Simulation based analysis of job shop manufacturing planning

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Abstract

The study attempts to model a complex and dynamic production system using discrete event simulation to conduct experiments for alternative manufacturing strategies in a cost effective way. The case study of a batch type manufacturing system illustrates a methodology to address the manufacturing aspects like delivery, inventory and resource management.

Keywords: simulation, manufacturing strategy, resource utilization,

Introduction

In order to study the manufacturing system behavior, it is essential to model and simulate the system. The analysis of the system is performed by varying the input parameters and corresponding system behavior is studied. The manufacturing system analysis is difficult to perform on the actual shop floor. Simulation modelling is a real system imitating technique is used to address the problems associated with the manufacturing operations. It is cost effective and gives deeper insights into the problems of the shop floor by extrapolating the shop floor scenarios in a shorter time span. Therefore it is a useful tool in the planning stage. Present study employs simulation technique to study the impact of changes in the input parameters on the system evaluation parameters such as resource utilization, inventory status and bottleneck operations. Utilization defines the operational performance to the rated performance normally expressed as percentage. It is the proportional engagement time of the resource for production to the total available time of the resource. It is one of useful manufacturing indicator of performance of a manufacturing facility. Lower utilization ratio means the less returns on investment and it is an indicator of inefficiency of the manufacturing operation. This study is an attempt to use ARENA software for simulation and identification of the utilization level of the resources in a production process and suggest an alternative manufacturing strategy to improve resource utilization. Rockwell Software solutions has developed this discrete-event simulation which is widely used in variety of decision making scenarios in the areas such as and not restricted to supply chain management, business process outsourcing apart from manufacturing. The study is focused on the manufacturing operations of some of the high volume and high demand products of a certain job shop manufacturing set up. In this paper the production process will be studied only for discrete components flow with respect to the entities per arrival processed with the optimal resources.

Related work

A major difference of top floor & shop floor a simulation model is made to use in planning, to observe the synchronization amongst member and the way of communication is done is illustrated which is done with the help of the Web service technology (Lee et al 2007). It describes Simulation based decision(DSS), Stochastic flexible job shop (SFJS), Event condition action (ECA) , Simulation data exchange (SDE),As all the work carried under the supervision based on discrete-event simulation with event condition action for stochastic flexible job shop. A bilateral method for multi-performance criteria optimization combines a gradient based (Mahdavi et al).The paper provides scenario of the entire process from planning to Dispatch With the important parameters lead-time, safety stock & lot size by illustration of VNS Search Trajectory by running a set of experiment as evidence (Gansterer et al 2013).The case study of direct comparing the system of German and Japan with respect to order fulfillment process. The different types of product and mixed model job shop (Staeblein, Aoki 2014). This paper reports the results of a review of simulation applications published within peer-reviewed literaturebetween 1997 and 2006 to provide an up-to-date picture of the role of simulation techniqueswithin manufacturing and business. The review is characterized by three factors: wide coverage, broad scope of the simulation techniques, and a focus on real-world applications. A structured methodologywas followed to narrow down the search from around 20,000 papers to 281. Results include interesting trends and patterns.(Jahangirian et al 2009)
The dynamic model system of pastoral properties futures simulator (PPFS) it's the environmental concerned of the model which fits for Pastoral Properties Futures Simulator. The model includes social learning of the industrial stack holders, Greenhouse, lack of output volition.(Greiner et al 2014). It's the study of effects of Dynamic due date assignment models (DDDAMs) measuring the performance by mean flow time, percentage of tardy parts, mean flow allowance &Tardiness (Joseph, Sridharan 2011). The illustrate about the maintenance of the machinery the two cases are been considered in the periodic preventive maintenance and second then there is low productivity in order to find out the best way to compromise the cost (Bochian et al 2008). Anova is used for examination which revealed insensitivity of near optimal values to real time events. Here the dynamic disturbance between the planned and the manufacturing difference. The systems response is observed under different arrival pattern of orders and real time events machine failure (Georgiadis, Michaloudis 2011). It's a Digital enterprise technology combined optimization algorithms on the prototype of the system and evaluates the robustness of weekly

schedules against the uncertainties in order to perform sensitive analysis (Monostori et al 2009). The virtual reality of the product, process design, planning verification , ergonomics & robotics the tools including CAX, factory layout, material information flow, manufacturing networking planning(Mourtzis et al 2014). The optimal utilization of the human resource in order to distribute as per the skills of work force with help of personal oriented simulation tool (ESPE) Engpassorientierte Simulation Von Personalstructure) (Zulch et al 2003).In order to improve the Performance the system is customer oriented and improvement of JIT & flow time (Weng, Fujimura 2011). It consist about the inline cells along with the conveyor the SIGMA id used to verify the event graph model (Song et al 2011). This paper presents a comprehensive framework for strategic capacity expansion of production equipment at Agere Systems wafer fabrication facility. The integrate simulation modeling, statistical analysis, design of experiments, and economic justification tool to support the highly complex decision-making process which is elaborated with the flow chat (Nazzal et al 2005).

METHODOLOGY

The study is focused on the work station involved in the production or flow for selected products and it is assumed that there is discrete part flow. The study ignores the other evaluation parameters such as inventory management and delay issues. Also the factors affecting the utilization of machines such as layout, absenteeism, human errors, product design etc. are ignored. Zero lead time, defect free raw material, are no breakdown and absentees are other assumptions made in the study The focus of study is to analyses the effect of schedule dependent parameters such as parts arrival rate on the utilization pattern of the machines. The Figure 1 shows the flow chart illustrating the methodology employed for carrying out the study.

Company selection

The nature of the study required job shop company with multiple product category with moderate volume of production. The manufacturing set up considered for conducting the study; manufactures a wide variety of products which are used in oil & gas equipment's, Measurement & sensing instruments. Which are commercializes in different markets. The company produces a wide number of components under most rigorous standard of quality. Company is selected due to its variety and quantity in the production line. Which provides the appropriate setting as it correlates with the objective of the study with its resource.

Setting objectives

Basically the process has various problems such as quality issues due to stringent tolerances on measuring instruments, missing delivery deadlines, resource utilization issues and huge in process inventory problems. We have focused on resource utilization improvement.

Components Selection

Company is currently producing more or less 150 components in which the requirement and Part type is completely Depend up on the customers requirement hence the nature of the requirement is random in nature some of the regular parts can be considered for the study the process of each component was studied and the model was built in the ARENA software.

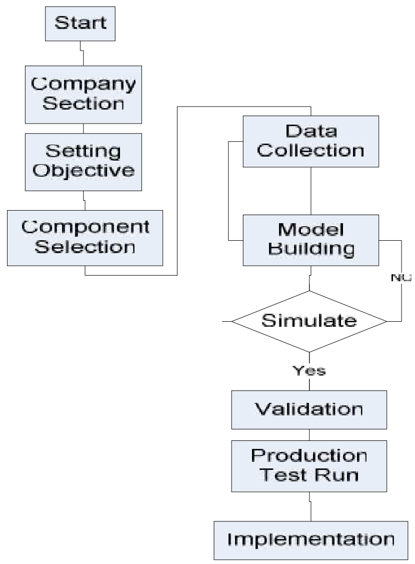

Figure 1 Flow Chart for Methodology

Data collection

In order to represent the real manufacturing set up in the simulation model the most important components is accuracy of the data pertaining to the system. Therefore the primary data needed for the model building is collected from the shop floor. The data includes the process parameters, machine parameters and the system parameters. The process parameters such sequence of operation and processing time are collected using stop watches and interviews with the workers. The machine parameter data is collected from the interviews and machine catalogues and dealers. The system parameter data such as layout, master production schedules etc. are collected from the plant engineers, process engineers and by observation.

All the data required for developing the model of this study is summarized here. There are eight jobs processed and the number of machines used to process these jobs are twenty eight. Table 1 states the sequence of operation of the jobs, the operation, the machine used and the cycle time for the operation.

Table 1 Machining data for simulation model

THE COMPONENT ONE PROCESS PLAN			
MACHINE	PROCESS No.	PROCESS NAME	CYCLE TIME (sec)
BAND SAW	j1p1	BLANK	70
CNC 21	j1p2	ROUGH CNC 1	210
CNC 22	j1p3	FINISH CNC 2	90
VMC 3	j1p4	FINISH VMC 1	120
FITTING	Fitting5	DEBURRING & CLEANING	120

THE COMPONENT TWO PROCESS PLAN			
MACHINE	PROCES S No.	PROCESS NAME	CYCLE TIME (sec)
BAND SAW	j2p1	BLANK	13.3
CNC 12	j2p2	FINISH CNC 1	150
CNC 8	j2p3	FINISH CNC 2	270
VMC 4	j2p4	FINSH VMC 1	90
FITTING	j2p5	DEBURRING & CLEANING	180

THE COMPONENT THREE PROCESS PLAN			
MACHINE	PROCESS No.	PROCESS NAME	CYCLE TIME (sec)
BAND SAW	j3p1	BLANK	300
VTL	j3p2	ROUGHT CNC 1	600
5TH AXIS	j3p3	FINISH 5TH AXIS	80
CNC 13	j3p4	ROUGHT CNC 1	480
CNC 1	j3p5	ROUGHT CNC 2	420
CNC 12	j3p6	ROUGHT CNC 2	390
GRINDING 1	j3p7	FINISH G1	300
GRINDING 2	j3p8	FINISH G2	300
FITTING	j3p9	DEBURRING & CLEANING	600

THE COMPONENT FORTH PROCESS PLAN			
MACHINE	PROCESS No.	PROCESS NAME	CYCLE TIME (sec)
BAND SAW	j4p1	BLANK	15
CNC 15	j4p2	ROUGH CNC 1	90
CNC 16	j4p3	FINISH CNC 1	90
GRINDING 1	j4p4	FINISH GRINDING 1	15
FITTING	j4p5	DEBURRING & CLEANING	60

THE COMPONENT FIFTH PROCESS PLAN			
MACHINE	PROCES S No.	PROCESS NAME	CYCLE TIME (sec)
BAND SAW	j5p1	ROUGH CNC 1	15
CNC 9	j5p2	ROUGH CNC 1	90
CNC 10	j5p3	ROUGH CNC 1	120
CNC 11	j5p4	ROUGH CNC 2	480
CNC 14	j5p5	FINISH CNC 1	360
CNC 17	j5p6	FINISH CNC 2	95
GRINDING 1	j5p7	FINISH GRINDING 1	95
GRINDING 2	j5p8	FINISH GRINDING 2	95
FITTING	j5p9	DEBURRING & CLEANING	120

THE COMPONENT SIXTH PROCESS PLAN			
MACHINE	PROCES S No.	PROCESS NAME	CYCL E TIME (sec)
VMC 1	j6p1	ROUGH CNC 1	40
VMC 3	j6p2	FINISH VMC 1	1020
VMC 2	j6p3	ROUGH VMC 2	2100
VMC 6	j6p4	FINISH VMC 2	600
FITTING	j6p5	DEBURRING & CLEANING	600

THE COMPONENT SEVENTH PROCESS PLAN			
MACHINE	PROCESS No.	PROCESS NAME	CYCLE TIME (sec)
BAND SAW	j7p1	BLANK	70
CNC 6	j7p2	ROUGH CNC 1	20
CNC 14	j7p3	ROUGH VMC 2	30
CNC 13	j7p4	FINISH CNC 1	80
CNC 17	j7p5	FINISH CNC 2	480
CNC 18	j7p6	FINISH CNC 2	270
FITTING	j7p7	DEBURRING & CLEANING	210

THE COMPONENT EIGNHT PROCESS PLAN			
MACHINE	PROCESS No.	PROCESS NAME	CYCLE TIME (sec)
BAND SAW	j8p1	BLANK	30
CNC 21	j8p2	FINISH CNC 1	210
CNC 2	j8p3	FINISH CNC 2	180
VMC 6	j8p4	FINISH VMC 1	60
VMC 7	j8p5	FINISH VMC 2	30
VMC 8	j8p6	FINISH VMC 3	60
FITTING	j8p7	DEBURRING & CLEANING	210

Model building

Based on the data collected a model is built using ARENA software. The model building is done by using inbuilt functions of the software. There are twenty eight workstations doing twelve different types of machining operations. The data from the table 1 is entered in the model for each product and process. The ARENA simulation model of the manufacturing set up is shown in the Figure1.

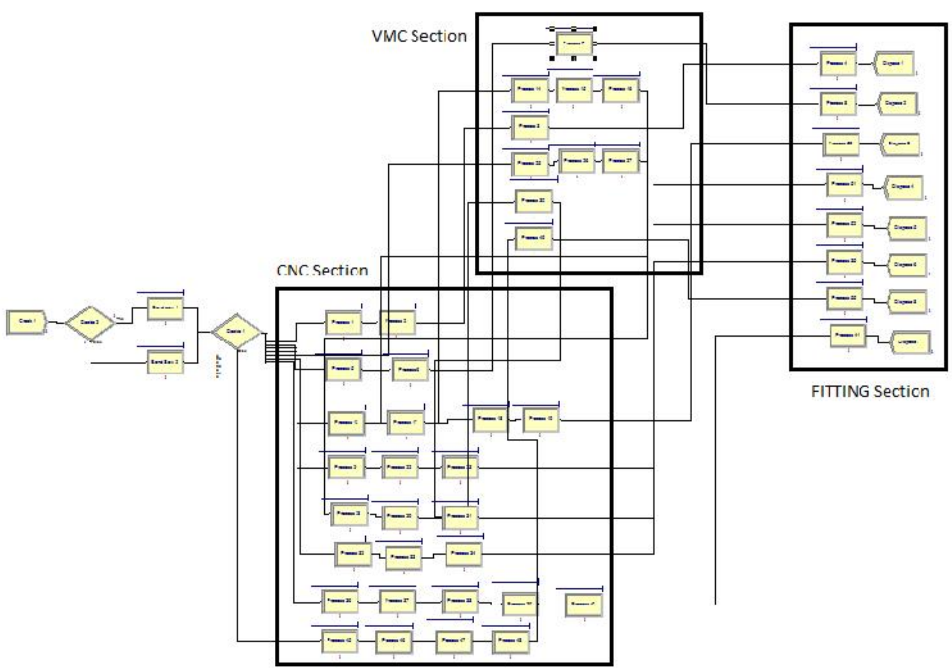

Figure 1ARENA model of the manufacturing set up

Result and analysis

The data such as processing time, sequence of operation, the machine used is provided to the ARENA to build the model accurately. In addition to this, other parameter such as arrival distribution is considered as constant and exponential wherever applicable. Delays are introduced in the model by selecting delay and proceed as process block to accommodate any in process waiting time. The accuracy of the model is verified by taking the trial runs and verifying with the actual values from the shop floor. The simulation results are shown in the Figure 3. The evaluation parameter is machine utilization.

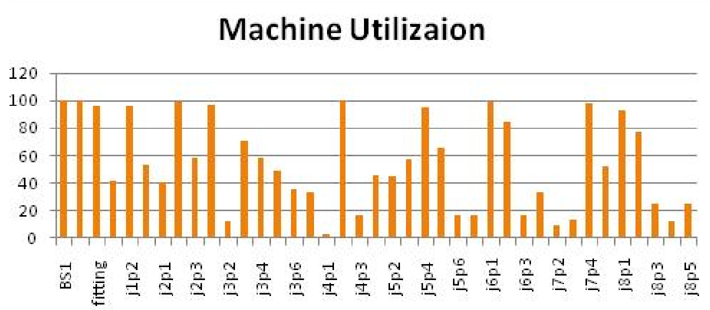

Figure 2Machine utilization

It is evident from the figure 3 that some machines are having hundred percent utilization indicating those machines are bottlenecks in the process and some machines are under-utilized. We changed the schedule parameters to alter the machine utilization and removal of bottlenecks. We identified resources which can process more than one component as shown in Table 2.

Table 2Alternative usage of machine resource

Components Resources	J1	J2	J3	J4	J5	J6	J7	J8
Bandsaw	p1	p1	p1	p1	p1,p2		p1,p2	p1
CNC1			p5,p6					
CNC8	P3	p3	p3,p4					
CNC11					p4,p5			
CNC12		p2	p6					
CNC13			p4				p4	
CNC14					p5		p3	
CNC17					p6		p5	
CNC21	p2							p2
CNC22	p3	P3						
VMC3	p5					p2		
VMC4		p4	p4					
VMC6						p6		p4
VMC7								p5,p6
Grinding1			p7	p4	p7			
Grinding2			p8		p8			
fitting	p5	p5	p9	p5	p9	p7	p7	P7

The result of routing analysis helped us to offload bottleneck machine load on to the under-utilized machines. This information is fed to the ARENA model and a new model is developed, as shown in Figure 4, according to revised routing and scheduling information.

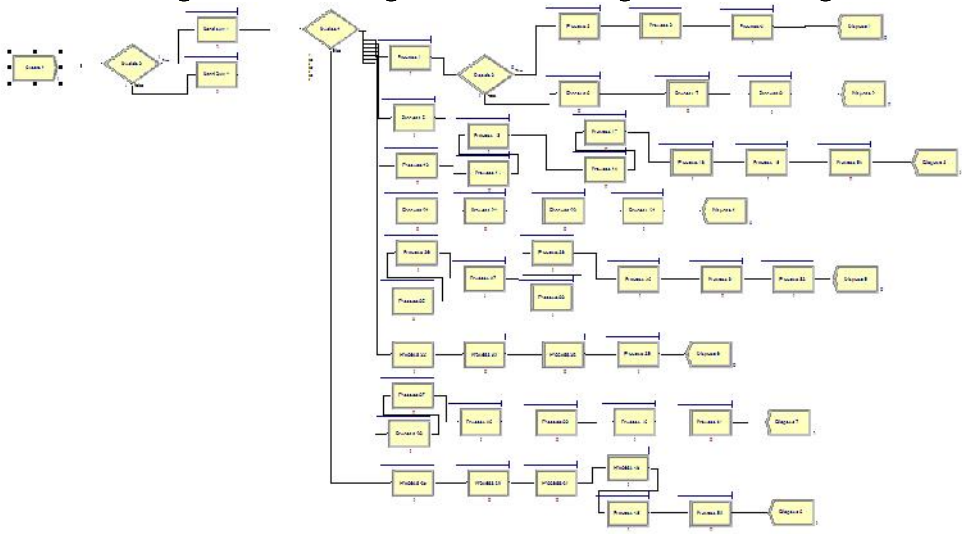

Figure 3New simulation model

Table 3 shows that the revised utilization of the resources has increased while some of the machines are eliminated for alternative uses.

Table 3Revised resource utilization

Process	**Old Utilization**	**New Utilization**	**Result Improvement**
j3p2	12.22	83.61	71.39
j3p3	70.56	81.39	10.83
j3p4	58.06	25	33.06
j3p5	48.75	24.72	24.03
j3p6	35.97	Eliminated	
j3p7	33.33	Eliminated	
j5p1	45.83	87.71	41.88
j5p3	57.5	92.78	35.28
j5p4	94.58	5.27	89.31
j5p5	66.25	5.27	60.98
j5p6	17.15	Eliminated	
j5p7	17.15	Eliminated	
j7p3	13.82	97.92	84.1
j7p4	97.92	52.5	45.42
j7p5	52.5	Eliminated	
j8p4	12.5	38.75	26.25
j8p5	25	Eliminated	

Conclusion

Based on this paper we developed a simulation model for the job shop production system to study the effect of routing parameter on the utilization of the resources. We were able to establish the improvement in the utilization of the machines and also were able to eliminate some machines and release the resource for alternative usage. The proposed approach provides other possibilities of evaluating other manufacturing performance indicators such inventory monitoring, delivery schedules and the study can be generalized for the similar analysis of the entire manufacturing operations of any enterprise with the help of simulation techniques. Further study may include the study of impact of product mix, batch sizing, layout changes etc. on the utilization pattern of the resources.

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