

Line Balancing and Throughput Improvement Using Simulation Software

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Abstract:- Simulation is the most effective tool in conducting a study of line balancing. By using a simulation software, we can view the results very quickly which helps in taking the big decisions. The bottlenecks of the system can be easily identified with simulation. This study focuses to meet the targeted throughput for the maximum demand of the customer. A simulation tool is used to carry out the analysis of the current system and improvements are suggested by conducting various experiments. The aim is to balance the line by reducing the losses or to suggest the alternate ways to achieve the targeted throughput of the system. A small-scale industry is selected where the customer demands for peak requirement are not met. In simulation, the study of bottle-necks present in the system are identified and solutions are given to minimize them as possible. The bottle necks are identified by studying machine utilization statistics, Queue parts statistics. System throughput is monitored for every experiment.

Keywords: Simulation, Throughput, Bottle-neck, Statistics, Machine Utilization.

I. INTRODUCTION

Prasad Industries is an IATF 16949:2016 and ISO 9001:2015 certified CNC machine shop. Prasad Industry is manufacturing components for various sectors such as Automobile, Machine tool Industry, Oil and Gas Exploration Industry, Fire Fighting Equipment's manufacturing. In Automobile sector, Prasad Industries manufacture Brake Tandem Master Cylinders (TMC). In this part family of TMC, there is a huge demand for one of their parts called TMC 128 which has a monthly requirement of average 10000 pieces per month. The peak requirement of this part goes to 12000 pieces per month. The process on this part consist of Casting, Coating, Turning, Milling, Drilling, Tapping and Fine Boring. The machining is done in House.



Fig.1 : Part TMC 128

Currently Prasad Industries is striving to meet the customer demands for quantitative requirements for the part TMC 128. Problems which company is facing are,

1. Industry is unable to meet the customer demand during peak requirements.
2. Machines and are underutilized.
3. Planning of machines is inefficient.

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. ABOUTTPM-TRAK SOFTWARE

TPM-Trak is a IOT (Internet of Things) software which provides the live data of machine to the computer. There is hardware module of TPM-TRAK which is connected to machines and the machines are connected to server computer with the help of Lan network. TPM-Trak OEE provides real-time data acquisition, analytics, dashboards and reports for OEE, downtimes, in-cycle stoppages and other advanced machine production parameters that are vital to increasing shop-floor production and profits.

IV. LAYOUT OF THE SHOP FLOOR

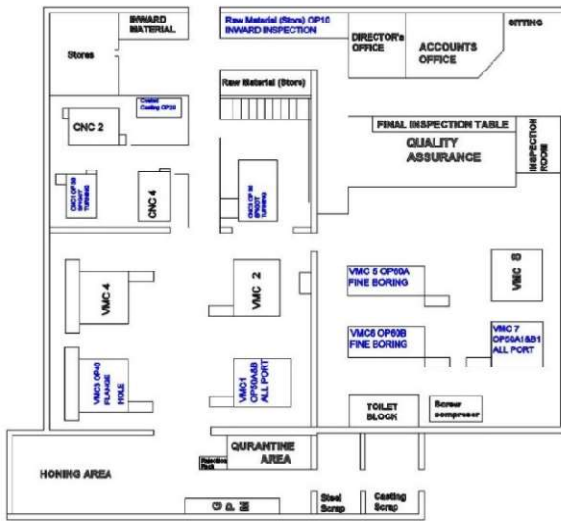


Fig. 2: Shop Layout

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



Fig. 3: Conceptual Simulation Model in FlexSim Software.

In the above model we have covered all the possible elements and objects of the shop floor of Prasad Industries which necessary 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.

V. 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.

VI. INPUTDATA PREPARATION

To build any model, a vast amount of relevant data is needed to take the simulation as close to the real-world scenario as possible. Hence, it is important to understand all the details of data collection. 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.



Fig.4: TPM- TRAK Company dashboard view

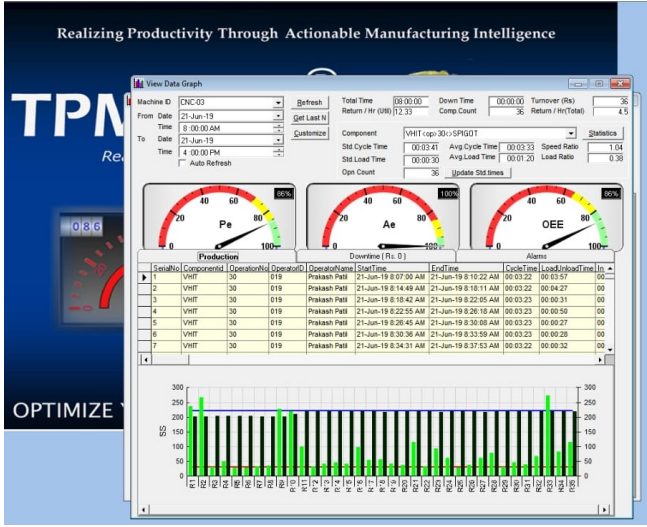


Fig.5: TPM TRAK Live Machine details window

Table I : Input Data Preparation Time Details in Minutes

Operation no.	Processing time Average (Min)	Processing Std Deviation (Min)	Setup time Average (Min)	Setup time std. deviation (Min)
30	3.46	0.1	0.3	0.22
40	1.38	0.004	0.42	0.313
50	18.5	0.197	0.91	0.39
60 A	10.17	0.004	1	0.44
60 B	10.672	0.089	0.9	0.368

Model Translation in pictures is shown as below:

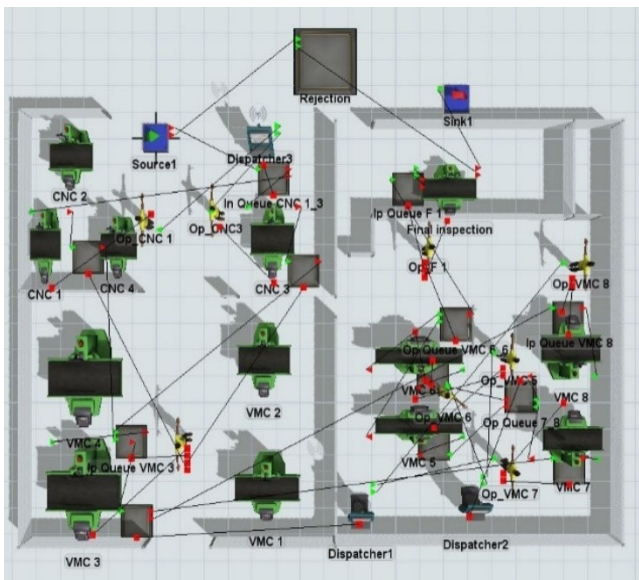


Figure 6: Initial Model translation: Connected

VII. 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, we should use deterministic model.

To check our simulation model with the real-life scenario, We have run our deterministic model for about one week working, which is 453600 sec considering 21 hours a day and 6 days a week.

Table II: Deterministic model- Trial Run

Model Run	System Output	Model Run	System Output
Run 1	2382	Run 6	2382
Run 2	2382	Run 7	2382
Run 3	2382	Run 8	2382
Run 4	2382	Run 9	2382
Run 5	2382	Run 10	2382

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	2436
Week 2	2388
Week 3	2432
Week 4	2404
Week 5	2356
Average	2403

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	2376	Run 6	2411
Run 2	2376	Run 7	2395
Run 3	2447	Run 8	2415
Run 4	2421	Run 9	2436
Run 5	2382	Run 10	2410
Average	2407		

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.

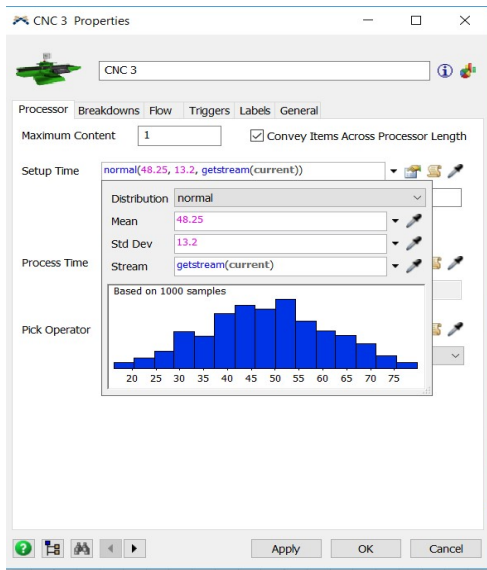


Figure 7: Normal distribution of cycle time for stochastic model

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	Process time %	Blocked Time %	Setup time %	Waiting for Operator %	Waiting for Transport %
CNC 1	Machine	33.062	0	7.725	0.000	0.000
CNC 3	Machine	80.597	0	0.283	0.000	0.420
VMC 3	Machine	45.311	0	30.318	0.893	0.000
VMC 7	Machine	72.228	0.69	0.692	0.000	0.893
VMC 8	Machine	26.597	0	0.608	0.000	0.016
VMC 5	Machine	76.247	0	18.735	0.000	0.000
VMC 6	Machine	75.617	0.01	18.473	0.000	0.000
Final. Insp	Processor	38.696	0.01	0.000	0.000	0.010

From the above table it is observed that the machines CNC 1 and VMC 8 are having less process time as they are used for not more than 35% for processing. We can also observe that VMC 5 and 6 are contributing 76 % towards processing, while CNC 3 is contributing 80.6% of its time for processing of the part. We can also see that there is scope to produce more parts for VMC 3. From the above we can conclude that there is a bottle neck on CNC 3 then to VMC 5 and VMC 6. Below table shows the statistical run for operators

Table VI: Operator utilization statistics

Object	Class	Idle time %	Busy %	Travel Loaded %	Travel Empty %
Op CNC 1	Operator	92.265	0.000	0.000	0.000
Op CNC 3	Operator	80.596	0.000	0.210	0.000
Op VMC 3	Operator	65.046	0.000	1.700	1.453
Op VMC 7	Operator	97.010	0.000	1.138	0.869
Op VMC 8	Operator	99.127	0.000	0.469	0.020
Op VMC 5	Operator	98.665	0.000	0.484	0.629
Op VMC 6	Operator	99.940	0.000	0.020	0.020
Op F1	Operator	99.890	0.000	0.050	0.050

Below table shows the statistical run for Queues

Table VII: Queues Statistics

Object	Class	Input parts	output parts	Balance parts
Ip Queue CNC 1/3	Queue	2880	2480	400
Op Queue CNC 1	Queue	721	721	0
Op Queue CNC 3	Queue	1758	1756	2
Ip Queue VMC 3	Queue	2477	2476	0
Op Queue VMC 3	Queue	2476	2470	6
Ip Queue VMC 7	Queue	1848	1842	6
Ip Queue VMC 8	Queue	1848	1842	6
Op Queue VMC 7/8	Queue	2456	2456	0
Ip Queue VMC 5	Queue	1228	1227	1
Ip Queue VMC 6	Queue	1228	1227	1
Op Queue VMC 5/6	Queue	2450	2442	8
Ip Queue F1	Queue	2442	2438	4

From the above table it is clear that at all places except for Input Queue for CNC 1 and 3 the parts are stacked in huge quantity. This happens because the 500 parts scheduled each day and at the end of the day 100 out of 500 are processed and 400 are remained as a opening stock for next week. This phenomenon is quite normal and acceptable. But as per the system performance very few parts are kept for waiting in both the queues, Input queues as well as output queues.

VII. EXPERIMENTATION

I. Experiment 1:

If we look at our stochastic model, the waiting components in Input Queue for CNC 1 and 3 are more. As per the feedback from company, machine CNC 1 is not used full time. It is used for only 2-3 days for processing the part TMC 128. Rest of the days, CNC 1 is used for processing of other parts. The processing of the part is same as that of CNC 3. The fixtures are duplicated for doing processing on CNC 1.

Our target is to achieve the throughput of the part as close to 3000 parts per week. To achieve this for our first experiment, We suggest to use CNC 1 dedicatedly for the operation no. 30.

System throughput for 10 production runs.

Table VIII: System Output for Experiment 1

System Output			
Run	Parts	Run	Parts
1	2524	6	2529
2	2534	7	2535
3	2527	8	2524
4	2541	9	2516
5	2521	10	2528
Average	2528		

Below are the performance measure statistics of machines for experiment 1

Table IX: Machine utilization statistics for Experiment 1

Object	Class	Process time %	Blocked Time %	Setup time %	Waiting for Operator %	Waiting for Transport %
CNC 1	Machine	65.980	0	15.387	0.000	0.025
CNC 3	Machine	66.082	0	15.330	0.000	1.521
VMC 3	Machine	52.694	0.000	35.262	1.038	0.000
VMC 7	Machine	78.677	0.886	0.886	0.000	0.000
VMC 8	Machine	30.693	0.000	0.713	0.000	0.000
VMC 5	Machine	77.334	0.000	21.564	0.000	0.000
VMC 6	Machine	77.397	0.016	21.483	0.000	0.000
Final. Insp	Processor	40.615	0.000	0.000	0.000	0.000

Below is the statistics for the Queues:

Table X: Queue statistics for Experiment no. 1

Object	Class	Input parts	output parts	Balance parts
Ip Queue CNC 1/3	Queue	2880	2880	0
Op Queue CNC 1	Queue	1439	1439	0
Op Queue CNC 3	Queue	1441	1441	0
Ip Queue VMC 3	Queue	2880	2880	0
Op Queue VMC 3	Queue	2880	2869	11
Ip Queue VMC 7	Queue	2152	2148	4
Ip Queue VMC 8	Queue	716	714	2
Op Queue VMC 7/8	Queue	2860	2860	0
Ip Queue VMC 5	Queue	1430	1281	149
Ip Queue VMC 6	Queue	1430	1293	137
Op Queue VMC 5/6	Queue	2570	2560	10
Ip Queue F1	Queue	2560	2560	0

II. Experiment no. 2:

In experiment no. 1 we saw that there is scope in reducing the idle time of the turning centres CNC 1 and CNC 3. In order to do that we need to increase the inward quantity of the product.

When we discussed this problem with the industry, they decided to add a safety stock of 2000 nos. of this part at the end of every month so that there will be opening stock of 2000 nos. at the start of the month.

Below is the system model for Experiment 2

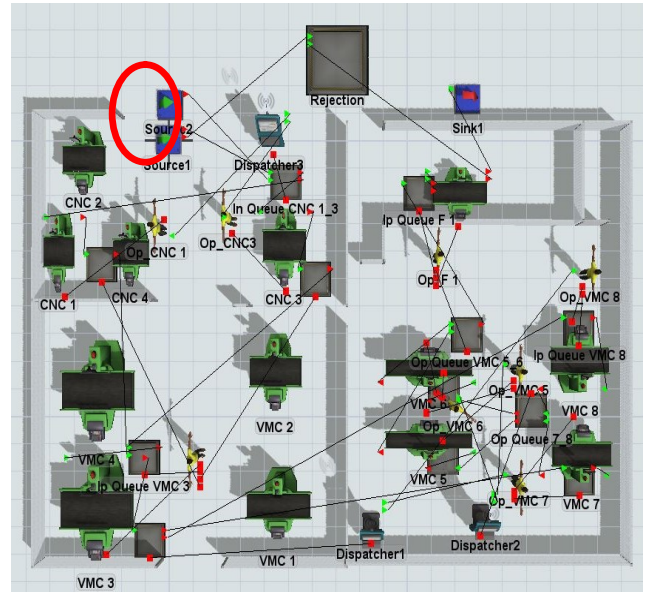


Figure8: Simulation model of Experiment no. 2

Here we have added one more source which will provide a fix and one-time input of 2000 nos. We have also not changed any conditions of previous experiment. As we have added stock of 2000 nos. the parts will be utilized by the turning machines and now the machined will not starve. This will not remove the bottle neck in system entirely.

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

Table XI: System output for experiment 2

System Output			
Run	Percentage	Run	Percentage
1	2524	6	2529
2	2534	7	2535
3	2527	8	2524
4	2541	9	2506
5	2521	10	2528
Average	2528		

Below is the table for statistics of machines:

Table XII: Machines utilization statistics of experiment 2

Object	Class	Process time %	Blocked Time %	Setup time %	Waiting for Operator %	Waiting for Transport %
CNC 1	Machine	79.043	0.00	18.452	0.000	0.029
CNC 3	Machine	79.142	0.00	18.363	0.000	1.835
VMC 3	Machine	57.430	0.00	38.426	1.113	0.000
VMC 7	Machine	73.132	0.96	0.957	0.000	0.000
VMC 8	Machine	33.328	0.00	0.774	0.000	0.000
VMC 5	Machine	77.556	0.00	21.342	0.000	0.000
VMC 6	Machine	77.397	0.01	21.483	0.000	0.000
Final. Insp	Processor	40.606	0.00	0.000	0.000	0.012

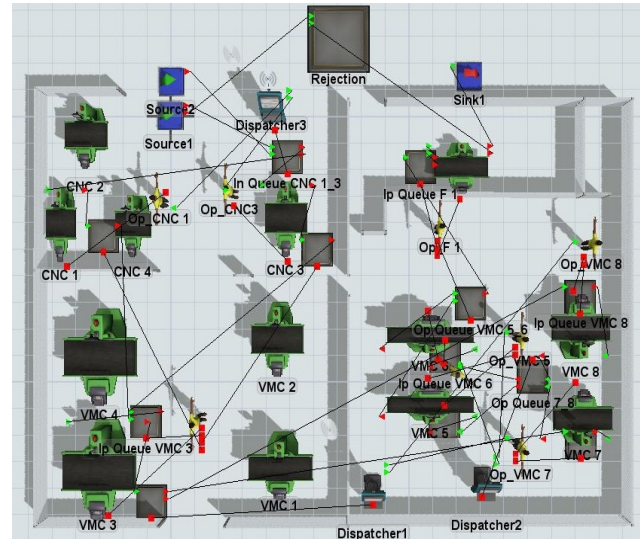


Figure 9: Simulation model for experiment no. 3

Below is the table for statistical data of Queues

Table XIII: Queues statistics for Experiment no. 2

Object	Class	Input parts	output parts	Balance parts
Ip Queue CNC 1/3	Queue	4880	3451	1429
Op Queue CNC 1	Queue	1723	1723	0
Op Queue CNC 3	Queue	1726	1725	1
Ip Queue VMC 3	Queue	3448	3139	308
Op Queue VMC 3	Queue	3138	3138	0
Ip Queue VMC 7	Queue	2352	2250	103
Ip Queue VMC 8	Queue	779	776	3
Op Queue VMC 7/8	Queue	3018	3018	0
Ip Queue VMC 5	Queue	1509	1280	229
Ip Queue VMC 6	Queue	1509	1293	216
Op Queue VMC 5/6	Queue	2569	2560	9
Ip Queue F1	Queue	2560	2560	0

III. Experiment No. 3

When we reviewed the fixture design, it was observed that the part is clamped using a nut and a spanner which consumes on an average 55 seconds to load and unload the part. After discussion with company, we concluded that this timing can be reduced by using a square threading bolt with a spline headed nut. With this improved method wereduced the setup time to 35.36 sec.

Below is the system 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	Percentage	Run	Percentage
1	2534	6	2529
2	2534	7	2535
3	2527	8	2524
4	2541	9	2526
5	2530	10	2528
Average	2530.8		

Below is the table for machine statistics of the system.

Table XV: Machine utilization statistics for experiment no. 3

Object	Class	Process time %	Blocked Time %	Setup time %	Waiting for Operator %	Waiting for Transport %
CNC 1	Machine	79.043	0	18.441	0	0.029
CNC 3	Machine	79.142	0	18.363	0	1.835
VMC 3	Machine	63.050	0	27.124	1.2	0.000
VMC 7	Machine	72.221	0.5	0.517	0	0.035
VMC 8	Machine	71.624	0	3.187	0	0.000
VMC 5	Machine	77.270	0	21.875	0	0.000
VMC 6	Machine	77.819	0.01	21.307	0	0.000
Final. Insp	Processor	40.683	0	0.000	0	0.012

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

Table XVI: Queues Statistics for Experiment no. 3

Object	Class	Input parts	output parts	Balance parts
Ip Queue CNC 1/3	Queue	4880	3451	1429
Op Queue CNC 1	Queue	1723	1723	0
Op Queue CNC 3	Queue	1726	1724	1
Ip Queue VMC 3	Queue	3447	3446	1
Op Queue VMC 3	Queue	3445	3438	7
Ip Queue VMC 7	Queue	1719	1715	4
Ip Queue VMC 8	Queue	1719	1715	4
Op Queue VMC 7/8	Queue	3424	3424	0
Ip Queue VMC 5	Queue	1712	1284	428
Ip Queue VMC 6	Queue	1712	1296	416
Op Queue VMC 5/6	Queue	2576	2570	7
Ip Queue F1	Queue	2570	2566	4

Table XVII: System Output Experiment no. 4

System Throughput			
Run	Percentage	Run	Percentage
1	3342	6	3340
2	3344	7	3342
3	3342	8	3331
4	3359	9	3337
5	3333	10	3339
Average	3341		

Below is the statistics table of machine for experiment 4:

Table XVIII: Machine utilization statistics for experiment 4

Object	Class	Process time %	Blocked Time %	Setup time %	Waiting for Operator %	Waiting for Transport %
CNC 1	Machine	79.096	0.00	18.463	0.000	0.029
CNC 3	Machine	79.124	0.00	18.360	0.000	1.847
VMC 3	Machine	63.068	0.00	27.130	1.244	0.000
VMC 7	Machine	72.243	0.51	0.518	0.000	0.035
VMC 8	Machine	71.651	0.00	3.187	0.000	0.000
VMC 5	Machine	76.591	0.00	12.161	0.000	0.000
VMC 6	Machine	75.807	0.01	12.257	0.000	0.000
VMC 2	Machine	74.276	0.00	22.181	2.081	0.377
Final. Insp	Processor	53.709	0.01	0.000	0.000	0.016

IV. Experiment no. 4

In earlier experiment it is found that the operation no. 60 is the bottle necking operation. To remove it we have added one more machine to the system on which this same operation will be carried out. We have used this third machine dedicatedly for this operation. By doing this we have got the drastic change in the system output.

Below is the system model for experiment no. 4

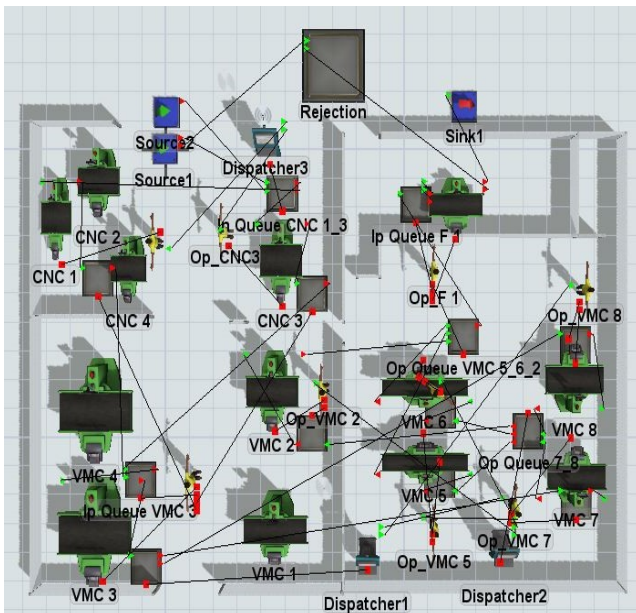


Figure 10: System model of Experiment no. 4

Below is the table of system output for the experiment 4

Below is the statistics table of Queues for Experiment 4:

Table XIX: System Output Experiment no. 4

Object	Class	Input parts	output parts	Balance parts
Ip Queue CNC 1/3	Queue	4880	3452	1428
Op Queue CNC 1	Queue	1724	1724	0
Op Queue CNC 3	Queue	1725	1724	1
Ip Queue VMC 3	Queue	3448	3447	1
Op Queue VMC 3	Queue	3446	3438	8
Ip Queue VMC 7	Queue	1719	1715	4
Ip Queue VMC 8	Queue	1719	1715	4
Op Queue VMC 7/8	Queue	3422	3422	0
Ip Queue VMC 5	Queue	1141	1140	1
Ip Queue VMC 6	Queue	1141	1140	1
Op Queue VMC 5/6	Queue	3399	3392	7
Ip Queue VMC 2	Queue	1124	1124	0
Ip Queue F1	Queue	3392	3392	0

V. Experiment no. 5

In pervious experiment we saw that the throughput is achieved more than the target. In order to do that we have used this machine for only 40% for its total time in week for this part which means 2 days and 1 shift. To make use only 40% of its total time we distributed the parts to machines VMC5, 6 and 2 in flowing order, VMC 5 will get 42.8% of the load from Output queue of VMC 7/8, VMC 6 will get 42.8% of load from Output queue 7/8, VMC 2 will get remaining 14.3% of the load from Output queue VMC 7/8. The system throughput which we got was as close to the target.

Below is the system model for experiment no. 5

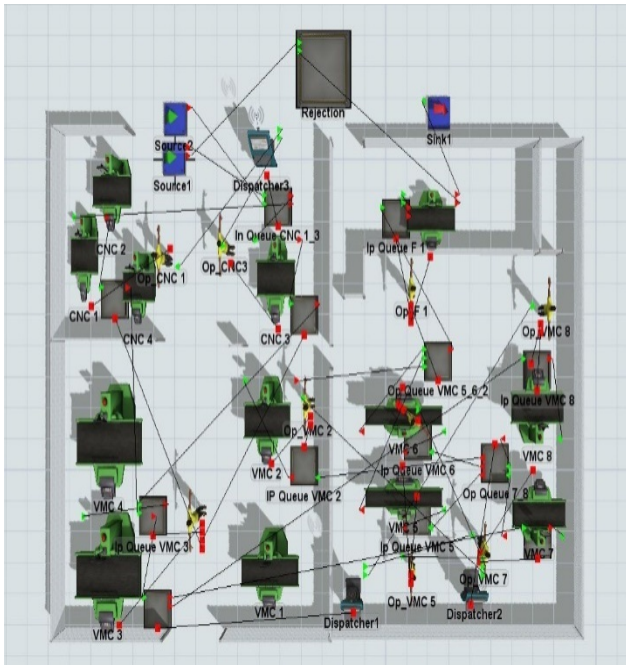


Figure 11: System model of Experiment no. 5

Below is the table of system output for the experiment 5

Table XX: System Output Experiment no. 5

System Throughput			
Run	Percentage	Run	Percentage
1	3173	6	3280
2	3246	7	3224
3	3242	8	3191
4	3259	9	3250
5	3204	10	3220
Average	3229		

Below is the statistics table of machine for experiment 5:

Table XXI: Statistics of queues for experiment 5

Object	Class	Process time %	Blocked Time %	Setup time %	Waiting for Operator %	Waiting for Transport %
CNC 1	Machine	79.095	0.000	18.459	0.000	0.029
CNC 3	Machine	79.121	0.000	18.355	0.000	0.271
VMC 3	Machine	63.067	0.000	27.083	1.244	0.000
VMC 7	Machine	72.214	0.518	0.518	0.000	0.035
VMC 8	Machine	71.610	0.000	3.191	0.000	0.000
VMC 5	Machine	77.338	0.000	21.586	0.000	0.000
VMC 6	Machine	77.681	0.015	21.317	0.000	0.000
VMC 2	Machine	32.658	0.000	9.745	0.666	0.189
Final. Insp	Processor	48.417	0.000	0.000	0.000	0.014

Below is the statistics table of Queues for experiment 5:

Table XXII: Statistics of queues for experiment 5

Object	Class	Input parts	output parts	Balance parts
Ip Queue CNC 1/3	Queue	4880	3452	1428
Op Queue CNC 1	Queue	1724	1724	0
Op Queue CNC 3	Queue	1725	1724	1
Ip Queue VMC 3	Queue	3448	3447	1
Op Queue VMC 3	Queue	3446	3438	8
Ip Queue VMC 7	Queue	1719	1715	4
Ip Queue VMC 8	Queue	1719	1715	4
Op Queue VMC 7/8	Queue	3422	3422	0
Ip Queue VMC 5	Queue	1141	1140	1
Ip Queue VMC 6	Queue	1141	1140	1
Op Queue VMC 5/6	Queue	3399	3392	7
Ip Queue VMC 2	Queue	1124	1124	0
Ip Queue F1	Queue	3392	3392	0

VIII. RESULTS AND DISCUSSION

From the table of system output for experiment no. 4, it can be observed that, Throughput has increased to on an average 3341 nos. per week. The company was targeting the throughput of minimum 3000 nos. per week. So as per our experimentation, if the machine VMC 2 is used dedicatedly for this operation, We can achieve the targeted throughput for this part as per customer's peak demand. Improvement in throughput with respect to previous experiment is as follows:

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

$$= \frac{3341 - 2530}{2530} \times 100$$

$$= 34.51 \%$$

From the above study we it is seen that the throughput of the system is increased by 34.51 % than pervious experiment.

From the table of statistics of machine utilization for experiment no. 4, it is found that most of the machines are contributing for more than 70% of their available time for processing. When we dedicatedly used VMC 2 for operation no. 60 the machine was utilized for 74.27% for proceeding of the parts. But as we can see the throughput was more than 3000 nos. per week, perhaps we should use this machine for less than 74.27% and free its capacity for producing other parts.

From the table of statistics of queues, it can be seen that there is very less material pending for processing. In earlier experiment it was seen that there were 428 parts remaining to be processed for VMC 5 and 416 parts remaining to be processed on VMC 6 for operation 60. After adding VMC 2 machine on this line it was observed that these remaining unprocessed parts were shifted to VMC 2 for processing. Also, it is observed that there are no parts remaining to be processed for operation no. 60 on VMC 2 machine.

In Experiment no. 5, From the table of system output for experiment no. 5, we can see that the throughput average of 10 production runs is 3229 nos./ week. We can also see that the minimum throughput is 3173 nos. per week and maximum throughput is 3280 nos. per week. This indicates that our decision to use the machine VMC 2 for 40% of time is satisfying the throughput requirement of the company.

The Throughput improvement for this experiment with respect to stochastic is as follows:

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

$$= \frac{3329 - 2407}{2407} \times 100$$

$$= 38.30\%$$

For this final experiment the system throughput has increased to 38.30 % than the stochastic model.

From the table of statistics of machine utilization for experiment no. 5, we can see that the machine VMC 2 is contributing 32% of its time for processing, 9.7 % of the time for setup. Remaining time its idle and can be used for processing of other parts.

From the table of statistics of Queues, it can be found that, when we decrease the use of VMC 2 the parts are stacked in the input queue of VMC 5 and 6. From the above statistics parts in input queue VMC 5 are 202 nos. and in input queue

VMC 6 are 179 nos. These are the parts pending for operation no. 60.

For every experiment the expense to be done on the system to be calculated, this expense should be precisely calculated and should be recommended to the industry.

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 we have achieved the increase in throughput of the part TMC 128 as per below:

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

$$= \frac{3329 - 2407}{2407} \times 100$$

$$= 38.30\%$$

For our final experiment we have achieved increase in throughput of 38.30% to achieve the target which will meet the customer's peak demand of 12000 nos. per month.

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