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Analysis of Inventory Management through Flexible Manufacturing System

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***Abstract* - Analysis of Inventory Management through Flexible Manufacturing System (FMS) by Using Simulation consists of Inventory Management, scheduling of the system & optimization of FMS objectives. Flexible Manufacturing System is an integrated computer controlled configuration in which there is some amount of flexibility that allows the system to react in the case of changes. This system requires scheduling when there is frequent variation in the part designs of incoming jobs efficiently by complete utilization of available resources and maximizing system utilization, where machines tool are equipped with different tools and tool magazines but can be assigned to single operation. This paper focuses on scheduling of incoming jobs into the system efficiently; maximizing the system utilization, warehouse average inventory level. Lost percentage of customer & amount lost per customer.**

Keywords – Flexible Manufacturing System (FMS), Shortest Processing Time (SPT), Arena.

I. INTRODUCTION

Today, manufacturers have to modify their operations to ensure a better and faster response according to need & demand of customers. The objective of manufacturing industry is to achieve a high level of throughput, flexibility and system utilization, high level of productivity which can only be done in a computer integrated manufacturing environment. Flexible Manufacturing System is an integrated computer-controlled system in which there is some amount of flexibility that allows the system to react in the case of changes. Issues like reduction of inventories, quick response to market for fulfill customer demands, flexibility in adaptation according to market, reduction in cost of product, better services to grab more market shares etc., while producing good quality and cost effective supplies have made Flexible Manufacturing System a reliable and a viable means to achieve and accomplish the desired requirements.[12] FMS refers to a highly automated Group Technology machine cell which consist of a group of computer numerical control (CNC) machine tools and supporting workstations, connected by an automated material handling and storage system and controlled by a distributed computer system.[13] The reason, the FMS is called flexible, it is capable of processing a variety of part styles simultaneously with rapid tooling and instruction changeovers.

II. LITERATURE REVIEW

Great works have been made in the scheduling and control literature of FMS. Now, a mature literature using different methodological approaches. Recent work done is in investigating the use of the methodologies in the practical field, to making the control systems more user-friendly, and to developing more comprehensive control systems. M. Shivhare et al. (2014) ensures quality product at lowest cost. The layout of flexible manufacturing system is important to achieve high productivity. [12] M. Al-Kahtani et al. (2014) offers flexibility in dealing with various parts and product design, and also allows the variation in parts' processing sequences and production volume changes.[2] A. Singh et al. (2014) a real time methodology with full routing flexibility is used for minimizing mean flow time in FMS.[13]

III. FLEXIBLE MANUFACTURING SYSTEM

A system which consists of numerous programmable machine tools connected by an automated material handling system and can produce an enormous variety of items. Flexible manufacturing system is a computer controlled manufacturing system, in which NC machines are interconnected by a material handling system and master computer controls both NC machines and material handling system.[3] The primary goal of any manufacturing industry is to achieve a high level of throughput, flexibility and system utilization. System utilization computed as a percentage of the available hours and it can be increased by changing in plant layout, by reducing transfer time between two stations and defined as the number of parts produced by the machine of a manufacturing system over a given period of time. If the no of parts increases productivity increases and system utilization also increases.

Flexible manufacturing system consists following components:

A. *Work Station:* Work station consist computer numerical controlled machines that perform various operations on group of parts. FMS also include inspection stations, assembly works and sheet metal presses.

B. *Automated Material Handling and Storage System:* Work parts and sub-assembly parts between the processing stations are transferred by various automated material handling systems. Most of the automated material handling devices are used in flexible manufacturing systems like automated guided vehicle, conveyors etc. There are two types of material handling system:

   a) Primary handling system – It establishes the basic layout of the FMS and is responsible for moving work parts between stations in the system.

   b) Secondary handling system – It consists of transfer devices, automatic pallet changers, and similar mechanisms located at the work stations in the FMS.

C. Computer Control System: This system is used for control the activities of the processing stations and the material handling system in the FMS.

Figure 1, shows the relative study between the number of machines & Investment, Production rate, Annual volume of the flexible manufacturing system depending upon the number of machines. As the number of machines increases, investment, production rate & annual volume will be increased.

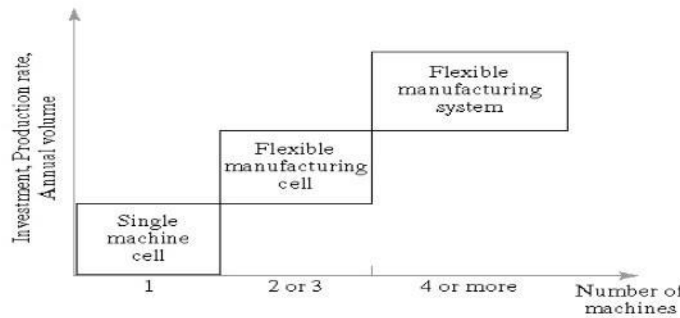


Figure 1: Comparison for three categories of FMS

IV. SEQUENCING OF JOBS

The set of jobs which have different operations are to be processed in a FMS environment in which machines are arranged in a typical layout. According to their processing time and due dates, these jobs are scheduled to minimized make span. There are following rules from many existing priority scheduling rules to have the optimum sequence.

A. First Come, First Serve: - It is simple, fast, and fair to the customer. Disadvantage of this rule, it is least effective as measured by traditional performance measures. As a result long job makes others wait resulting in idle downstream resources and it ignores the job due date and work remaining.

B. Shortest Processing Time: - The job which has the smallest operation time enters service first. Advantages of this sequencing rule are simple, fast, generally a superior rule in terms of minimizing completion time through the system. It minimizing the average number of jobs in the system usually lowers in-process inventories and downstream idle time. Disadvantages are it ignores downstream, due date information, and long jobs wait.

C. Earliest Due Date: - The job which has the nearest due date, enters service first and it is simple and fast. Generally it performs well with regards to due date. It is because the rules does not consider the job process time. It has high priority of past due job and it ignores work content remaining.

D. Critical Ratio: - Sequences jobs by the time remaining until due date divided by the total remaining processing time. The ratio of ((Due Date - Present Time)/Remaining Shop Time) where remaining shop time refers to queue time, set-up time, run time, wait time, and move times at current and downstream work centers. It recognizes job due date and work remaining but in this sequence, past due jobs have high priority and does not consider the number of remaining operations.

E. Slack per Operation: - Where job priority determined as a slack of remaining operations. It recognizes job due date and work remaining i.e. incorporates downstream information.

F. Least Changeover Cost: - Sequences jobs by set-up cost or time. It is simple and fast. Generally, it performs well with regards to set-up costs. It does not consider the job process time, due date and work remaining.

V. ARENA MODELING SYSTEM

The Arena modeling system is a flexible and powerful tool that allows analyst to create animated simulation models that accurately represented virtually any system. In 1993, Arena employs an object-oriented design for graphical model development and Simulation analysts place graphical objects called modules on a layout in order to define system components like machines, operators, and material handling devices. Arena is developed on the SIMAN simulation language. After creating a simulation model graphically, Arena automatically generates the underlying SIMAN model used to perform simulation runs. Arena was designed to make creating simulation models an entirely graphical process.[1] All system behaviors are represented by using the graphical modules described above. For system logics such as IF/THEN/ELSE and queue selection rules, the user creates a flowchart for the system by placing the appropriate graphical modules on the Arena layout and directly connecting these modules. The Non-animated modules from the Arena template that make up the majority of this flowcharts which freely interspersed with modules that contain animation.

Arena contains additional tools which are valuable for successfully conducting entire simulation projects. The Input Analyzer is useful to determine an appropriate distribution to input to an Arena model. The Input Analyzer allows the user to take raw data like time studies on process breakdowns and fit it to a statistical distribution. This distribution then can be incorporated directly into your model.[5]

The Output Analyzer is used to display and analyze model data after the simulation run has been performed. The multiple replications can be presented on a single chart. The Output Analyzer also provides analysis of confidence intervals, one-way analysis of variance, and comparisons.

In Arena, the user builds an experimental model by placing modules that represents processes or logic. While modules have specific actions relative to entities, flow, and timing.. Statistical data, like cycle time and work in process levels, can be recorded and generate as a report.

VI. RESEARCH METHODOLOGY

In this research, a model using Arena software is build. The model focuses on a Warehouse Operation where the supply is allied with the demand. A minimum stock is initially stored and thereafter the production is carried out on the basis of demand arriving. The Warehouse Operation implement the (r,R) inventory control policy, where the warehouse has a capacity (target level) of R=500 units. The production process stops when the inventory in the warehouse reaches the target level; from this point and on, the production process remains inactive until the inventory level drops to or below the reorder point of r=150 units. At this point the production process is restarted until the warehouse inventory level reaches the target level R=500 units. The inter-arrival time between successive customer arrivals are uniformly distributed between 3 to 7 hours, and individual demand size are uniformly distributed between 50 and 100 units. On customer arrival, the inventory is always checked and if there is sufficient stock that demand is promptly satisfied, and otherwise the unsatisfied portion of the demand is considered a loss.

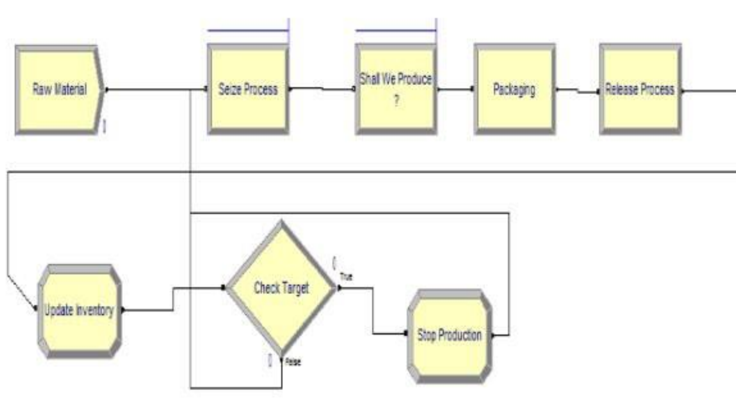


Figure 2: Inventory Management

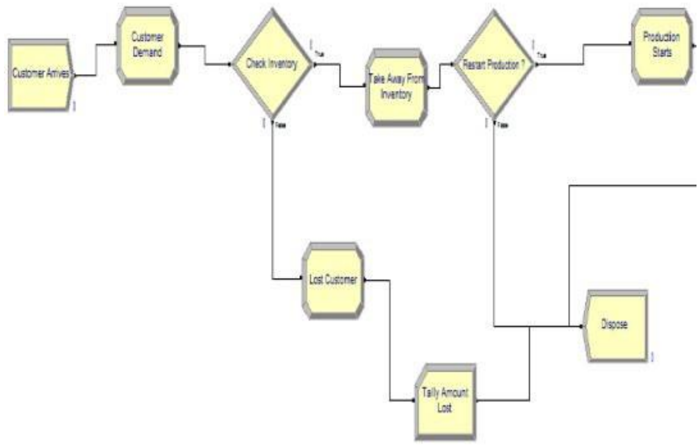


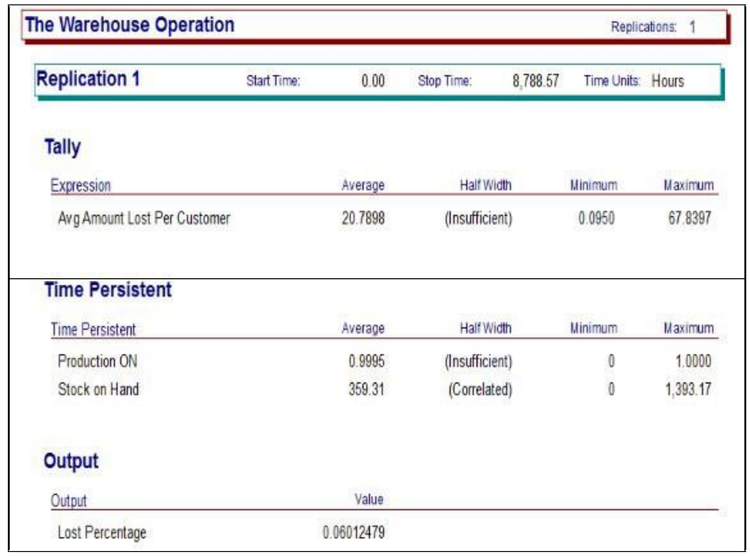
Figure 3: Demand Management

VII. RESULT AND DISCUSSION

The various system performance measures, of interest, on which the Arena model was developed and thereafter simulated, are as follows:

- Process utilization.
- Process downtime probability.
- Warehouse inventory level.
- Percentage of customers whose demand is not completely satisfied on arrival at the warehouse.
- Average size of lost customer demands at the warehouse; given that the demands are not completely satisfied.

The simulation was run for one replication of length slightly more than one year. The reports produced include User Specified report and Frequencies reports which are of keen interest and show our user define inputs and required outputs.



The Warehouse Operation — Replications: 1

Replication 1 — Start Time: 0.00 — Stop Time: 8,788.57 — Time Units: Hours

Tally

Expression	Average	Half Width	Minimum	Maximum
Avg Amount Lost Per Customer	20.7898	(Insufficient)	0.0950	67.8397

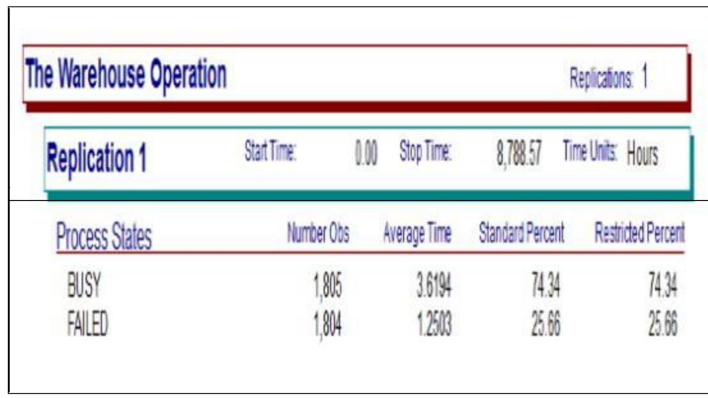
Time Persistent

Time Persistent	Average	Half Width	Minimum	Maximum
Production ON	0.9995	(Insufficient)	0	1.0000
Stock on Hand	359.31	(Correlated)	0	1,393.17

Output

Output	Value
Lost Percentage	0.06012479

Figure 4: User specified report.



The Warehouse Operation — Replications: 1

Replication 1 — Start Time: 0.00 — Stop Time: 8,788.57 — Time Units: Hours

Process States	Number Obs	Average Time	Standard Percent	Restricted Percent
BUSY	1,805	3.6194	74.34	74.34
FAILED	1,804	1.2503	25.66	25.66

Figure 5: Frequencies report.

Since, the lost percentage of the customers arriving is quite low (i.e. about 6%) for a simulation run for slightly more than a year. Also, simulation is carried out for different interval of time and a comparison was made on the basis of lost percentage. Figure 4 indicates a comparative study between simulation running time and lost percentage. As mentioned, the study is made for 1 replication only, and the figure illustrated below clearly shows that as the production is increased with time, the lost percentage gets decreased accordingly. The graphical view of the same, as mentioned below (figure 6), can justified the observations made.

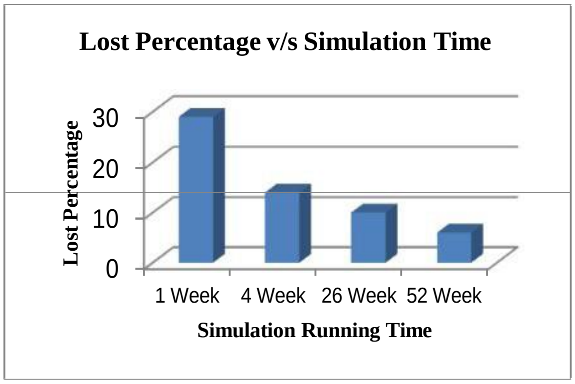


Figure 6: Comparative study for production process duration.

Further, during the entire simulation cycle the estimated percentage value of busy and failed of the process state was approximately 0.75 and 0.25 respectively.

Clearly, the customer service level is approaching to the acceptable level as the production increases. Thus, the only way to increase the customer service level in this model is to increase the level of on-hand inventory.

VIII. CONCLUSION

In this research, a simulation modeling and optimization of FMS objectives for evaluating the effect of factors i.e. demand arrival time and supply arrival time, were carried out. Customer satisfaction to the acceptable level was achieved with the increase in on-hand inventory by increasing the production process. Both the segments of the Arena model i.e. the modules made for the prescribed operation were simulated for analysis and we got near optimum solution on acceptable level.

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