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Evaluation of Performance Parameters by Hybrid Modelling of Pull Production Control System and by Simulation Approach

O. Srikanth[1], B.V. Ramana Murty[2], N. Selvaraj[3]

[1]Mechanical Engineering Department, Dhanekula Institute of Engineering and Technology, Vijayawada, A.P,INDIA
[2]Mechanical Engineering Department, Gayatri vidya Parishad College of Engineerin4, Visakhapatnam A.P, INDIA
[3]Mechanical Engineering Department, National Institute of Technology, Warangal, A.P, INDIA

[1]muralisrikanth11@gmail.com, [2]srisai66@yahoo.co.uk, [3]msr14988@yahoo.co.in

Abstract

This paper introduces a new mechanism for the co-ordination of machines and other facilities in multi stage multi line, manufacturing system. The methodology is mainly to control and optimize the resources in the intelligent manufacturing environment , using discrete event simulation to model, evaluate and compare the performance of two variants of kanban control mechanisms namely , Independent Extended Kanban Control System (IEKCS), Simultaneous Extended Kanban Control System (SEKCS). Here we are proposing these two systems hybridization of Conwip sytem to provoke Hybrid Independent Extended Kanban Control System (HIEKCS) and Hybrid Simultaneous Extended Kanban Control System (HIEKCS), to develop the combined advantages and also to study their effect in a typical manufacturing environment. A typical multi stage multi line assembly manufacturing system is considered and the system with each hybrid control mechanism is modeled and Simulation studies were performed for 2920 hrs to evaluate the performance parameters like Average Work-in-Process, Production rate and Average Waiting Time for all the control mechanisms with exponentially anecdotal demands.

Keywords-- **CONWIP, IEKCS, SEKCS, HIEKCS, HSEKCS.—**

I. Introduction

Primarily due to rapid development of technology in the last few decades, global market structure has changed considerably. Consequently, manufacturing companies are facing worldwide competition, forcing them to keep up with new concepts and even to proactively incorporate into their daily production routine continually strive to their competitive advantage particularly in automotive ,electronics and computer industries. These industries are responding to the challenge of e-commerce and customer ordering through Internet by shifting to re-configurable manufacturing equipment and a make-to-order environment. Just-in-time production relies on actual demand triggering the release of work into the system, and pulling the work through the system to fill the demand order. The kanban technique has been a kind of revolution in these circumstances. It aims at reducing lead times and Work-in-Process (WIP) levels in the factory. However, the limited applicability of Kanban has provoked researchers to find alternatives to this control strategy.

Therefore, new pull strategies have been developed. Optimization of production control in pull control systems is achieved by functionally aggregating several production activities into different production stages and then coordinating the release of parts into each stage, with the arrival of customer demands for final products.

Spearman ML, Woodruff B L & Hoop WJ *et al*[1] proposed CONWIP policy which provides safety stock to reduce effect of variation and demand fluctuations in JIT environment. George L & Yves D *et al*[2] The two variants of Extended Kanban Control System have been found more productive in extending to manufacturing industrial applications. They developed the Extended Kanban Control System (EKCS) pull production control mechanism which consists of base stock and kanban control system. They have compared both IEKCS and SEKCS and found that, these policies are more useful in assembly manufacturing system.

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The authors have proposed Hybrid mechanisms where IEKCS and SEKCS were combined with CONWIP; i.e, Hybrid Independent Extended Kanban Control System (HIEKCS) and Hybrid Simultaneous Extended Kanban Control System (HIEKCS) to exploit the combined advantages and also to study their effect in a typical manufacturing environment with machine breakdowns. Simulation studies were performed using Process Model software to evaluate the performance measures like production rate, average waiting time and average WIP for all the control mechanisms.

II. Problem Definition

An assembly system consists of three flow lines producing three different components for final assembly as shown in fig-1 is considered. Each line has three machines, Where i=1, 2,3 and j=1,2,3.The three machines from one cell. Finally these three lines converge into final assembly station.

The each flow line had one production kanban card for authorizing the production. The assembly system is modeled as network diagrams SEKCS and IEKCS individually and also combined with CONWIP. The Process Model simulation were made and the processing times follow exponential distribution with mean times 20,30,40,50,60,70,80and 90 min and the degree of imbalance is considered as 0.1,0.15,0.2,0.25 and 0.3. The entire assembly line is simulated for 1,75,000 min (4 months @ 8hrs/day) with15replications.

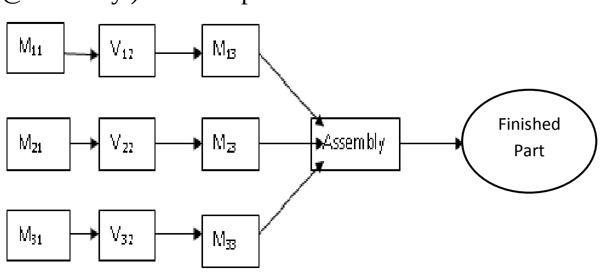

Fig.1 Diagrammatic Representation of Assembly System

Simulation analysis of multi line ,multi-stage assembly manufacturing system for all the five pull control mechanisms namely IEKCS,SEKCS,CONWIP, HIEKCS and HSEKCS is done and the performance measures like Average Work-in-Process, Production rate and Average Waiting Time were computed and relatively evaluated for each other.

III. Assumptions

- The inter arrival time of product demand is Stochastic Process.
- Each production has two inventory points, one at the beginning and the other at the end of the stage.
- There is a transportation stage between two adjacent production stages. However, the transportation time is considered to be negligible as the transportation times between production stages is always much shorter than production time.
- The production system for assembly consists of three lines and each line consists of three stages. The three stages are connected parallel leading to final assembly. The entire system is pull type system in which the processing time of each stage follows normal distribution.

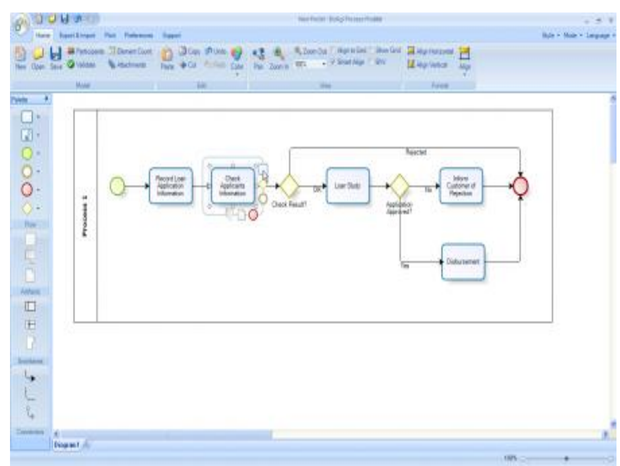

Fig.2 Process Model Software Modelling window

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IV. CONTROL POLICIES

There are five pull control mechanisms were discussed in this section as follows.

Conwip system

CONWIP is a generalized form of Kanban.Like kanban, it releases signals or cards as shown in fig-2. The CONWIP system , the cards are traverse a circuit that include the entire production line. A card is attached to a standard container of parts at the beginng of the line. When the container is used at the end of the line, the card is removed and sent back to the beginning where it waits in a card queue to eventually be attached to another container of parts. One of the main advantage s that CONWIP offers is that the flow times of CONWIP lines are fairly predictablebeause the WIP levels are nearly constant. It is much easier to coordinate production in a line with constant WIP than one where the WIP levels can't be known a prori.

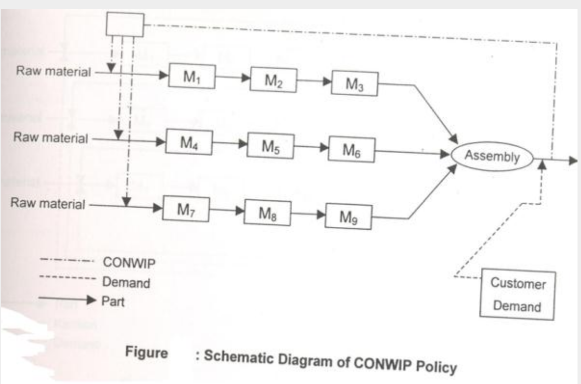

Fig 3.Schematic Diagram of CONWIP Policy

Extended kanban control system (EKCS):

The EKCS philosophyis when a customer demand arrives to the system, it is highlighted to all the stages in the system. Thus the part is released from up stage to down stage, if the production kanban associated with that stage is available. The two variants of extendended kanban control system are IEKCS and SEKCS as shown in fig 3 and 4.

The differences between IEKCS and SEKCS are in the way the kanban are transferred to the cells. In the SEKCS all the Kanbans are transferred simultaneously,where as in the IEKCS they are transferred independentlyof each other.

Hybrid extended kanban control system (HEKCS):

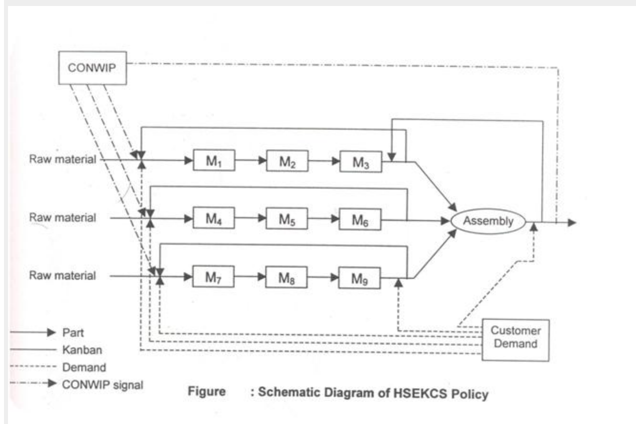

Fig 4.Schematic Diagram of HSEKCS Policy

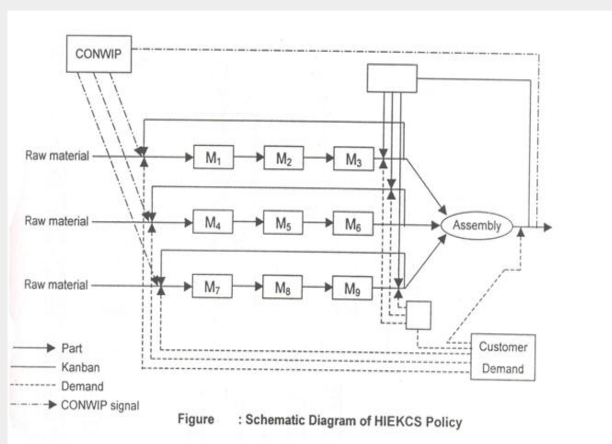

Fig 5.Schematic Diagram of HIEKCS Policy

Hybrid of CONWIP and the two variants of EKCS gives HIEKCS pull control policies.These policies may have the combined advantages of CONWIP and EKCS and are shown shown fig.4 and 5.

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V. Simulation Control Policies

The results of the simulation were compared are presented in the figures 1,2 and 3.The corresponding graphs were also plotted and presented in figres 6,7 and8.

DEMAND	SEKCS	IEKCS	HSEKCS	IEKCS
E(20)	3388	3276	3476	3356
E(30)	2884	2776	3384	3256
E(40)	2452	2264	3188	2940
E(50)	2168	1876	2840	2456
E(60)	1892	1672	2580	2280
E(70)	1672	1416	2296	1944
E(80)	1436	1288	1936	1732
E(90)	1144	1048	1568	1440

TABLE I Production rate with mean time of 25 min

DEMAND	SEKCS	IEKCS	HSEKCS	HIEKCS
E(20)	871.08	529.32	575.2	349.32
E(30)	957.28	659	584.24	402.04
E(40)	1086.52	881.68	603.88	490.2
E(50)	1191.28	1109.32	690.56	643.4
E(60)	1520.32	1199.84	780.76	690.12
E(70)	1744.52	1368.2	879.8	822.36
E(80)	2052.24	1560.2	1081.64	1062.64
E(90)	2278.36	1789.48	1352.96	1264.64

TABLE II Average waiting Time with mean time of 25 min

DEMAND	SEKCS	IEKCS	HSEKCS	HIEKCS
E(20)	59.28	63.4	45.8	49
E(30)	55.8	59.84	44.8	48
E(40)	52.56	56.96	44.36	47.72
E(50)	50.68	56.88	43.4	47.2
E(60)	50.32	56.04	42.32	46.72
E(70)	48.36	55.08	41.4	46.32
E(80)	46.52	54.8	40.68	43.88
E(90)	45.4	54.48	39.6	42.6

TABLE III Average Queue length (WIP) with mean time of 25 min

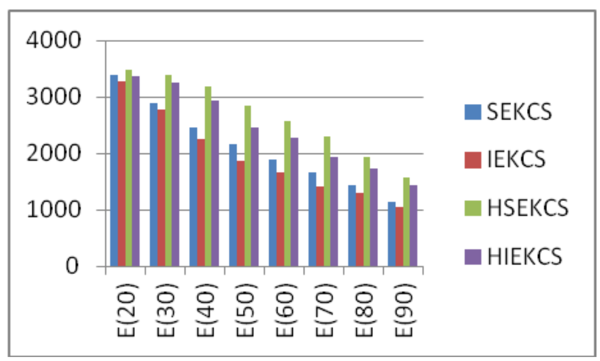

Fig.6 Effect of Production rate for Mean Time of 25 min.

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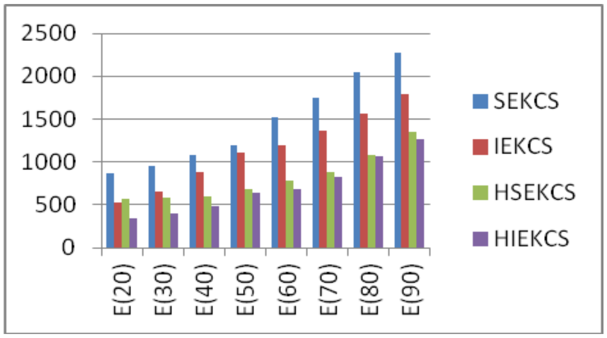

Fig.7 Average Waiting Time with mean time of 25 min

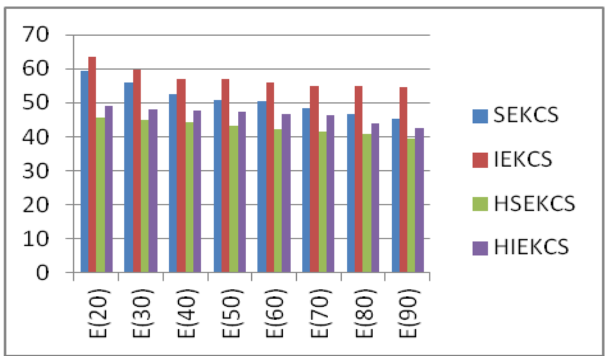

Fig.8 Average Waiting Time with mean time of 25 min

From the simulation studies it is observed that,the performance measures such as aproduction rate,Average waiting time and average Work In Process are affected by change in demand for various control policies.

It was observed that, for a given mean time of 25 min and demand rate of 90 min,the production rate is approximately equal.Whaen the demand rate increases the production rate also gradually increase s. Whaen the demand rate is exceeds further no significant improvement is observed in the production of all pull mechanisms that is almost constant.

The comparision of Average Work-in-Process, Production rate and Average Waiting Time of all four pull production control mechanisms are compared and the effect of imbalance also tested.

The cycle time of each flow line is constant and it is observed that the degree of imbalance does not have any effect on the system.

VI. Conclusions

In this paper, the authors used simulation to evaluate the performance of five pull production control mechanisms, in a typical multi line, multi stage assembly manufacturing system. The authors had drawn the conclusion that the proposed methods namely HSEKCS and HIEKCS have been observed to be performing superior to other control mechanisms. Within HIEKCS and HSEKCS, HSEKCS performance better than HIEKCS. Finally, it was noticed that there is no significance and effect of degree of imbalance in the system.

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