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Design of bi-criteria kanban system using simulated annealing technique

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Abstract

In the kanban system, the main decision parameters are the number of kanbans and lot size. In this paper, an attempt has been made to set the number of kanbans at each station and the lot size required to achieve the best performance using simulated annealing technique. A simulation model with a single-card system has been designed and used for analysis. A bi-criterion objective function comprising of mean throughput rate and aggregate average kanban queue has been used for evaluation. Different perturbation schemes have been experimented and compared. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Kanban; Simulated annealing

1. Introduction

Just in time (JIT) production system is the manufacturing philosophy of producing what is needed at the right time and in right quantity (Hutchins, 1993). Kanban coupled with pull system of production is used as means of implementing JIT. Kanban means a 'visible card', which serves as a planning and information tool to smoothen the flow of material through the manufacturing and assembly process. The workstations located along the production lines only produce or deliver desired components when they receive a card and empty container, indicating that more parts will be needed in production. Each workstation will only produce enough components to fill containers and then stop. In addition, kanban limits the amount of inventory in the process by acting as an authorisation to produce.

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The essential elements in the design of kanban production system are the number of kanbans needed to link processes together and the appropriate unit of lot size (Berkley, 1992a).

2. Literature review

Kanban based operational planning and control issues have been tackled in a number of studies by means of analytical or simulation modelling. Berkley (1992a) has reviewed 50 papers in the area of kanban production control and organised them based on the type of system. He has also listed 24 vital operation design factors of kanban system. Price, Gravel and Nsakanda (1994) have reviewed optimisation models of kanban based systems. They have concluded that interesting direction for future development would be in the incorporation of models in decision support systems for production control.

2.1. Mathematical models

Several researchers have attempted mathematical modelling approach. They have assumed deterministic demand and material handling as being carried out periodically and the periods correspond to fixed withdrawal cycles. Kimura and Terada (1981) have developed a model for the kanban system, which can be considered to be a pioneering work in the area of kanban modelling. Their model has served as a reference for subsequent researchers. Bitran and Chang (1987) have extended the work of Kimura and Terada and offered a mathematical model for kanban system in a multi-stage production setting. Their deterministic model is designed to assist in the choice of the number of kanbans to use at each stage and thus to control the level of inventory. Bard and Golany (1991) have developed a mixed integer linear program to extend Bitran and Chang's model, by considering material shortage and the production of multiple parts at each stage. Fukukawa and Hong (1993) have developed a mixed integer programming model to determine the number of kanbans. Mitwasi and Askin (1994) have developed a non-linear model for a multi-item single stage kanban system. Price, Gravel, Nsakanda and Cantin (1995) have formulated an integer linear programming model for kanban based assembly shop. It is a multi-period model and the variables track the flow of kanbans in the shop floor, and in between time periods. Constraints are used to ensure conservation of flow of kanbans, maximum number of kanbans, availability of the parts for an operation, to limit production to demand and the machine availability. The objective is to minimise the make span. Solution for ILP is possible for some parts. However, it cannot be applied for parts having complex assembly diagrams. They have concluded that a large number of cards are unlikely to reduce the makespan significantly and it is certain to increase the work in progress. Gupta and Al-Turki (1998) have described a new kanban system called flexible kanban system. This system uses an algorithm based on mathematical model of the system to dynamically and systematically manipulate the number of kanban and starvation caused by stochastic factors.

2.2. Queuing and Markov chain models

Formulating kanban-controlled lines as Markov chains has been a popular strategy to find the optimal number of kanbans. In these models, researchers usually assume processing times to be exponential and give the state of the system by the number of full containers between each pair of stations. Deleersnyder,