In business-to-business (B2B) markets, customers consider various issues such as price, quality, technological capability, financial stability, just-in-time (JIT) delivery practices in the supplier selec-

☆ An earlier version of this paper was presented at the 6th International Conference on Modeling, Simulation, and Applied Optimization (ICMSAO'15), Istanbul, Turkey, May 27–29, 2015. http://dx.doi.org/10.1109/ICMSAO.2015.7152246.

* Corresponding author.
E-mail addresses: hulya.gucdemir@gmail.com, hulya.gucdemir@cbu.edu.tr (H. Güçdemir), hasan.selim@deu.edu.tr (H. Selim).

http://dx.doi.org/10.1016/j.jmsy.2017.02.004
0278-6125/

tion process [1]. Among them, timeliness is an important concern and both earliness and tardiness damage the reputation of manufacturing companies and may cause loss of customers in the long run. Especially companies in a make to order environment adopting JIT philosophy need high level of on time delivery performance [2]. In this concern, setting reasonable due dates and keeping promises becomes important for the manufacturers to ensure customer satisfaction. To overcome these difficulties, manufacturers can use lot streaming (LS) as a PPC technique to shorten the manufacturing lead time by accelerating the flow of a production lot through the production system [3]. LS denotes splitting a production lot into sublots (transfer lots) and then processing the sublots simultaneously over the machines [4]. More specifically, LS problem consists of two major parts; lot splitting and scheduling, and it deals with the optimal number of sublots, their sizes and processing sequences that optimize some pre-specified objectives that can be time-based such as makespan, mean flow time, number of tardy jobs or cost-based such as production cost, inventory cost, setup cost.

In this study, a simulation optimization based decision support system that integrates CRM and PPC approaches is developed in order to use manufacturing capabilities more effectively in satisfying customers. In this regard, a job shop system is dealt with and LS is applied to improve flow time. In sublot scheduling phase, dynamic scheduling is performed by considering machine-based dispatching rules. Sublot and dispatching rule configurations are determined simultaneously. In addition, multiple customer segments with different importance weights, their expectations and penalties on tardiness, earliness and order completion rate on due date are considered and a customer focused objective function is formulated.

The remainder of this study is organized as follows. Section 2 summarizes the literature on job shop LS problem. The proposed research framework is presented in Section 3. While Section 4 explains the dispatching rules, Section 5 defines the characteristics of the problem under concern. The proposed solution approach is presented in Section 6. Section 7 is devoted to the presentation of the computational experiments. The results are discussed in Section 8, and finally, conclusions and future research directions are presented in Section 9.

2. Related literature

LS problem in flow shops has been extensively studied. However, in recent years, LS is also applied to job shops [5]. In this study, our literature overview focus on the studies handling the job shop LS problem. The reader may refer to Chang and Chiu [6] and Cheng et al. [3] for a detailed review of the LS studies.

There exist numerous studies on job shop LS problem that aim to find LS conditions. In one of the earliest studies, the equal sized sublots are studied by Jacobs and Bragg [7]. They consider the flow time minimization and use simulation to compare several scenarios. In another study, Dauzere-Peres and Lasserre [8] propose an iterative procedure finding the optimal sublot sizes and sequences that minimize makespan. In the first step, optimal sublot sizes are computed, and then a better sequence is obtained by using a shifting bottleneck based heuristic in the second step. Jeong et al. [9] focus on the effect of setup time and job composition on the performance of schedules in job shop environment. They use modified shifting bottleneck procedure to obtain an effective schedule by splitting production lots and performing setup activities before the job arrival. Jin et al. [10] develop a heuristic that combines Lagrangian relaxation and backward dynamic programming to solve the job shop LS problem. The objective of their study is to ensure on time product delivery with low work-in-process (WIP) inventory. Wang et al. [11] handle LS problem by considering multiple resource constraints. They focus on makespan minimization and used genetic algorithm (GA) to solve the problem. They use fuzzy processing times apart from the other studies. A three-phase algorithm is proposed by Buscher and Shen [12] in order to solve the job shop LS problem that aims to minimize makespan. They consider equal sized sublots and use tabu search (TS) method to determine the schedules of sublots on machines. Chan et al. [13], propose a GA based approach solving lot sizing and job shop scheduling problems simultaneously. A mathematical programming model is constructed by Low et al. [14] for job shop LS problem. Apart from other studies, material handling, setup and inventory costs are considered in the study. Huang [15] use ant colony optimization (ACO) to solve the job shop LS problem based on the objective of minimizing the weighted sum of stock, machine idle time and carrying costs. A TS based algorithm is proposed by Shen [16] in order to solve job shop LS problem with makespan minimization objective. In another research, Liu [17] apply LS to the customer order scheduling problem where the orders consist of more than one product type. The researcher employ GA to solve the problem. Defersha and Chen [18] dealt with LS problem in flexible job shops. They consider sequence dependent setup times, attached and detached nature of setups and machine release date and lag time in their study. They propose parallel GA to solve the problem, and aim to minimize makespan. In another research, the effect of lot splitting on the number of setups required is analyzed by Simons et al. [19]. They perform simulation experiments for closed job shop systems by considering three performance measures namely mean flow time, standard deviation of flow time and number of setups per job. The researchers use decision rules to find the sublot configurations that can improve flow time while avoiding extra setups.

There exist some studies that extend the traditional job shop LS problem by including transportation activities. Among them, Edis and Ornek [4] aim to find the number of equal sublots (NES) for job sets and analyze the effects of transporter queue disciplines by using simulation. Lei and Guo [5] propose a modified artificial bee colony algorithm. In the study, a schedule is built in the first step and then transportation tasks are dispatched in the second step.

All of the abovementioned studies are summarized in Table 1. In addition to system configuration, problem characteristics of job shop LS problem such as sublot types, sublot sizes, transportation and setup activities, performance measures and solution methodologies are presented in the table. As reported in Table 1, most of the studies in the related area do not consider customer related issues, and focus on primarily the production efficiency based performance measures. However, customer satisfaction is the key success factor for the companies, and greater satisfaction can lead great profit and collaborative business relationships [20]. Therefore, customer satisfaction should be used as a performance measure in handling the PPC problems. In addition, customers have different expectations and tolerances on various issues and their values differ for a company. These differences should also be considered in PPC decisions. In addition, manufacturing companies should analyze their sensitivity to the customers' needs and expectations.

In the light of the above statements, the novel aspects of this study can be summarized as in the following:

- This study integrates CRM and PPC approaches in order to use manufacturing resources of job shops more effectively in satisfying customers. To this aim, a simulated annealing (SA) based simulation optimization approach is proposed.
- Dispatching rules that incorporate both processing and customer information are proposed
- Lot splitting and machine based dispatching rules are applied in an integrated way
- A customer focused objective function is formulated in handling PPC problem in job shop systems. Multiple customer segments