Productivity Improvement Using Modeling and Simulation Techniques Using Flexsim

Mandar S. Aundhakar[1], Prof. H. M. Thakur [2]

[1]*PG Student, Industrial Engineering, Department of Production Engineering, KIT's College of Engineering (An Autonomous Institute), Kolhapur, Maharashtra, India.*

[2]*Adjunct Faculty, Department of Production Engineering, KIT's College of Engineering (An Autonomous Institute), Kolhapur, Maharashtra, India.*

Abstract:-**Simulation software is basically used to identify the bottlenecks in the industries. Simulation is basically visual representation of a working model which predicts us the behaviour of the model which we can relate to the real life scenario, also simulation can tell us the existing productivity & from which we can make some experiments in the model to improve the productivity. The main advantage of the simulation is we can make any changes in the existing model which is very difficult to change physically. If we get improved results by doing such experiments then we can change the layout or locations of machines in real life scenario. A small-scale industry is selected where the customer demands for peak requirement are not met. The study is conducted by using a simulation software (Flexsim). In simulation, the study of bottle-necks present in the industry are identified and solutions are given to minimize them as much as possible. The bottle necks are identified by studying machine utilization statistics, Queue parts statistics. System throughput is monitored for every experiment. After taking some experiments the results are improved as compare to existing results.**

Keywords: Productivity Improvement, **Simulation, Bottle-neck, Lean Manufacturing, Machine Utilization.**

I. INTRODUCTION

Arnimech Group established in 1984 As "Akanksha Enterprises" followed by "Pioneer Industries" in 1992.

The quality products, timely deliveries, low manufacturing cost and customer trust, forced us to expand and became essential to establish the bigger setup and "Arni Mech products Pvt. Ltd." Came in existence in 1997. The heavy schedules started becoming a regular routine.

In 2001 Arni Mech qualified as a QS certified company and the next objective was to excel in exports. After achieving all the previous goals, "Arni Mech Machinist" & "Microtech CNC Engineers" setup came into existence in 2005 & 2006 respectively to cater the need of CNC & VMC machines. The Arnimech industry manufactures wide range of products from which Dowel ring have maximum production output in the company. Dowel ring is used in the Cummins engine for bushing purpose. This particular component is given to the Company for manufacturing since 2005.

Fig.1 : Dowel Ring

Currently the industry have more customer demand of the dowel ring. To fulfill the need of customer industry is facing following problems:

The company is facing the shortage of raw material because of this the industry do not fulfill the demand of customer.

The process of making dowel ring is done by several processes in which to make final product the process passes through two different industries, because of this sometimes due to improper work of these two industries the Arnimech Industry did not get the material in time.

II. STEPS OR PROCEDURE INVOLVED IN METHODS STUDY

1. Study the current manufacturing scenario.
2. Collect the relevant data for the analysis.
3. Using Proper methodology converting the data into flex-sim model.
4. Carry out what-if analysis for different experimental ideas derived from lean manufacturing principles, theory of constraints and facility planning and plant layout.
5. Analyse the outcomes and to prepare a solution set agreed upon after discussions with the management.

III. LAYOUT OF THE SHOP FLOOR

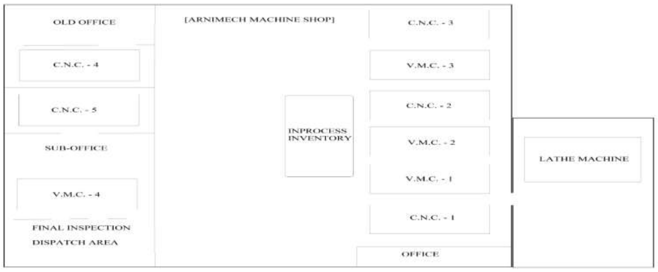

Fig. 2: Shop Layout

We have created a conceptual simulation model of the shop floor of Prasad Industries in FlexSim.

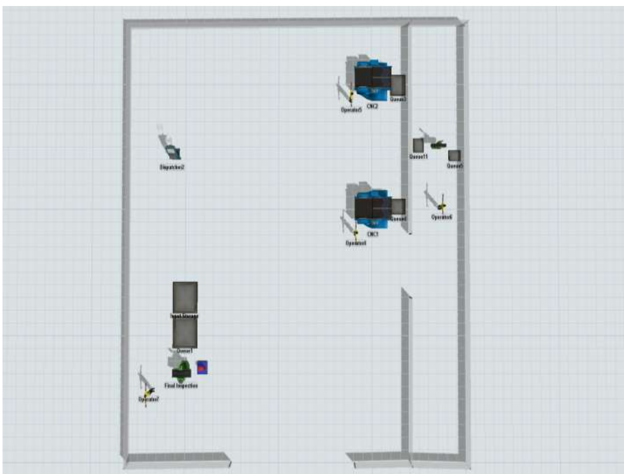

Fig. 3: Conceptual Simulation Model in FlexSim Software.

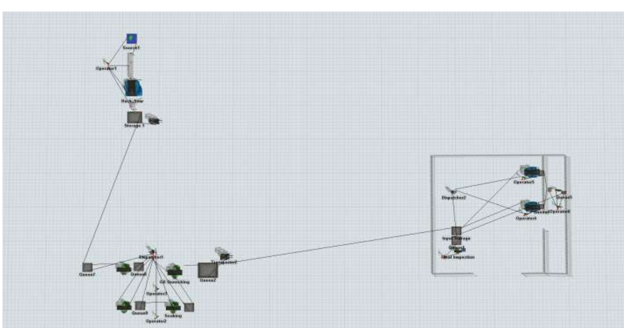

Fig 4: Conceptual Simulation Model in FlexSim Software of whole system.

In the above model we have taken all the possible elements and objects of the shop floor of Arnimech Industries which required to carry out our simulation of this project. The actual operations being carried out on the floor need to be converted into equivalent and suitable objects so that they can be used in the software i.e. FlexSim.

IV. PRELIMINARY DESIGN

After completing the conceptual design, we have to measure the performance of the system. It is essential to know what performance we have targeted for our system in order to take the decisions during experimentation. The main goal of this project is to improve the throughput of the system. In order to achieve our aim, we have to evaluate and measure the performance of each essential element in the system for various parameters. Having the detailed plan at this early stage facilitates better understanding of the system and the system variables

The process parameters that we have chosen to vary are as follows,

i. System output – System output is of the prime concern and the project will focus on maximizing the system output.
ii. Machine utilization – It is imperative that the machines stay in the processing mode for as much time as possible.
iii. Operator utilization – The operators should be busy for as much time as possible.
iv. Capacity planning- Bottlenecks hamper the system in a very adverse way and hence the total output of the system is diminished. In order that the plant is utilized to the maximum possible limit, the bottlenecks should be understood and alleviated.

V. INPUT DATA PREPARATION

To make any model, a vast amount of relevant data is required to take the simulation as same to the real world scenario as possible. Hence, it is important to understand all the details of data collection. We should check what data is already available and after deciding what data is actually needed. We proceeded with input data preparation in the following manner.

i. Understanding the process in general.
ii. Understanding the processes of each machine.
iii. Understanding the role of every operator.
iv. Breaking the processes in discrete measurable parts.
v. Measuring the time taken by various activities using a TPM TRAK software.
vi. Recording the time in tabular form.

Table I : Input Data Preparation Time Details in Minutes

Machine Name.	**Processing time Average (Min)**	**Processing Std Deviation (Min)**	**Setup time Average (Min)**	**Setup time std. deviation (Min)**
Hack Saw Machine	1033.36	5.91	2342.48	8.23
Hardening	3591.55	57.51	7217.3	84.88
Tempering	2695.7	40.79	7222	66.35
Soaking	2090.7	56.33	3626.8	57.37
Oil Quenching	612.6	16.12	3629	53.91
CNC1	2425.2	3.03	1559.18	10.8

Model Translation in pictures is shown as below:

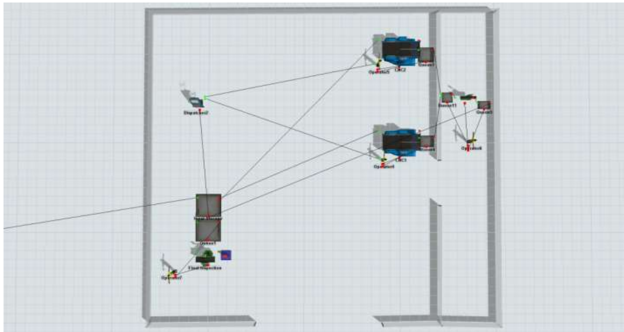

Figure 5: Initial Model translation: Connected

VI. VERIFICATION AND VALIDATION

Before proceeding with our experimentation and suggestions for the improvement of the system, we should ensure that our model represents the real-world system with considerable accuracy. To verify this, we have to compare the simulation model with the real-world scenario. In order to verify this. A deterministic model tells us the average performance of the system in all manners but the fact is for every test iteration it shows the constant result.To check our simulation model with the real life scenario, We have run our deterministic model for about one week working, which is 302400 sec considering 14 hours a day and 6 days a week. We have compared the production run of each and every output of the system.

Table II: Deterministic model- Trial Run

Model Run	System Output	Model Run	System Output
Run 1	5252	Run 6	5252
Run 2	5252	Run 7	5252
Run 3	5252	Run 8	5252
Run 4	5252	Run 9	5252
Run 5	5252	Run 10	5252

The Output of the real world was recorded for 5 weeks continuously, the output is shown in below table.

Table III: Real world week wise system output

Weeks	System Output
Week 1	5198
Week 2	5200
Week 3	5125
Week 4	5220
Week 5	5205
Average	**5189**

As can be seen from the readings, the behaviour of the simulated model is very close to the average performance of the real-world system, which shows that the simulation model we have modelled is considerably accurate and can be used as a basis for further experimentation.

I. Stochastic model:

We have performed a production run of 10 test runs of stochastic models and the results of which are shown in the below table.

Table IV: Stochastic model run

Model Run	System Output	Model Run	System Output
Run 1	5398	Run 6	5236
Run 2	5300	Run 7	5321
Run 3	5325	Run 8	5337
Run 4	5220	Run 9	5325
Run 5	5205	Run 10	5329
Average	**5299**		

As it can be seen from the above table, the output varies for every trial run and the average result of all trial runs is very close to the real-world system output.

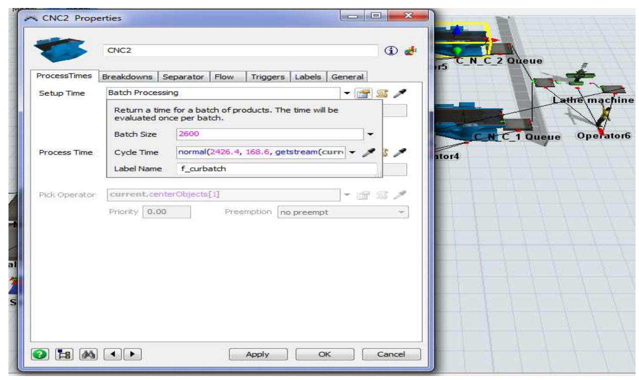

Figure 6: Normal distribution of cycle time for stochastic model

This model therefore can be used for the further experimentation to improve the system performance and to achieve the objectives of the study. Below is the statistical table of one of the production runs of the stochastic model.

First table shows the statistical run of machines.

Table V: Machine utilization statistics

Object	Class	Proces s time %	Setup time %	Bloc ked Tim e %	Waiti ng for Oper ator %	Waiting for Transpo rt %
CNC 1	Machine	79.79	0.765	0.00 0	0.000	CNC 1
CNC 2	Machine	80.05	0.808	0.00 0	0.000	CNC 2
Lathe Machine	**Machine**	**19.757**	**6.177**	**0.00 0**	**0.000**	**Lathe Machine**
Final Insp.	Processor	56.145	11.93 1	0.00 0	0.000	Final Insp.

From the above table it is observed that the machines Lathe Machine is having less process time as they are used for not more than 35% for processing. We can also observe that CNC1 and CNC2 are contributing 79% & 80% towards processing respectively. We can also see that there is scope to produce more parts from the Lathe Machine. From the above we can conclude that there is a bottle neck on Lathe Machine.

Below table shows the statistical run for operators.

Table VI: Operator utilization statistics

Object	Class	Idle time %	Busy %	Travel Loaded %	Travel Empty %
Op_ 4CNC 1	Operator	0.000	89.68	4.619	3.279
Op _5CNC 2	Operator	0.000	88.546	5.100	5.208
Op_6Lathem/c	Operator	0.000	18.499	39.392	36.262
Op_7Final Insp	Operator	0.000	84.137	3.567	5.714

Below table shows the statistical run for Queues

Table VII: Queues Statistics

Object	Class	Max Content
Op Queue CNC 1	Queue	25
Op Queue CNC 2	Queue	25
Ip Queue Lathe Machine	Queue	1907.6
Op Queue Lathe Machine	Queue	1
Ip Queue Final Inspection	Queue	186

From the above table it is clear that the Input Queue for Lathe Machine parts are stacked in huge quantity.

VII. EXPERIMENTATION

I. Experiment 1:

If we observe in the stochastic model we can see that waiting components in the input queue of the lathe machine is more. It shows the bottleneck at the lathe machine & because of this the machine used for almost all time of the shift.

To overcome this problem, in experiment 1 we are using the lathe machine which is already situated in the industry but not used for the same work. For this we are adding the lathe machine in the simulation model with one worker & one dispatcher to work on it.

Below is the model of Experiment 1

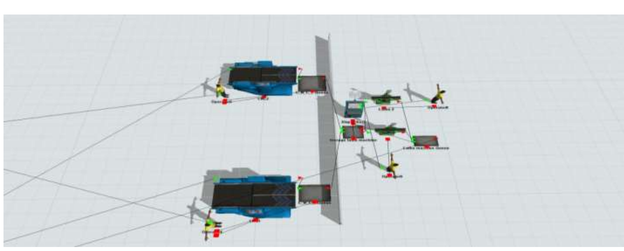

Fig 7: Plant Layout for Experiment no. 1

System throughput for 10 production runs.

Table VIII: System Output for Experiment 1

System Output			
Run	Parts	Run	Parts
1	5591	6	5592
2	5588	7	5577
3	5598	8	5585
4	5586	9	5581
5	5581	10	5583
Average	5586		

Below are the performance measure statistics of machines for experiment 1

Table IX: Machine utilization statistics for Experiment 1

Object	Class	Process time %	Setup time %	Blocked Time %	Waiting for Operator %	Waiting for Transport %
CNC 1	Machine	79.79	0.765	0.000	0.000	CNC 1
CNC 2	Machine	80.05	0.808	0.000	0.000	CNC 2
Lathe Machine	Machine	11.511	3.600	0.000	0.000	Lathe Machine
Final Insp	Processor	55.678	11.832	0.000	0.000	Final Insp

Below is the statistics for the Queues:

Table X: Queue statistics for Experiment no. 1

Object	Class	Max Content
Op Queue CNC 1	Queue	25
Op Queue CNC 2	Queue	25
Ip Queue Lathe Machine	Queue	21
Op Queue Lathe Machine	Queue	100
Ip Queue Final Inspection	**Queue**	**2131**

II. Experiment no. 2:

After the experiment no.1 we see that the bottleneck at the lathe machine is shifted to the next operation which is final inspection. Because of using two lathe machines the work load is decreased at the lathe machines. This results in that the components from both lathe machines are increased in the numbers. To reduce the bottleneck at the final inspection we add the one more worker to reduce the effort of existing operator.

Below is the system model for Experiment 2

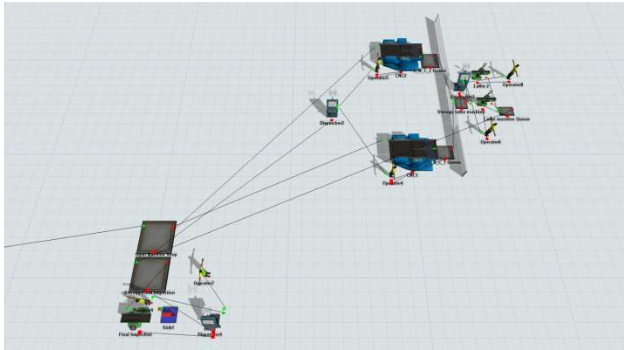

Figure8: Simulation model of Experiment no. 2

Below is the statistics of system output for the Experiment no. 2

Table XI: System output for experiment 2

System Output			
Run	**Parts**	**Run**	**Parts**
1	6003	6	6002
2	5997	7	5987
3	6010	8	5995
4	5999	9	5992
5	5993	10	5595
		Average	**5997**

Table XII: Machines utilization statistics of experiment 2

Object	Class	Proces s time %	Setup time %	Bloc ked Time %	Waiti ng for Opera tor %	Object
CNC 1	Machine	79.79	0.765	0.00 0	0.000	CNC 1
CNC 2	Machine	80.05	0.808	0.00 0	0.000	CNC 2
Lathe Machin e	Machine	11.511	3.600	0.00 0	0.000	Lathe Machi ne
Final Insp	**Processo r**	**59.775**	**12.710**	**0.00 0**	**0.000**	**Final Insp**

Below is the table for statistical data of Queues

Table XIII: Queues statistics for Experiment no. 2

Object	Class	Max Content
Op Queue CNC 1	Queue	25
Op Queue CNC 2	Queue	25
Ip Queue Lathe Machine	Queue	20.40
Op Queue Lathe Machine	Queue	100
Ip Queue Final Inspection	**Queue**	**1721**

III. Experiment No. 3

After doing the experiment no.2 we still did not get the targeted system output. There is small change between experiment no. 1 & experiment no. 2 but not that big as we required.

To increase the system output of experiment no. 2 we added one more inspection unit & the worker in the experiment no. 2 is assigned on the new inspection unit for the same work

Below is the system model for experiment no. 3

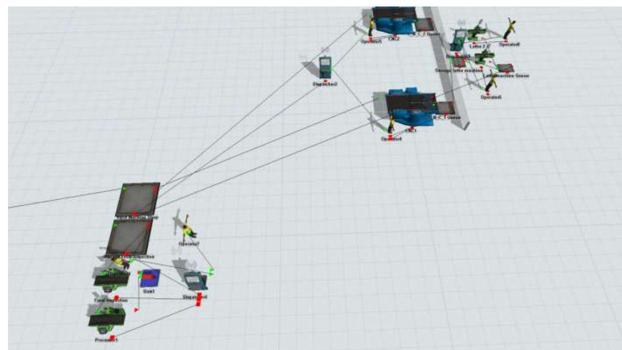

Figure 9: Simulation model for experiment no. 3

Below is the throughput improvement table of part for experiment 3,

Table XIV: System throughput for the experiment 3

System Throughput			
Run	**Parts**	**Run**	**Parts**
1	7640	6	7649
2	7630	7	7610
3	7654	8	7655
4	7632	9	7641
5	7624	10	7646
Average	**7638**		

Below is the table for machine statistics of the system.

Table XV: Machine utilization statistics for experiment no. 3

Object	Class	Proces s time %	Setup time %	Block ed Time %	Waitin g for Operat or %	Object
CNC 1	Machine	79.79	0.765	0.000	0.000	CNC 1
CNC 2	Machine	80.05	0.808	0.000	0.000	CNC 2
Lathe Machine	Machine	11.511	3.600	0.000	0.000	Lathe Machin e
Final Insp	Processor	38.10	8.100	0.000	0.000	Final Insp

Below is the table for the statistics of Queues of the system.

Table XVI: Queues Statistics for Experiment no. 3

Object	Class	Max Content
Op Queue CNC 1	Queue	25
Op Queue CNC 2	Queue	25
Ip Queue Lathe Machine	Queue	20.40
Op Queue Lathe Machine	Queue	100
Ip Queue Final Inspection	**Queue**	**98**

VIII. RESULTS AND DISCUSSION

From the table of system output for experiment no. 1, it can be observed that, As we use the one more lathe machine in the experiment no. 1 the output of the system is increased by 110 parts per week. The increase in throughput can be calculated as below formula:

$$Increase\ in\ throughput = \frac{Improved\ Output - Stochastic\ Output}{Stochastic\ Output} X\ 100$$

$$\frac{5586 \quad - \quad 5299}{5299} X\ 100$$

=5.41%

As we used the another lathe machine with one more worker the productivity is increased by 5.41%.

After doing the experiment no.2 we still did not get the targeted system output. There is small change between experiment no. 1 & experiment no. 2 but not that big as we required.

To increase the system output of experiment no. 2 we added one more inspection unit & the worker added in the experiment no. 2 is assigned on the new inspection unit for the same work.

$$Increase\ in\ throughput = \frac{Improved\ Output - Pervious\ Output}{Earlier\ Output} X\ 100$$

=

$$\frac{7638 \quad - \quad 5299}{5299} X\ 100$$

=44.14%

IX. CONCLUSION

To achieve the targeted throughput of the system, We have performed the simulation of the entire system with all possible experiments which will incur minimum expense. So for from our simulation of process As we see that by adding total two operators & one final inspection unit with two dispatcher in simulation model we can achieve the increased output of 2449 parts per week.

$$Increase\ in\ throughput = \frac{Improved\ Output - Pervious\ Output}{Earlier\ Output} X\ 100$$

=

$$\frac{7638 \quad - \quad 5299}{5299} X\ 100$$

=44.14%

For our final experiment we have achieved increase in throughput of 44.14% to achieve. In order to achieve the throughput by suggested by us, we have recommended the company to invest 19,000 INR as per the table of cost expense for experiment no. 3.

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