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Modeling and Simulation of Manufacturing Performances using WITNESS

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ABSTRACT : *Production methodology aims to improve overall productivity through elimination of wastes and that leads to improve quality is 'Just-In-Time'. The Simulation is the imitation of operation of the real word process. Integration Just-In-Time with Simulation is beneficial to identify the obstacles in implementation and to take appropriate options to implement successfully. For this integration, there are different Simulation Softwares. To study this integration, with the help of "WITNESS" Simulation Software the model is created. This model is based on literature review. The input parameters are Setup Time, Machine Alteration and Shift Alteration and output parameter is Throughput. With the help of Taguchi Method, Design of Experiment is made and obtained results are used for Statistical Analysis. For this Statistical Analysis, "MINITAB" Statistical Software is used. This analysis concludes the optimal solution to get maximum Throughput.*

Keywords - *Just-In-Time, Manufacturing Performances, Simulation, WITNESS.*

I. INTRODUCTION

Companies in order to succeed and attain competitive advantage in global market scenario have to conceive and implement new strategies which give them the advantages such as flexibility, quick responsive, cost, efficiency, quality, reliability and service. The most popular technique to achieve is Just-In-Time (JIT). The purpose of JIT is to create manufacturing system which eliminates all waste and supports to continuous improvement [1]. A Simulation is the imitation of the operation of real world process or system over time. A simulation model is a descriptive model which represents a dynamic phenomenon, a set of decision alternatives, cause- effect relationship. It is also known as the experimental arm of operation research. Simulation is methodology for conducting experiments using a model of the real system. Simulation of JIT manufacturing before actual implementation will help the company to identify the obstacles in implementation and take the actions appropriate achieve to successfully implement and reap the benefits of JIT. Thus, a simulation study of JIT is called for and fruitful above context to reduce the risk of future. This study aims to develop a model for implementation and performance measurement of JIT manufacturing and establishing relationship between key JIT practices and manufacturing performances using Simulation.

II. LITERATURE REVIEW

The implementation of JIT is only depending upon the company's willingness and its commitment to become and remain "world class" in manufacturing. The review studied about the Implementation and Obstacles in implementing the JIT. Computer based simulation tools and linear mathematical models are studied by Sandanayake and Oduoza [2]. With the help of ProModel software, the three proposed models HEKCS (hybrid extended Kanban control system) with EKCS (extended Kanban control system), and CONWIP (constant work in process) in a single line manufacturing are studied and compared by Selvaraj [3] with or without machine breakdown. The description of a simulation study and development of models were used by the company to gain valuable knowledge of the operational characteristics of their plant of Engine Manufacturing using Witness Simulation software given by J. F. O'Kane et al [4]. The analysis and evaluation of the effect of process parameters on the performance of manufacturing systems were done using two softwares Arena 10.0 and SPSS 9.0 statistical package by Ekren and Ornek [5]. The comparative study of seven different production control system in complex factory set up through computer simulation is done by Cheraghi and Adashzadeh [6]. For studying the output parameters Work-In-Progress and Throughput, they used ARENA simulation software. How simulation was used to design new manufacturing systems and to improve the performance of existing ones with explaining different simulation software such as

FACTOR/AIM, Pro-Model, Taylor II and WITNESS by Law and McComas [7]. Roongrat Pisuchpen [8] presented the newly developed Kanban system into the production system of JIT flexible manufacturing, assembly and disassembly system with simulation technique.

III. METHODOLOGY

The methodology followed for the problem is shown in Fig.1.

1. **Literature Review**: the literature review done to study JIT practices, performance measurement and use of Simulation Software.
2. **Development of Conceptual Model**: the conceptual model is developed to establish relationship between JIT practices (Input Parameters) and Performance measurement (Output Parameters).
3. **Development of Simulation model using Simulation Software WITNESS**: the model is created using the WITNESS simulation software.
4. **Design of Experiment**: for the Design of Experiment, the parameters are three and the levels are two. Hence with the help of Taguchi method L_{16} orthogonal Array is designed and total 16 runs are taken.
5. **Statistical Analysis using MINITAB software and results**: the results obtained after the 16 runs are analyzed using Statistical Software MINITAB and the Results are obtained.

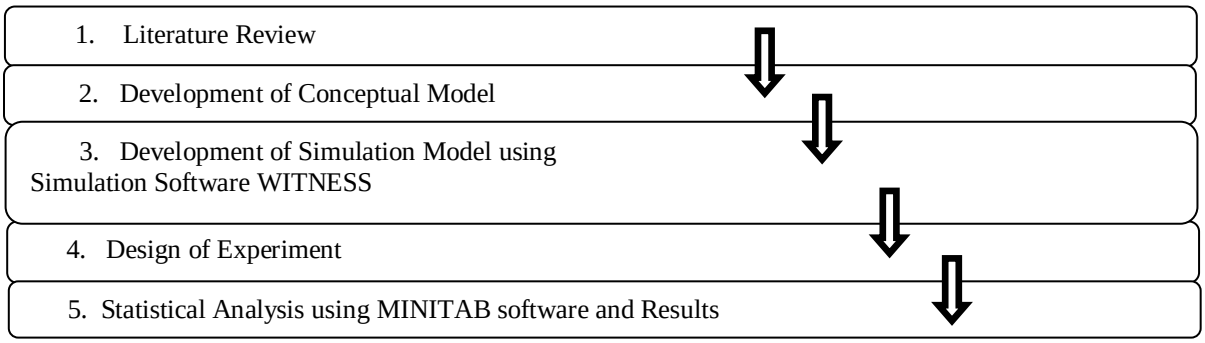


Fig.1: Methodology for the Problem

IV. PROBLEM STATEMENT

This is the Case study of XYZ Manufacturing Company. It has total six machines. The machines done the operations like Machining operations, Assembly and Sub-Assembly operations. This model is explained in the Fig.3. These machines are connected with the Conveyors. There are total five conveyors present. Hence, the statement of the problem is that the company wanted to improve the throughput. For that problem, following the conceptual Model, model using WITNESS and analysis is explained as below.

V. MODELING, SIMULATION AND STATISTICAL ANALYSIS

1. Modeling:

It explains the model developed is Trial Model and it is on the basis of literature review. Before that there is conceptual model of this trial model which explains about the relationship between input and output parameters. The conceptual model of trial model is shown in fig.2. The appropriate JIT practices (process variables) and the performance measures (response variables) are selected. The Input parameters will be used such as Set-up Time, by altering machines, using shifts alteration. The Output Parameters will be used such as Lead Time, Throughput.

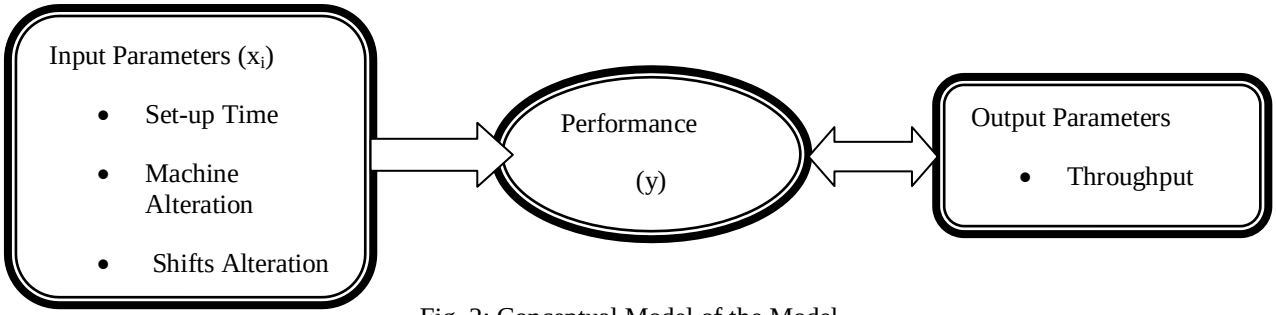


Fig. 2: Conceptual Model of the Model

2. Simulation:

There are different simulation software packages are available in the market. These are 'ARENA', 'ProModel', 'FlexSim', 'WITNESS'. WITNESS simulation software is selected for this study. This software is used to conduct simulation experiments to achieve the objectives of the study. The WITNESS is VISM (Visual Interactive Simulation) system developed by Lanner Group. It gives beneficial approach to the users not only to work on creating and using witness models but also to built and test the models on small incremental stage.

2.1 Development of Simulation model

With the help of WITNESS Simulation software, the model is created. It is based on following assumptions:

Table 1: Assumptions for the Model

Sr. No.	Assumptions
1.	Parts are always available at the Sore-Room.
2.	The Model is flexible and new elements can be easily add or remove.
3.	No stoppage occurs during the production in the model,
4.	In the model, no allowance is made for machine breakdown and Repair Time.
5.	For parts, First-In-First-Out (FIFO) rule is applied.
6.	The model works under ideal JIT Conditions.

The screenshot of the model created using WITNESS Simulation Software is shown in fig.3. It contains different notifications which explain different entities. Machines are denoted by M1, M2, M3, M4, M5 and M6.

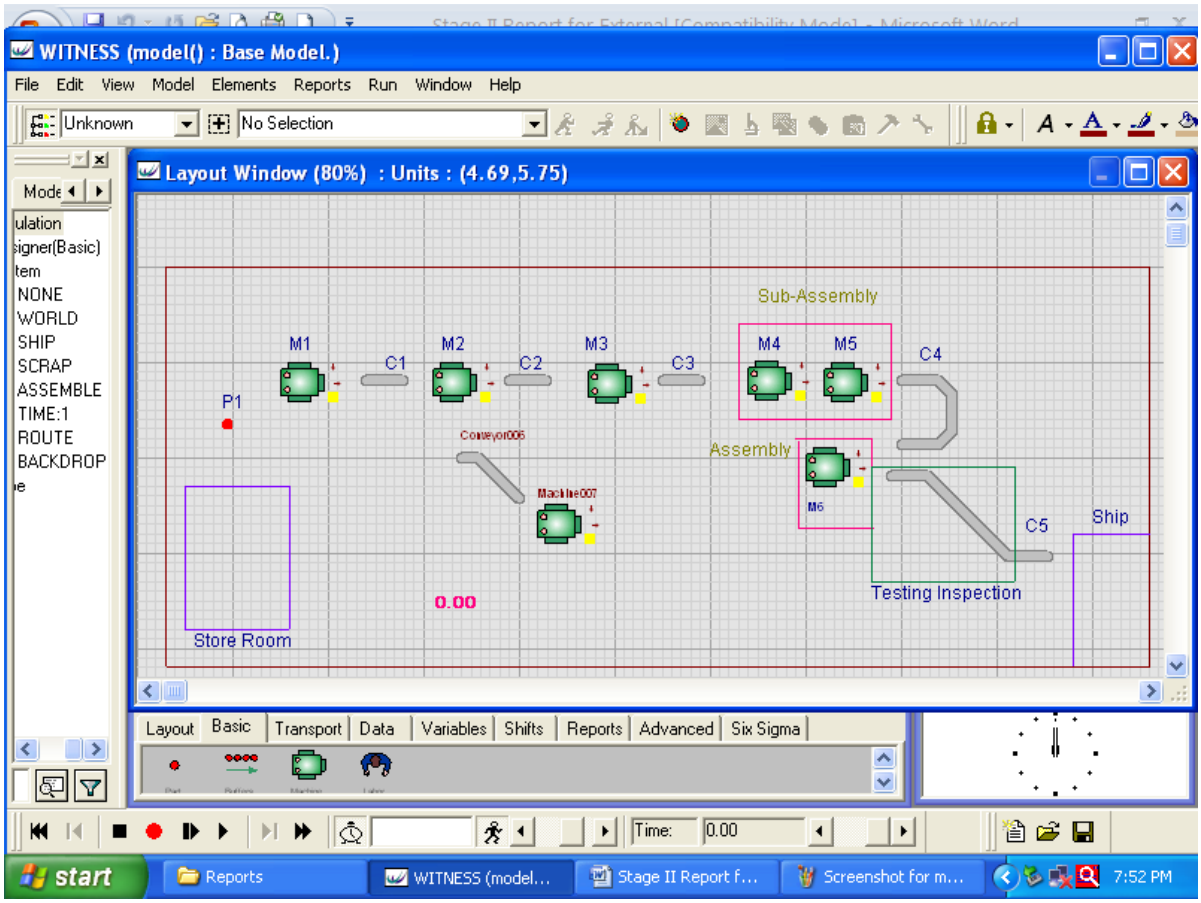


Fig. 3: Development of Model using WITNESS Simulation software

Conveyors are denoted by C1, C2, C3, C4, and C5. The part which used for different operations and assembly and sub-assembly is denoted by P1. In this model, when part P1 moves towards the machine M1 then after setup time then its machining done and P1 forwarded to conveyor C1. Similarly done up to C5. Then P1 forwarded to Ship. The normal flow of part P1 is:

M1- C1- M2- C2- M3- C3- M4- M5- C4- M6- C5

The Conveyor 'Conveyor006' and machine 'Machine007' is used for addition of machine in further DOE.

2.2 Design of Experiments

DOE is used to determine best set of factors for the model optimization. For this purpose, the study of Taguchi design is done. The three factor two level Taguchi design is designed. For that L16 orthogonal array is used. It is shown in the Table 2.

Table 2: Design of Experiment

Run	Setup Time	Machine Alteration	Shift Alteration
1	5	Removing 1 m/c	8
2	5	Removing 1 m/c	8
3	5	Removing 1 m/c	12
4	5	Removing 1 m/c	12
5	5	Adding 1 m/c	8
6	5	Adding 1 m/c	8
7	5	Adding 1 m/c	12
8	5	Adding 1 m/c	12
9	10	Removing 1 m/c	8
10	10	Removing 1 m/c	8
11	10	Removing 1 m/c	12
12	10	Removing 1 m/c	12
13	10	Adding 1 m/c	8
14	10	Adding 1 m/c	8
15	10	Adding 1 m/c	12
16	10	Adding 1 m/c	12

This is the design of experiment drawn with the help of statistical software 'MINITAB'. Here, in this design, the 1 indicates Low and 2 indicates high. The three input parameters Setup time, Machine Alteration and Shift Alteration. The low and high level for the DOE is explained in Table 3.

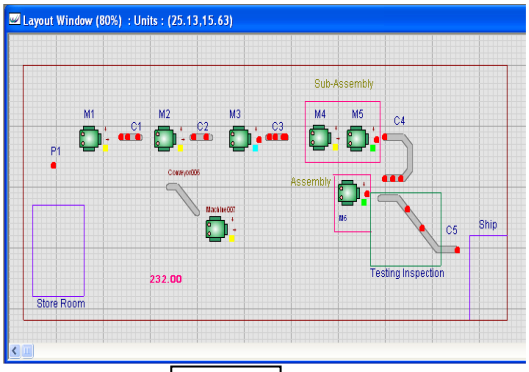
Table 3: Low and High levels of parameters

Sr. No.	**Input Parameters**	**Units**	**Low**	**High**
1	Setup Time	min.	5	10
2	Machine Alteration	-	Removing 1 m/c	Adding 1 m/c
3	Shift Alteration	Hrs.	8 (Current shift)	12 (current shift with overtime)

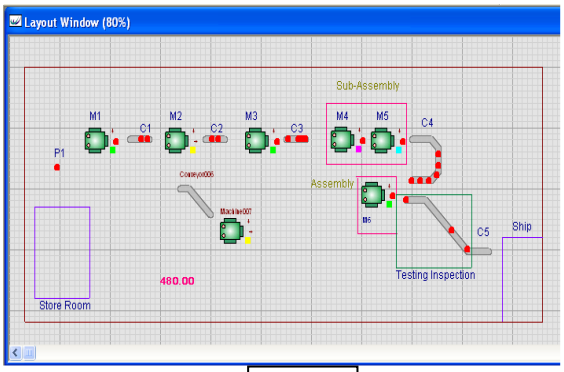
The Setup Time explains the time required for the machine to be ready for the any function or operation. So, the time 5 min is low level and 10 min is high level. The Machine Alteration means adding and removing the machine from the developed model. In this factor at low level, the Machine M2 is not considered so the line has five machines and five conveyors; at high level, the Machine 'Machine007' and Conveyor 'Conveyor006' is connected

to the main line of developed model. The third factor is Shift Alteration explains the shift hours at the low level, the shift hrs are 8 hrs similar to current shift and at high level, extra 4 hrs are added to the current shift becomes 12 hrs.

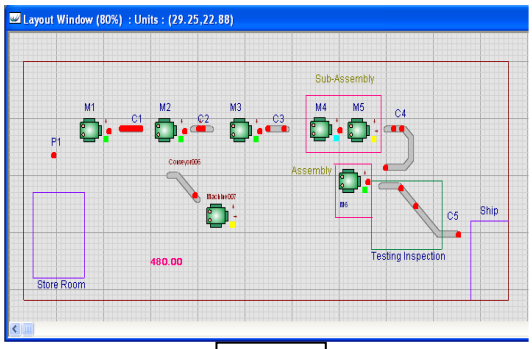
With the help of this DOE table, Total 16 runs are taken. The Screenshot for some of the Runs are as follow:



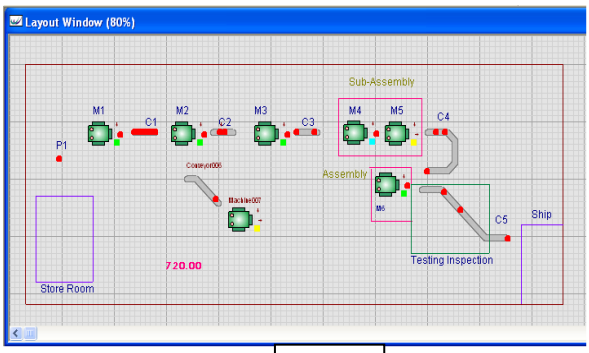
Run 1



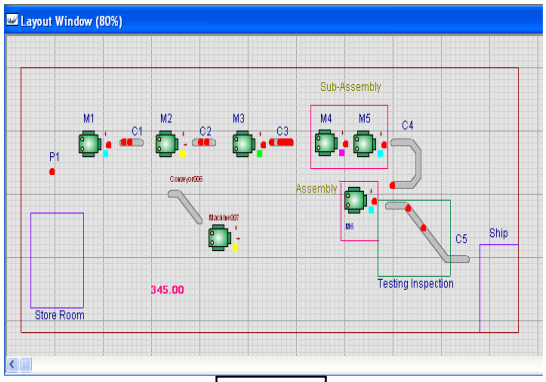
Run 3



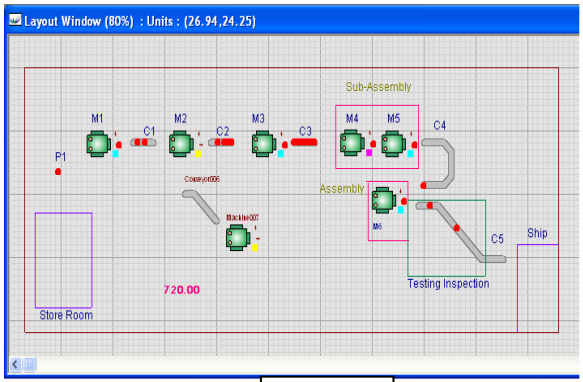
Run 5



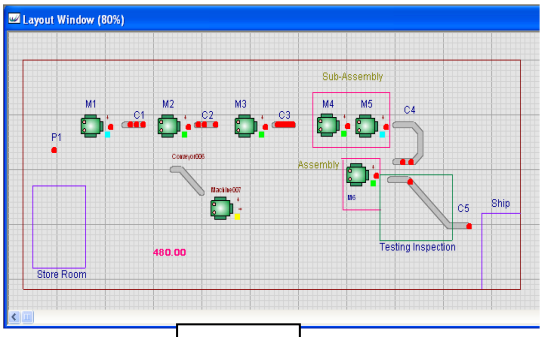
Run 7



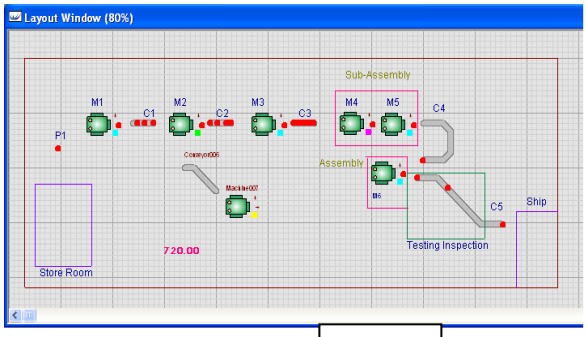
Run 9



Run11



Run 13



Run 15

3. Statistical Analysis:

The statistical data shown by the software after taking the 16 runs. The output parameter is 'Throughput'. The results obtained after 16 runs are shown below at Table 4. The statistical Analysis using these results is done. For this Analysis, the MINITAB statistical Software is used.

Table 4: Result Sheet for Model

RUN	Throughput (Products)
1	34
2	34
3	58
4	58
5	28
6	28
7	50
8	50
9	23
10	23
11	42
12	42
13	20
14	20
15	36
16	36

The Main Effect plot of Throughput for Signal - to - noise ratio is shown in Fig. 4. The line explains the effect of input parameters on the output parameters. In the Main Effect plot for the Throughput, the condition is 'larger is better', because the throughput should be high for satisfying the aim of the company. In the graph generated, as the throughput should high the points above the line should be considered. The low level given by number 1 and high level is given by number 2. Hence, from the graph, the optimal solution is obtained. Hence, the low level of Setup Time is above the line, low level of Machine Alteration is above the line and High level of Shift Alteration is above the line. The Shift Alteration shows higher effect on the Throughput. To get the optimum solution for Throughput, Setup Time and Machine Alteration should be lower and Shift Alteration should be higher.

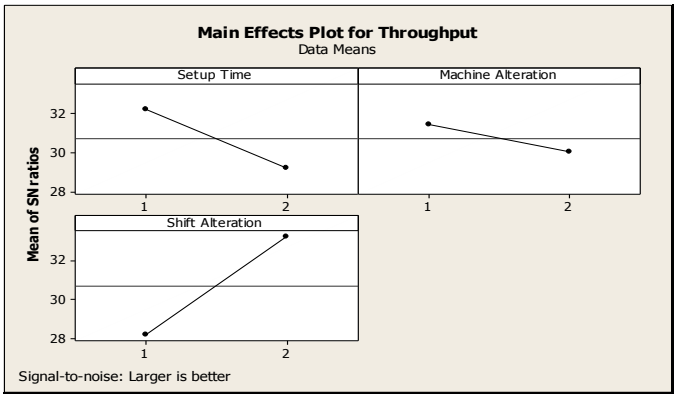


Fig. 4: Screen Shot of Main Effect Plot for Throughput.

VI CONCLUSION

With the help of WITNESS Simulation software, the model is created and runs are taken. From the WITNESS Simulation software, the output data collected and used for Statistical Analysis. With the help of MINITAB statistical software, the Taguchi analysis is done and Main Effect plot for Throughput is generated. Hence, the optimized solution is obtained with the help of 'MINITAB' software i.e. Low level of setup time, Low level of Machine Alteration and high level of Shift Alteration. This is the optimal solution to get maximum throughput. This combination is Run No. 3 and 4; it gives maximum number of Products for Throughput. Hence, this combination satisfies the problem of XYZ Manufacturing Company and helps them to get Maximum Throughput.

VII Acknowledgements

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