Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 13 (2017) 1090–1095

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June 2017, Vigo (Pontevedra), Spain

A comparison of production control systems in a flexible flow shop

C. Silva[a], V. Reis[a], A. Morais[a], I. Brilenkov[a], J. Vaza[a], T. Pinheiro[a], M. Neves[a], M. Henriques[b], M.L. Varela[b], G. Pereira[b], L. Dias[b], N.O. Fernandes[b,*], S. Carmo-Silva[b]

[a]*Master Course in Systems Engineering, University of Minho, Campus de Gualtar, Braga 4710-057, Portugal*
[b]*Algoritmi Research Centre, University of Minho, Campus de Gualtar, Braga 4710-057, Portugal*

Abstract

Production control in make-to-order must address the companies' need for short delivery times and on-time deliveries. Several production control systems may be used to meet these needs. This paper presents a simulation study to evaluate the delivery performance of the TKS, GKS and POLCA production control systems, in the context of a make-to-order flexible flow shop. Since TKS is used for make-to-stock manufacturing, an adaptation of it is made to use in make-to-order. Results of a simulation study show that the adapted TKS outperforms POLCA, but performs worse than GKS. The study is a contribution for the alignment of production control theory to the industrial practice.

Peer-review under responsibility of the scientific committee of the Manufacturing Engineering Society International Conference 2017.

Keywords: Production control; make-to-order; kanban systems; simulation

1. Introduction

Production control approaches in make-to-order (MTO) manufacturing environments must address the companies' need for short delivery times and on-time deliveries. Card-based production control systems are simple and yet effective approaches to address these needs. They have gained in popularity since their introduction at Toyota. White & Prybutok [1] reported that about 60% of non-repetitive and 70% of repetitive manufacturers that they surveyed had adopted kanban systems.

* Corresponding author. Tel.: +351272339373
E-mail address: nogf@ipcb.pt

2351-9789
Peer-review under responsibility of the scientific committee of the Manufacturing Engineering Society International Conference 2017.
10.1016/j.promfg.2017.09.169

These systems control both, the release and the flow of jobs throughout the shop floor, towards meeting manufacturing performance objectives. Many card-based control systems, such as the TKS (Toyota Kanban System) [2], have been developed for low product variety and make-to-stock production, requiring therefore a certain amount of inventory at production stages and/ or at finished goods. In high product variety and make-to-order these systems would require a large, most probably unacceptable, amount of inventory. In such environments, different card-based systems are necessary. The reader may refer to [3] for a review regarding variations of the TKS and to [4] for a review regarding card-based systems underpinning TKS. Examples of card-based systems specifically developed for the make-to-order production are the GKS (Generic Kanban System) [5] and the POLCA (paired-cell overlapping loops of cards with authorization) system [6, 7]. An underlying characteristic of both systems is that they are job-anonymous, i.e., cards are not specific of any job or end item, but can be used by any type of jobs manufactured in the system, contrarily to what happens with the TKS where each card can only be used by a given type of job.

In this paper, we adapt TKS to become job anonymous and compare its performance with that of GKS and POLCA in the context of a make-to-order flexible flow shop. The following research questions are addressed:

- How do card based systems perform in the context of a make-to-order flexible flow shop?
- How does the adapted TKS perform in this context?

The adapted TKS (ATKS) uses the same loop structure of TKS, i.e. one loop of cards per production stage, where the card acquisition process of a job overlaps with the production process. This means cards are attached to the job as it goes through the production stages and not before release, as it happens in the GKS where the card acquisition process is separated from the production process. This card acquisition process of ATKS, inherited from TKS, leads to a capacity control process like the POLCA system, where the available cards at a production stage signals availability of capacity at downstream stages. Thus, after processing at each production stage, the card is detached from the job only if a new card from a downstream production stage is available to be attached to it. This means that cards loops overlap instantaneously and not during processing at production stages or cells as it happens in the POLCA system. This may avoid the blocking effect of POLCA reported by some authors [8, 9] for the pure job shop.

The remainder of the paper is organized as follows. Section 2 outlines the simulation model that is used to examine the performance of above production control systems and how production is controlled in our production system. Then, Section 4 details the experimental design and the performance measures considered in the study. The results are then presented and discussed in Section 5. Finally, concluding remarks are made in Section 6, where managerial implications and future research directions are also outlined.

2. Shop floor scenario and production control

This section presents the shop floor scenario used in our study and details the production control systems applied to control job release and job flow though the shop floor.

2.1. Simulated shop

The simulated shop floor consists of a make-to-order flexible flow shop with three production stages. A real-world scheduling study with a similar shop configuration, with two stages and three machines per stage has been reported by Costa et al [10]. Each stage has three interchangeable identical machines, as illustrated in Fig. 1. At each production stage, each of the interchangeable machines performs the same operation at each product type. Jobs of three product types arrive to the system with equal probability. Each job has three operations - one per production stage. Operation processing times follows the truncated 2-Erlang distribution. The average processing times for each product type is as indicated in Table 1. This setting together with the arrival and service rates creates a balanced shop with a steady utilization at all machines of 90%.