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Performance Appraisement of Pull Production Control Mechanisms by Simulation and Analytical Analysis on EKCS and HEKCS Policies

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Keywords:

WIP;
KCS [Kanban Control System];
EKCS [Extended Kanban Control System];
HEKCS [Hybrid Extended Kanban Control System];
CONWIP;
Performance parameters.

Abstract

Inside the busines and organizations to support multifarious decision making an advanced analytical technology used is predictive simulation. This paper brings a new policy for the synchronization of machining facilities and the other machines in a multi-line, multi-stage manufacturing environment. In the smart manufacturing situation, this tactic is mainly used for optimizing the resources and for controlling the process parameters. Modeling, assessing and contrasting the performance of the proposed HEKCS [Hybrid Extended Kanban Control System] with EKCS [Extended Kanban Control System] by using distinct event simulation method.

In this paper it is proposed that hybridization of KCS [Kanban Control System] with CONWIP [Constant Work in Process] to exaggerate HEKCS [Hybrid Extended Kanban Control System] to study their consequences and to extend the merged benefits in a distinctive manufacturing situation. A distinctive assembly manufacturing system with muli-line, multi-stage is considered and the assembly system with every control policy is modeled and for 1,72,800 minutes performed the simulation studies to assess the performance parameters akin to Average Waiting Time, Average WIP, Production rates with exponentially subjectivedemands.

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1. Introduction

For the precedent three decades, indispensably due to hasty development of technology all-inclusive market configuration has transformed considerably. As a consequence, foreign investors are investing in local markets, who are not only able to perform well in their newly established territory, but due to the progressd technology still able to excel more. Scrupulously in computer, automotive and electronic sectors, Manufacturing industries are subjecting to global hostility, struggling them to maintain with new perceptions and even to proactively fit on their every day production schedule recurrently to their competitive advantage.

These manufacturing firms are moving to a make-to-order environment and re-configurable production resources by reacting to the brazen out of customer ordering through Internet and e-commerce. In JIT [Just-in-Time} manufacturing system to fill the demand order the actual demand producing the discharge of work into the production system, dragging of the work from end to beginning in the system will be done.In these situations the kanban practice has been a sort of insurrection. In the manufacturing firms it endeavors at reducing WIP [Work-in-Process] levels and sinking the lead times. on the other hand, the Kanban limited pertinence has motivated investigators to find the substitutes to this controlpolicy.

New pull policies therefore have been build up. Prognostic simulation permits manufacturing analysts to go further than trends and basic data representations, simple models, appending awareness of process intricacies, variability and interactivity. Analysts through the process modeling able to be aware of that process change has the effect on business performance.

Only the first step is identifying the risks and prospects in the data, before decisions are made and actions are taken, process simulation enables resolutions to be tried, optimized and tested. In pull control systems optimization of manufacturing process control is attaind by decisively comprehending numerous manufacturing activities into diverse manufacturing stages and subsequently coordinating the discharge of parts into every stage, with coming of final products demands from the customers.

The two variants of Extended Kanban Control System have proposed by Yves Dallery and George Liberopolous and these are found more productive in the manufacturing industrial applications. CONWIP policy proposed by ML Spearman, B L Woodruff and WJ Hoop which put forward the safety stock to decrease the consequence of disparity and demand variations in Just-in-Time atmosphere. The EKCS [Extended Kanban Control System] developed by them having the pull manufacturing control policy which contains kanban control system and base stock control system. They instituted that, in assembly manufacturing system these mechanisms are further useful.

In a distinctive production environment, to study their effect and also to exploit the combined advantages the authors have proposed a hybrid mechanism where CONWIP [Constant WIP] is merged with EKCS [Extended Kanban Control system] forming HEKCS [Hybrid Extended Kanban Control System]. Using the discrete event simulation software Process Model, simulation studies were carried out to appraise the performance parameters like Throughput or production rate, average WIP [Work-in-Process] and average waiting time for the considered control mechanisms.

2. ProblemDefinition

As shown in fig-1 a multi -line , multi-stage is production system is considered with three production lines in parallel with three manufacturing stages in series in each line manufacturing three dissimilar processes on parts sequentially. Each line is having three manufacturing facilities, whereeach line i=1,2,3 and each line is having three machines j=1,2,3. At last from all the three manufacturing operations a part sent into the final shipping station. At the beginning for authorizing the production, every flow line had one production authorization kanban card.

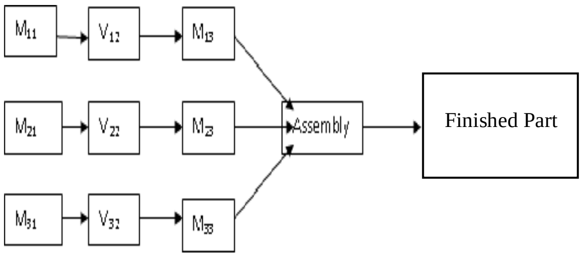

Figure 1.*A multi-line, multi-stage assembly production control system.*

By combining with CONWIP and individually, HEKCS [Hybrid Extended Kanban Control System] and EKCS [Extended Kanban Control System] are modeled and configured as network diagrams for the assembly manufacturing system. In this work, the authors broadened Di mascolo's decomposition based method to study and analyze the EKCS [Extended Kanban Control System] and HEKCS [Hybrid Extended Kanban control system] with three production feeding queues and the synchronization station. Primary with the peripheral demands which will arrives as per the Exponential distribution, the completed parts in a stage are harmonized with the cumulative arrivals and then with the next stage kanbans are synchronized. By Analytical process the same problem considered is modeled with standard stochastic mathematical methods such as basic Queing Theory, Continuous Time Markov Chains , Queuing networks and using Buzen's algorithm and Gordon and Newell theorem and evaluated. The Process Model is simulated with 9000 minutes as warmup period. Exponential distribution is considered for the manufacturing service times in assembly the manufacturing system. The processing times follow exponential distribution equal to 15 minutes and the demand also follows exponential distribution with 0.75, 0.875, 1, 1.2, 1.5, 2, and 3 parts/hr. The simulation time is considered 1,72,800 minutes (4 months at 3shifts per day 8hrsper shift) for the complete assembly line with 15 replications.

2.1. EKCS [Extended Kanban ControlSystem]

[Extended Kanban Control System] was suggested as a common approach to the pull production control system merging the Kanban Control and Base stock controlSystems.

As shown in Figure 2, whenever a demand arrives from the customer into the system it will be emphasized to all of the stages of the network in the EKCS philosophy. In this way from up stage to down stage the part is released if the production kanban related with the corresponding stage isaccessible.

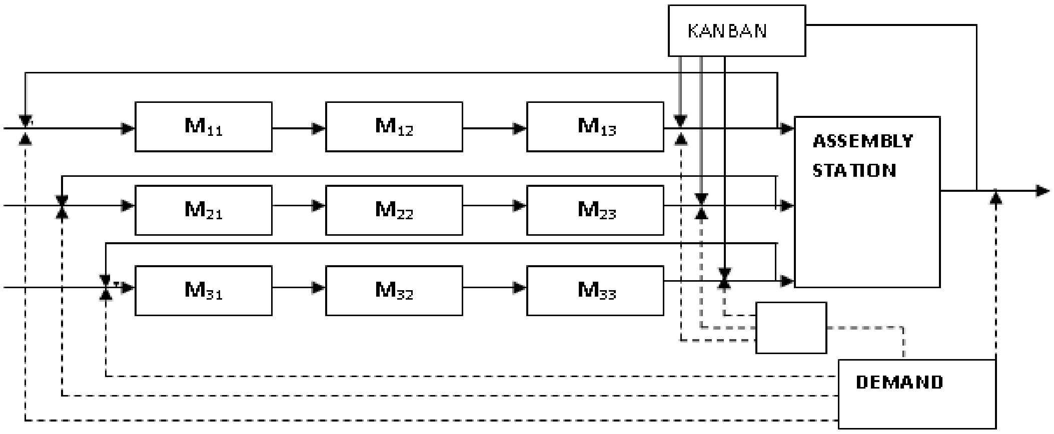

Figure 2.*Schematic Diagram of EKCS Control Policy*

2.2. CONWIP [Constant Work-in-Process] ControlSystem

Constant Work-in-Process [CONWIP] is a generalized structure of Kanban control system. The CONWIP process shown in Figure 3. In this, cards or signals are released into the system like Kanban control system..Here in the system, the cards pass through a path in the complete production line. At the commencement of each production line a card is fastened to a standard bin of parts. Whilst the bin is employed at the ending of the production line, the card is detached and it sends back to the commencement of the line there it will wait in a cards queue and finally to be fastened to another parts container. Where ever the WIP levels can't be acknowledged earlier in a manufacturing line it is very easy to synchronize the production with the constant Work-in-Process thanone.

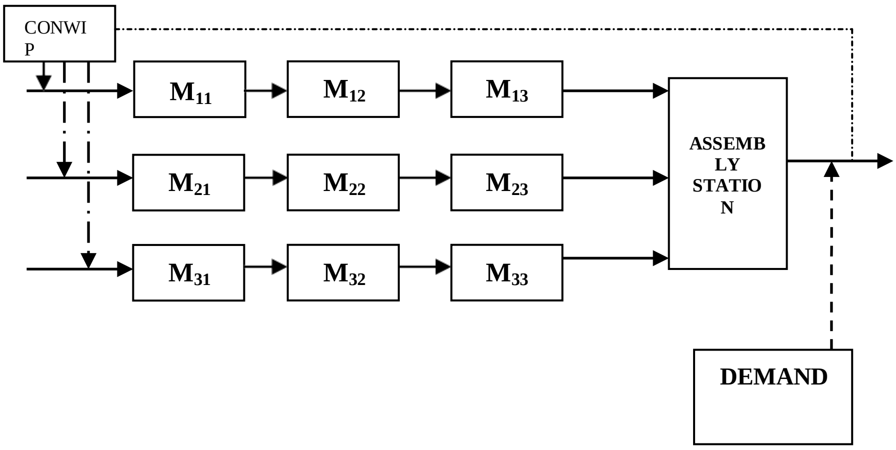

Figure 3.*Schematic Diagram of CONWIP Control Policy*

2.3. HEKCS [Hybrid Extended Kanban ControlSystem]

This new control mechanism proposed by the authors, in this system combines the control concepts of both EKCS & CONWIP thus proving tight control on the WIP in the system. This system also responds to customers demands quickly due to the inherent EKCS mechanism.

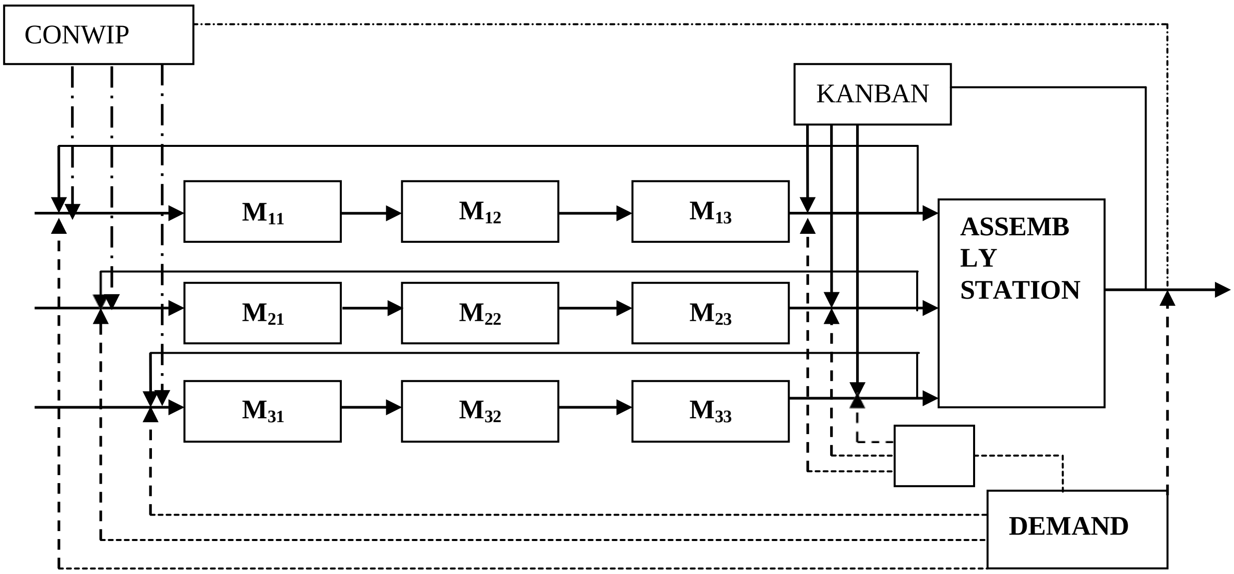

Figure 4.*Schematic Diagram of HEKCS Control Policy*

Mathematical modeling and Simulation analysis of multi-stage manufacturing system for both of the control mechanisms namely EKCS and HEKCS 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.

3. Performance ModellingTools

Performance evaluation methods for Production systems fall into two classes: Performance measurement and performance modeling. Performance measurement is carried out on obtainable, operational systems and is generally used for monitoring of key variables, detection of failures and for probable reconfiguration. Data collection and analysis are customarily done in factories as a part of Management Information Systems reporting.

Performance modeling of Production systems can be either simulation modeling or analytical modeling. Conventionally, discrete event simulation has been widely accepted and employed in factory environments for study of issue in design and operation. Analytical modeling tools such as those based on Markov chains, Queing theory and Stochastic Petrinets are now becoming increasingly popular and have emerged as an alternative to simulation.

3.1. SimulationModels

Discrete event simulation modeling offers the scope for building and analyzing detailed models of manufacturing systems. The performance estimates will be very precise if the number of simulation runs is made large. Simulation is quite popular because of its simplicity and power. Here we conducted the simulation process by Process Model software. Object-oriented simulation has become popular, powerful graphical animation features also support many of theselanguages.

3.2. AnalyticalModels

Analytical models can be solved either numerical techniques or by closed form or by using. Once a tractable analytical model has been formulated, the model and its solution can be fully validated. Typically, such models can be analyzed in a short time and quick feedback about system performance is possible. Often, analytical models can be used to validate simulation models and vice versa.

3.3. ProcessParameters

Mean Work in Process: Average number of semi finished products waiting in between stations and number of finished products waiting for dispatch. This number depends on the arrival rate of demands.

Production rate: Which is the rate at which jobs leaves the station with respect to the demand.

Mean waiting Time: For a part to be released from the system, the average time waited in the queue at all the processing stations.

4. Assumptions

- The product demands inter arrival time is a stochasticprocess.
- There are two inventory positions for each manufacturing facility one at the starting and the other at the end of thestage.
- Between any two adjacent manufacturing stages, negligible transportation time is considered. Since the production times are much longer than transportation times in between the productionstages.
- The complete system is a pull type of system in which exponential distribution is considered for the processing time of each stage. The assembly manufacturing system having three stages in each productionline.
- Raw parts are always available in the system and the manufacturing system produces only a single type ofpart.
- In the network, at each node the queue is considered with FIFO [First in First out] mechanism having infinite queuecapacity.

Provide a statement that what is expected, as stated in the "Introduction" chapter can ultimately result in "Results and Discussion" chapter, so there is compatibility. Moreover, it can also be added the prospect of the development of research results and application prospects of further studies into the next (based on result and discussion).

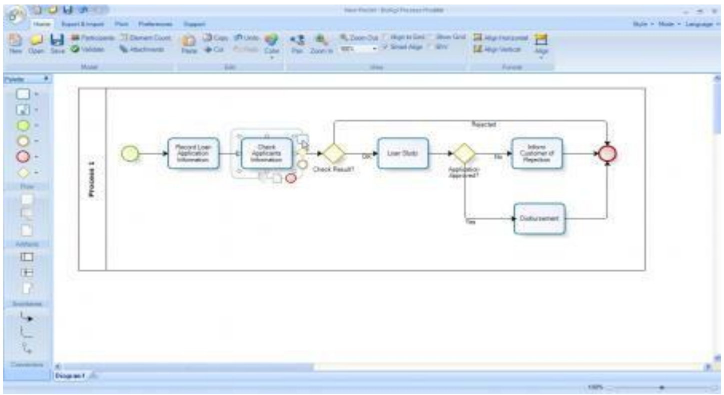

Figure 5.*Process Model Software Modeling window*

5. Results

Simulation and Analytical Analysis were performed and the results were tabulated.

The comparative performance of the two manufacturing assembly processes HEKCS [Hybrid Extended Kanban Control System] and EKCS [Extended Kanban Control System] shown in the corresponding graphs.

Table 1.Comparitive performance of Production Rate with Demand

Demand [Parts/Hour]	EKCS		HEKCS	
	Analytical	**Simulation**	**Analytical**	**Simulation**
0.75	523.8	513.2	628.8	548.1
0.857	575.1	589.8	719.8	633
1	657.7	724.3	831.2	809.6
1.2	846.15	839.5	1007.3	861.74
1.5	1067.2	1065.5	1260.69	1117.6
2	1392.8	1454.3	1680.1	1436.92
3	2020.10	2147.2	2520.1	2188.8

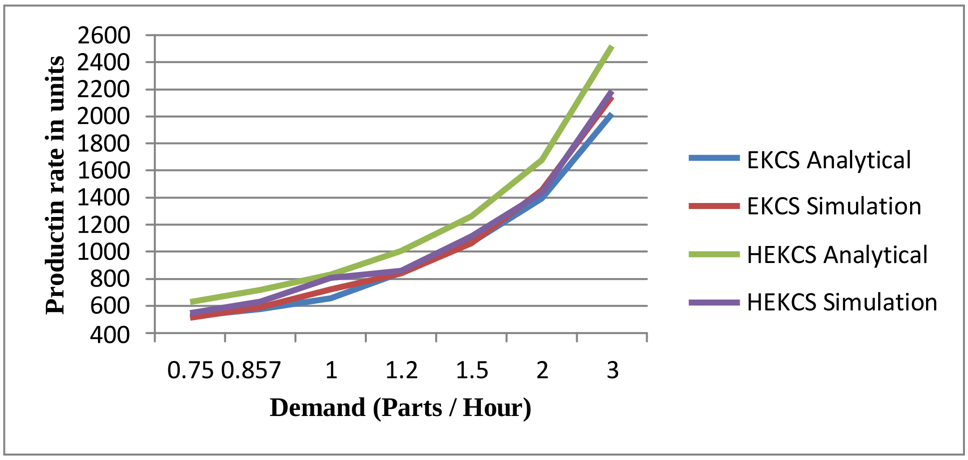

Figure 6.*Comparitive performance of Production Rate with Demand*

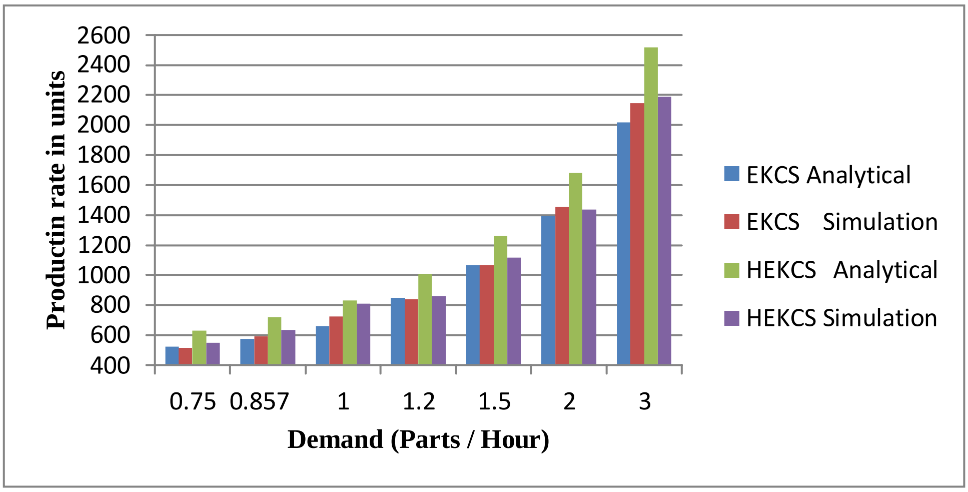

Figure 7.*Comparitive performance of Production Rate with Demand*

Table 2.Comparitive performance of Average WIP with Demand

Demand [Parts/Hour]	EKCS		HEKCS	
	Analytical	**Simulation**	**Analytical**	**Simulation**
0.75	21.72	23.01	9.88	11.04
0.857	21.62	22.47	9.88	11.00
1	21.59	22.07	9.81	10.73
1.2	20.92	21.58	9.74	10.37
1.5	20.76	21.09	9.52	9.74
2	18.91	19.59	9.33	9.02
3	16.49	18.01	9.18	8.76

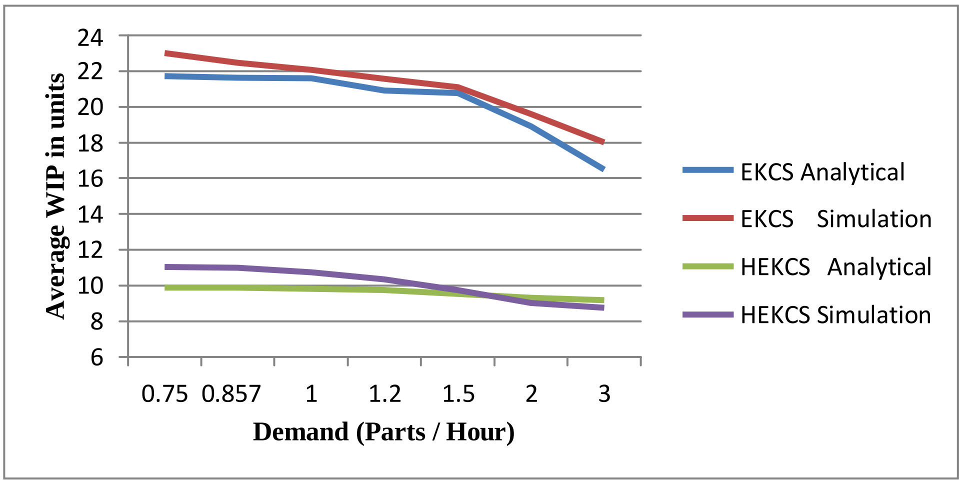

Figure 8.*Comparitive performance of Average WIP with Demand*

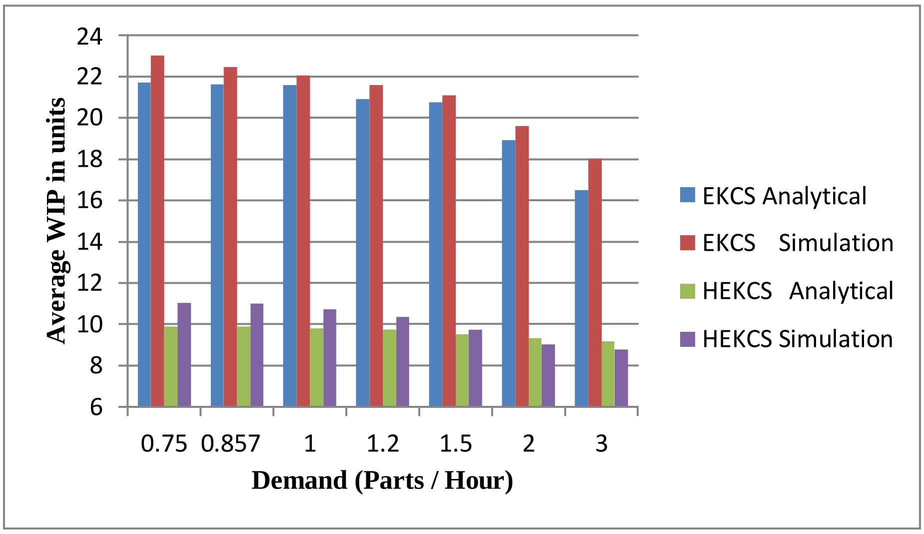

Figure 9.*Comparitive performance of Average WIP with Demand*

Table 3.Comparitive performance of Average Waiting Time with Demand

Demand [Parts/Hour]	EKCS		HEKCS	
	Analytical	**Simulation**	**Analytical**	**Simulation**
0.75	33.33	32.66	15.03	16.24
0.857	30.24	31.70	13.14	14.54
1	28.18	23.41	11.76	13.01
1.2	19.92	20.03	9.79	11.36
1.5	14.75	16.50	7.52	9.04
2	11.02	12.37	5.60	6.21
3	8.32	9.17	3.74	4.94

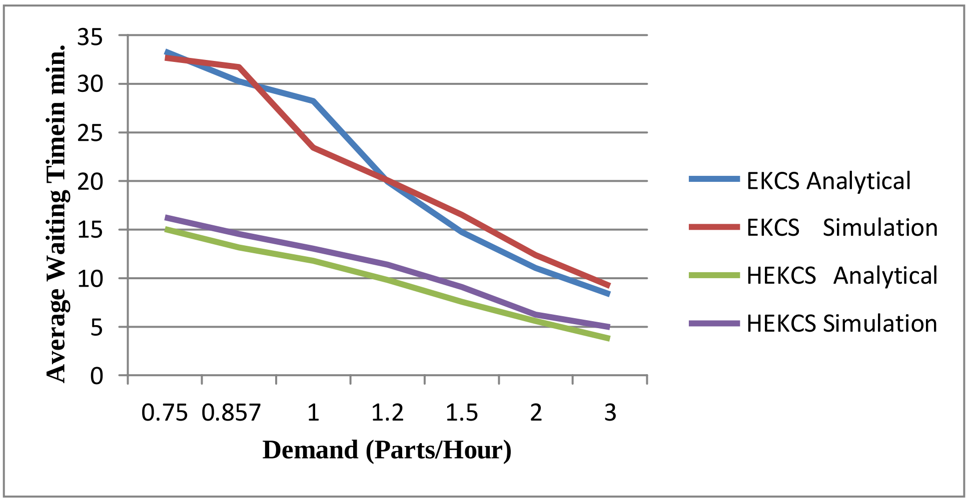

Figure 10.*Comparitive performance of Average Waiting Time with Demand*

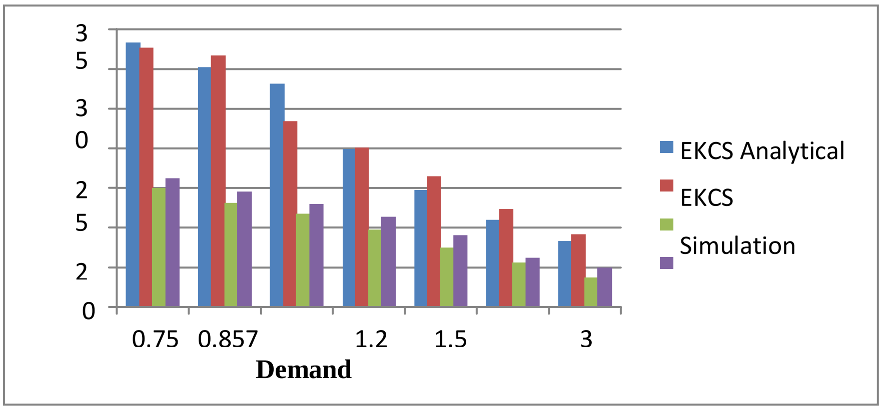

Figure 11.*Comparitive performance of Average Waiting Time with Demand*

6. Conclusions

HEKCS [Hybrid Extended Kanban control system] method has been studied executing better to other the control policies CONWIP and EKCS independently. The practical association between the input-output stages of the system will be preserved due to the exploitation of nonlinear regressionanalysis.

For the product line system a simulation environment will be created and the mathematical model will be executed against the simulation model. The simulation and model outputs will be evaluated to make sure the recommended modeling practice is proficient for suggesting model for a production linesystem.

Both the analytical and Simulation results in HEKCS [Hybrid Extended Kanban Control System] process parameters showing optimum results. That is lower the Average Waiting Time or lesser average queue length, Lower Average WIP [Work in Process] and Higher Throughput or Production rate are attained compared with EKCS [Extended Kanban Control System]. There is some variation of results between the analytical model and simulation model. The average variation of error between analytical and simulation model is about 9.8%. This variation take place because of the assumptions made and the approximation practice involved in analytical model and some simulation errors, also computer-programming error, comprise modeling error, error in parameter estimation in simulation model and sampling error. As per A. M. Law and W. D. Kelton [1991], generally allowable error is upto 15%. Hence the errors are within the permissible range only. Finally, there is no implication and consequence of degree of imbalance in the assembly manufacturing system wasnoticed.

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