A New Mathematical Modeling Technique for Pull Production Control Systems

O. Srikanth¹, B. V. Ramana Murty² & A.V. Sita Rama Raju³

¹Mechanical Engineering Department, Dhanekula Institute of Engineering and Technology, Vijayawada, A.P, India
²Mechanical Engineering Department, Gayatri Vidyapith College of Engineering, Visakhapatnam A.P, India
³Mechanical Engineering Department, Jawaharlal Nehru Technological University, Hyderabad, A.P, India
E-mail: †muralisrikanth11@gmail.com, ²srisai666@yahoo.co.uk, ³avsr_raju2005@yahoo.co.in

Abstract – The Kanban Control System widely used to control the release of parts of multistage manufacturing system operating under a pull production control system. Most of the work on Kanban Control System deals with multi-product manufacturing system. In this paper, we are proposing a regression modeling technique in a multi-stage manufacturing system to be coordinates the release of parts into each stage of the system with the arrival of customer demands for final products. And also comparing two variants stages of the Kanban Control System model and combines with mathematical and Simulink model for the production coordination of parts in an assembly manufacturing systems. In both variants, the production of a new subassembly is authorized only when an assembly Kanban is available. Assembly kanbans become available when finished product is consumed. A simulation environment for the product line system has to generate with the proposed model and the mathematical model have to give implementation against the simulation model in the working platform of MATLAB. Both the simulation and model outputs have provided an in depth analysis of each of the resulting control system for offering model of a product line system.

Keywords – pull production control, Kanban systems, Mathematical Model.

I. INTRODUCTION

In recent years, manufacturing firms are facing great challenges to minimize the total production costs of various products because of their shorter product life cycle times and varying customer interests and demands especially under the global competition. Therefore to retain their competitive advantages, it essential for the manufacturing firms to adapt to the changing environment by promoting continuous improvement. This improvement includes various number of factors like controlling the inventory especially controlling Work in Process (WIP) is the primary factor.

In general, pull systems use local information about the status of production and inventories to authorize the order releases, while push systems use global information including the firm and forecasted customer orders, lead times, capacities, etc. In a pull-based supply chain, procurement, production and distribution are demand-driven rather than to forecast.

A pull strategy is a make-to-order production strategy but not produce-to-order like a push production system. Pull production systems are applied to that portion of the supply chain with the advantages like demand uncertainty is high, Production and distribution are demand driven, almost no inventory, response to specific orders, Point of sale (POS) data comes in handy when shared with supply chain partners, Decrease in lead times.

An important question when implementing a pull control policy is how to define its parameters to achieve a good tradeoff between the customer service levels and the inventory costs. For this purpose, performance evaluation of the Kanban control systems for assembly systems should be performed using simulation or analytical approximate techniques.

Fig. 1: Structured Flow of Kanban Card
Spearman, M.L et al. have proposed single-class kanban controlled manufacturing system. Order release mechanism as in classical MRP was sensitive to the changes in the lead time according to the concept of lead time syndrome. The problem was modeled as a two-dimensional Markov chain, and it was solved explicitly by using matrix geometric techniques. Comparative analysis was done between static and dynamic lead time quoting procedures, and significant cost benefits of the dynamic procedure were shown under various scenarios. Guidelines for setting design parameters such as the number of kanbans and the frequency of updating the lead time were provided through numerical tests. Arianna Alfieri et al. have proposed an approximate representation for a class of production systems characterized by several stages, limited buffer capacities and stochastic production times. The main advantage of the proposed formulation was that it preserves its linearity even when used for optimization and, for such a reason, it could be adopted in simulation optimization problems to reduce the initial solution space. The approximate formulation was applied to relevant problems such as buffer capacity allocation in manufacturing systems and control parameters setting in pull systems.

P. Lavoie et al. have proposed a technique of production lines composed of multiple unreliable workstations producing a single part type with holding and shortage costs was considered. Using simulation, design of experiments and response surface methodology, various homogenous lines controlled by Kanban, CONWIP and the hybrid Kanban/CONWIP control mechanisms were optimized and then compared. It was observed that the hybrid mechanism always outperforms CONWIP and Kanban when storage space and inventory costs were considered explicitly. However, hybrid was equivalent to CONWIP when storage space costs were not considered explicitly but rather aggregated with the inventory costs in the holding costs as usually found in the literature. Furthermore, with the increase of storage space cost and the number of workstations, Kanban outperforms CONWIP.

Katsuhisa Ohno have discussed a discrete-time optimal control problem in a multistage JIT-based production and distribution system with stochastic demand and capacity, developed to minimize the expected total cost per unit of time. This problem could be formulated as an undiscounted Markov decision process (UMDP); however, the curse of dimensionality makes it very difficult to find an exact solution. They proposed neuro-dynamic programming (NDP) algorithm, the simulation-based modified policy iteration method (SBMPIM), to solve the optimal control problem. The existing NDP algorithms and SBM-PIM are numerically compared with a traditional UMDP algorithm for a single-stage JIT production system. It was shown that all NDP algorithms except the SBMPIM fail to converge to an optimal control.

From the review, it can be seen that most of the earlier research works have performed the Pull-control kanban system improvement process using regression modeling technique or adding some pre-processing method to the kanban card model. The Kanban model has been developed to preserve the linearity of the system, but here nonlinearity among the input and output plays major role. Moreover, the process modeling has not been enabled with regular optimization process. Both design and development stages of current manufacturing process modeling systems suffer because of the aforesaid key issues. Therefore the development and operation of the proposed a model firstly for the same simulation and mathematical modeling is presented. The results at the end show the performance of the proposed mathematical model.
analysis over the product line system and hence appropriate mathematical model.

The Model of Structured Input Boundary:

In this proposed production system mechanism and Kanban Control System (KCS) are modeled and simulated to exploit the combined advantages and also to study their effect in a typical manufacturing environment. For the proroposed modules of the Kanban Control System Simulation studies were performed using MatLab (SimuLink) to evaluate the release of components to the downstream. The basic idea is to impersonate the necessary machinery or resources according to the database. Therefore, in the initialization of the simulation model, the model is parameterized by an interface to the database according to the requirement.

Raw material Supplier:

The initial number of raw parts in the raw parts container (RM1 and RM2) the arrival the new parts into store database. Each container these parts are stored in to order to production that authorizes the production workstations. The demand is issued into the system in the form of order in normal distribution at the last stage of the each production control system. The maximum capacity of this demand input queue is set in orders. This number forms a limit on the system when the system is operating in an inefficient manner. When a customer demand arrives to the system, it is immediately transmitted to next workstation adding one demand to the container of queues.

Production System with Kanban Control:

After receiving materials we have to proceed for next level. Here we customize kanban card in material container, and send to the final assembly section for the end product and, with this knowledge, it controls what is produced in the total manufacturing system using the following procedure.

Production with kanbans card:

Production kanbans card is define the quantity of the supplier materials part that the producing work center should manufacture in order to replace those, which have been removed with kanban card. And after the supplying the materials part empty the container will moved from assemble section to production section.

Withdrawal kanbans:

In this section, we have Withdrawal kanban cards from empty container and that the subsequent process should withdraw from the preceding work center. Each card circulates between two work stations only.

Product Assemble System with Kanban Control:

To release a material part from production process into the assemble process of a stage, one requires the following:

- There must be at least one finished part in the output buffer in the upstream stage;
- There must be at lease one demand to release a ; and
- There must be at lease one production authorization to release a new part into the present stage.

In final assembly section will provide the final product to the inventory department. Any nonconformities information will cause a flow effect through the production system causing upstream work station to inventory stocks. Since each assembly schedule must be very similar to all other production schedules, it is essential that it is possible to freeze the master production schedule for a fixed time period. A logical conclusion from this is the need for balancing between all operations in order to synchronize the starting and ending of work process. This ensures that parts are fed to the assembly line at the same rate as they are consumed.

Proposed Technique for Modeling of Kanban Control System with Mathematical Formulations:

After the Simulation model phase, the mathematical model is developed for Kanban System. We consider a manufacturing system in which the production of parts proceeds in stages. Each stage is a production or an output buffer in the upstream stage; there must be at least one finished part in the output buffer in the upstream stage.

In manufacturing system having N cells in series $M_n$ consist of different types of manufacturing process with an output buffer. Thus, we have a finite set of row materials input. Number of WIP Kanban Assemble indexed is n with each material part assigned to a machine (RM1, ---RMn). Here, In the KCS each stage i has $K_i$ kanbans $a_i$ that are used to authorize the production of next stage. The developed mathematical model is,

$$M_i = \frac{P_i(n(s))}{[\tau(i) - \tau(T)]} \quad (1)$$

$$P_i(n(s)) = n(s)[T_i] - n(s)[T_i] \quad (2)$$

\[ \tau(t_i) = s(t_i) - s(T_i) \] (3)

In this paper, the initial number of raw parts in the raw parts buffer \( R_i \) and the arrival process of new materials parts into \( P_1 \) fall outside the scope of the control mechanism. Each material part \( M_i \) has authorize the production kanban card \( K_i \) production of workstation \( S \), initially, in workstation materials part actual time \( \tau(t) \) and delay time \( \tau(T) \).

In eq. (1), we have calculate the inventory and production information from \( M_i \). The \( P_i(n(s_i)) \) is part cell of finish production with kanban card demand arrives to the system, it is immediately transmitted to all cells adding on an authorization card (kanban) for the production of a new part, it is given in eq. (2). The materials demand timing of the Suppliers \( \tau(T) \) is found by the difference of the starting time with the starting workstation of the materials is computed with the help of the above eq. (3).

Algorithm Procedure

Begin
for each object \( RM_i \)
    for each \( O \) find \( n(S) \)
        select \( M_i \) from set of \( n(l) \)
        find \( P_i(n(s_i)) \) for other processing \( (l) \)

\[ P_i(n(s_i)) = n(s)[t_i] - n(s)[T_i] \]
find \( \tau(t_i) \)

\[ \tau(t_i) = s(t_i) - s(T_i) \]
end for

find \( M_i \)
\[ M_i = \frac{P_i(n(s))}{[\tau(t) - \tau(T)]} \]
end for
End

III. RESULTS

The following results were obtained for the developed Mathematical model and the simulation results obtained for various parameters with Matlab Simulink.
IV. CONCLUSION

In this paper, the authors used Simulink and mathematical model with regression modeling technique for evaluation of the performance of pull production control mechanisms, in multi production line, multi stage assembly manufacturing system with kanban control system. The authors had drawn the conclusion that the proposed Simulink model and regression model have been observed to be performing better to other control system. Finally, it was noticed that there is no significance and effect of degree of imbalance in the system.

V. REFERENCES


