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Impact of Loading and Unloading Strategy on Performance of a FMS at Different Level of Routing Flexibility

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Abstract

In this paper the author attempts to determine influence and signification of routing flexibility on the flexible manufacturing system to secure better result at different system of configuration. System configuration has been divided on the basis of loading and unloading station of different parts. Initially, the best system configuration has been selected on the basis of Average waiting time (AWT) and Average Work in Process (AWIP) on various levels of routing flexibility, and then responses of best system configuration evaluated using sequencing and dispatching rule. Also the responses of the best system configuration have been analyzed at various buffer capacities.

Keywords: — RF, AWIP, AWT and Simulation.

Introduction

Since the growing time of civilizations, man has been continuously trying to make easy and improve his work by inventing the better tools. This started with the development of stone tools and culminated into the growth of a totally automated factory. Since the human operators are considered to be the weakest link in the production process, the requirement for automation has been felt throughout the industry.

The existing market scenario is such that a consumer or customer has the requirement to demand a wide range of quality product at a very short time response. The increasing and fast changing responce of product variety has dramatically enhanced the complexity which requires more effective management of the production systems. The traditional systems of manufacture like transfer line system were unable to meet the market requirements. The transfer line system of manufacture had high production level but offered least flexibility. On the other hand, workshop system of product manufacture offered high degree of flexibility but had low production level. These systems were unable to satisfy the requirements of variety, quantity of product and production speed at the same time. It causes to the development of a system, which combined the flexibility of workshop system and productivity of transfer line system. The requirement of manufacturing flexibility in the production systems is a large cause effective challenge in effectively integrating material, information and decision flow in the various sector of system. This has led to innovation of new types of manufacturing system. These systems are often considered to as Flexible Manufacturing System (FMS). The emergence of FMS technology is helping to produce a variety of products without making any interfernce in the hardware set-up.

Model Summary

In this paper authors proposed model of flexible manufacturing system having seven numerically controlled machines with automatic numerically controlled operations, tools changing, operation monitory and material handling system. The flexible manufacturing system consists of with dedicated /universally loading and unloading station for parts to be machined on flexible machine. The proposed models are developed and then executed in ARENA simulation software at pre-determined scheduling rules for studying the effect of input parameter (AWIP and AWT) on the performance of flexible manufacturing system. Further the results are analyzed using **ANOVA** technique.

Methodology

The present work attempts to explore a methodology that fulfills the following objectives:

[1] To determine the impact of RF on flexible system performance.
[2] to determine the impact of loading and unloading strategies on the performance of flexible system.
[3] To study the impact of buffer size and sequencing rules on the performance of flexible system.
[4] To involve **ANOVA** analysis to establish the relative significance of different parameters of the system performance.

In this paper authors initially preceded literature review for finding the gap between proposed work and previous effort made by scholars for making effective in the sence of performance of flexible manufacturing system . Then the problem is identified followed by the development of conceptual model made to show pictorial view of all machines and other automated material handling system. Then the conceptual models are converted to simulation models with the help of **ARENA** simulation software package. With the help of simulation models, the series of experiments are conducted to generate the results. The results are further analyzed using **ANOVA** to find the effect of input variables on flexible system performance.

Conceptual model

Factively, we have developed a conceptual model for four different types of existing flexible manufacturing systems.On loading and unloading strategies. These forms are set in this way

i) **L1UL1** (loading station one and unloading station one).
ii) **L1UL5** (loading station one and unloading station five).
iii) **L5UL5** (loading station five and unloading station five).
iv) **L5UL1** (loading station five and unloading station one).

L1UL1 system configuration- In this system there is one universal loading and one universal unloading station. Operation time and the loading, unloading time remains same with change in configuration of system.

L1UL5 system configuration- In this system there is one universal loading and five dedicated unloading. Operation time and the loading, unloading time remains same with change in configuration of system, and so on.

L5UL5 system configuration- In this system there is five dedicated loading and five dedicated unloading stations. Operation time and the loading, unloading time remains same with change in configuration of system.

L5UL1 system configuration- In this system there is five dedicated loading and one universal unloading. Operation time and the loading, unloading time remains same with change in configuration of system, and so on.

Model assumptions

In the proposed FMS model, a list of assumptions has been made, which are as follows.

- Each machine is continuously available for processing; that is, machines never break down.
- The same operation processes by the same machine have the same operation time.
- All the parts are already at the start of the simulation.
- When RF=1, all the decisions are made dynamically, i.e. the choice of the machine for the part's next operation is based on dispatching rule immediately after it has finished the current operation.
- The set-up times are included in the operation times.
- Operation processing times are deterministic.
- Simulation stops when all the parts finish all their operations.

Input parameters

The input parameters are routing flexibility, number of pallets, production volume and buffer size.

Routing flexibility (RF)

The levels of RF were varied within the existing machines. The parts can be processed on one of the available alternative machines. The number of alternative machines available depends on the level of routing flexibility set in the system. The order of operations remains the same for all routing flexibilities. The routing flexibility concept can be described as follows:

I) RF = 0 means that there is exactly one machine for the component, ie there are no (zero) alternatively.
II) R = 1 means there are two possible machines for processing the same operation, ie exactly there
another alternative machine (other than the machine available at RF = 0) for any operation on any one part.
III) RF = 2 means that there are three possible machines for processing the same operation, ie Existing exactly two other machines available for processing the same operation (other than the machine that is available in RF = 0).
IV) RF = Full, means there are seven possible machines for processing the same operation, ie Existing
exactly six machines available for processing the same operation (other than machines that are available in RF = 0).

Number of pallets

The pallet is a device for work. Each pallet is supposed to contain one part. The number of pallets is to change the system load. In this paper we study the impact of the number of pallets (5,10, 15 and 20) about system performance. 6.3 Cache Capacity We assumed that each machine has a dedicated cache. Every machine can accommodate

Buffer capacity

We have assumed that there is a dedicated input buffer at every machine. Each machine can accommodate maximum number of parts according to their buffer capacity. In the present study we have taken buffer capacity as 5, 10, 15 and 20.

Process control strategies

The control strategies were modelled as a combination of a sequencing rule and a dispatching rule.

Sequencing rules

In the machine line, the parts priority is selected based on the sequence rule (SR).The serial rules of modeling are as follows:

(a) First Service First (FIFO): The part that comes first in the temporary queue is the highest priority and is presented first

(b) Smaller Processing Time (SPT): The part in which the minimum run-time is the highest priority is served befor

Dispatching rules

The alternative part of the alternative machine is based on the dispatch decision (DR). Shipping rule applied is the Minimum Queue (MINQ) - The machine with the least number of parts in the queue is selected treat the next one

Performance measures

*Machine Utilization***:** defined as the ratio of (Produced Parts, measured in processing hours) / (Available hours for the available operating machines).
*Work in process***:** defined as the total inventory of partial processed parts and part to be processed in the system.

Findings

Based on the conceptual and simulation model discussed in this paper, we obtained results by performing models in ARENA simulation simulation software. These results are further analyses and determine significant conclusions. As discussed in previous there are four configuration of flexible system **(L1UL1, L1UL5, L5UL5,** and **L5UL1**). These systems are operated at four levels of flexibility of routing (RF=0, RF=1, RF=2, RF=FULL). In addition the systems are run at different combination of dispatching and sequencing rules (MINQ/FCFS, MINQ/SPT). Another study is conducted on a system that provides the best performance with regard to different performance measures.

Impact of Routing Flexibility on AWIP for Different System Configuration.

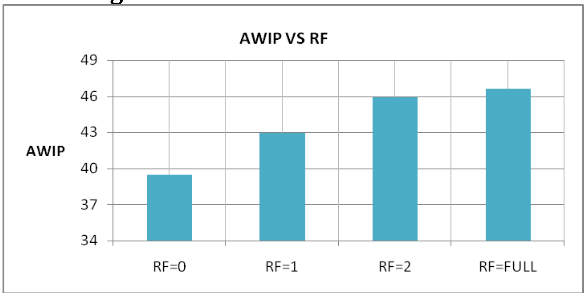

Figure 1: The Impact of RF on AWIP for L1UL1

Figure. (1) Shows the relationship between average work in process and the level of routing flexibility. AWIP is obtained for 500 parts. Combination of dispatcher and the sequence rule is MINQ / SPT. The total number of components in the system is 20 at any time and the buffer size is at individual machines are combination of dispatching and sequencing rule is MINQ/SPT. The graph shows that AWIP increases with increasing routing flexibility. That's because of the fact that with the increase of routing flexibility the number of parts for process also increases parallel. This helps in increasing the average work in process in the system. It is also observed from Table.1 that the maximum increment in AWIP

Table 1. Percent increment in AWIP with increase in RF in L1UL1 occurs when RF increases from 0 to 1 is 8.40%, from RF=1 to RF=2 is 6.80% and from RF=2 to RF=Full is 1.6 %.

Table 1:- Percent increment in AWIP with increase in RF in L1UL1

RF, Level	AWIP	% increment form each level
RF=0	39.47	*
RF=1	42.96	8.84%
RF=2	45.90	6.80%
RF=FULL	46.64	1.60%

Impact of Routing Flexibility on average waiting time (AWT)

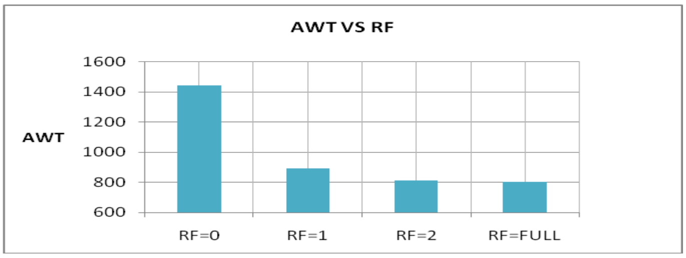

Figure .2 Impact of RF on AWT for L1UL1

Figure 2 shows the relationship between average waiting time and level of routing flexibility. The AWT is obtained for 500 parts. The combination of dispatching and sequencing rule is MINQ/SPT. Total number of parts in the system at any time is 20 and buffer size at individual machine is 20.machines. This helps in decreasing the average AWT in the system. It is also observed from Table .2 that the maximum

Table 2: Percentage decrements in AWT with increase in RF

RF=0	AWT	% Reduction from each level
RF=1	1450	*
RF=2	887	38.8
RF=3	818	7.70
RF=FULL	800	2.8

Increment in in AWT occurs when RF rises from 0 to 1 is 80.24%, from RF = 1 to RF = 2 is 13.50% and from RF = 2RF = Full is 2.2%. Therefore, we can assume that the maximum increment in AWT is reached whenthe level of routing flexibility increases from 0 to 1. As a result, the increase in the level of routing flexibility is minimal influence on average machines utilization performance

Table.3:- shows the comparative studies of all the four different types of system models.

Models	AWIP	AWT
LIULI	4	1
LIUL5	2	2
L5UL5	**1**	**1**
L5ULI	3	2

From the above studies , we have identified that system model **L5UL5** perform best with respect to all the performance measures. Additional studies are performed on this system model. We discuss the results in the following sections.

Analysis of results based on ANOVA

Scattering Analysis (ANOVA) is a statistical method that tests a significant difference in the impact of emissions
system factors. In this dissertation work ANOVA technique was used to find meaning different impact (NP, BC, RF and SC) on make-span time, average work in process, average waiting time in queue, average in machine utilization. ANOVA analysis is carried out using SPSS-10 statistical package. The test is conducted at confidence level 0.05.

Table 4:- dependent variable AWT R squared=.986(r adjusted=.985

Source	Type III sum of squares	df	Mean square	F	Sig.
NP	406244715	3	135414905.0	87.804	.000
BC	46710125.2	3	15570041.74	10.107	.000
RF	90956414.8	3	30318804.92	19.681	.000
SC	1642924.074	3	547641.358	0.356	.785
Error	374336107	243	1540477.807		
Total	7996075201	256			

From table 4,cache capacity and routing flexibility have a significant effect while system configuration is dependent on loadand landing strategies are less significant. This is also observed on loading and unloading strategies are less significant. It is also observed that routing flexibility has the maximum effect followed by number of parts and buffer capacity respectively.
it is observed that for AWT as performance measure there is significant impact of routing flexibility . The impact of buffer capacity and system configurations based on loading and unloading strategies are found to be less significant.

Table 5. .Dependent variable: AWIP R Squared = .472 (Adjusted R Squared = .446)

Source	Type III sum of squares	df	Mean square	F	Sig.
NP	406244715	3	135414905.0	87.804	.000
BC	46710125.2	3	15570041.74	10.107	.000
RF	90956414.8	3	30318804.92	19.681	.000
SC	1642924.074	3	547641.358	0.356	.785
Error	374336107	243	1540477.807		
Total	7996075201	256			

From Table 5, it is observed that for AWIP as performance measure there is significant impact of routing flexibility . The impact of buffer capacity and system configurations based on loading and unloading strategies are found to be less significant.

Conclusion

The study conducted in this paper is on a hypothetical model of a flexible manufacturing system having seven numerically controlled machines facilitated, dedicated and universal loading as well as unloading station whose performance is compared with results obtained with the help of ARENA simulation software. The flexible manufacturing system is divided into four sub systems based on loading and unloading strategies. The performances of these system configurations are measured in terms of average work in process and average machine utilization. From the results, it is observed that as the level of routing flexibility increases it is observed that average work in process and average machine utilization also increases with the increase in routing flexibility. On comparison of performance of all system configurations it is observed that the performance of models having dedicated loading and unloading station (L5UL5) yield the best result with respect to the system performance under consideration. We also notice that there is some effect of sequencing and dispatching rules and buffer size on this system configuration i.e., L5UL5.

Future scope of the study

In this dissertation work the impact of manufacturing the flexibility of the performance of the flexible production system is the studied. It is also the extended work of the authors having great contributions in flexible manufacturing system and its implications. There is wide scope of applying the impact of routing flexibility and scheduling of parts in real manufacturing systems. The comparison of cost involved in processing the parts against the measures of performance of the manufacturing system can further be evaluated. Also the study can be extended to other flexibility such as machine flexibility and process flexibility and volume flexibility

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