# Performance Evaluation and Optimization of Manufacturing Assembly Line by Using Discrete Event Simulation

**K.Amarnath, P.Surendernath, M.Gangadhar**

***Abstract:*** ***In today's global competition expectation of customers' and their needs are changing rapidly; this situation force organizations to work more effectively in their production processes due to different reasons. Discrete event simulation is a powerful tool in simulating and evaluating the performance of real time systems. In this performance evaluation the virtual environment of an Extrusion dies manufacturing and assembly line is built by object-oriented modelling technology. The simulation software is used to identify the problems in manufacturing and assembly line delays to reach target by simulating, collecting simulation data and analyzing simulation results, so that the overall efficiency and productivity of the plant assembly line is improved with same number of cells, labours, and working hours. The main aim of this paper is to reduce idle time improve the performance of different sections and human activities and hence improve the productivity of the organization.***

***Index terms; Performance, Simulation, Extrusion Dies***

## I .INTRODUCTION

This paper focuses on a dies and tooling manufacturing company, the main purpose to evaluate and improve the performance. Case study start with the covering various analyses on the manufacturing and problem definition, secondly discrete simulation model is built with process simulation software, to observe the results of the simulation process with manipulation of variable parameter, finally different solutions suggested for the manufacturing line problems.

In dies manufacturing assembly line plays an important role in enabling a factory to improve the production target, deliver on time and at the right quantity and right quality. According to the production manager of a dies manufacturer, the manufacturing company facing problem in production target and delivery time issue. The major cause is the human operator machine attempting and unwanted movements of various reasons at the same time the machines are too old regular break downs. In this manufacturing line, majority of the production manually operated, to complete a die. This research will attempt to overcome the problem by maximizing the productivity as well as efficiency.

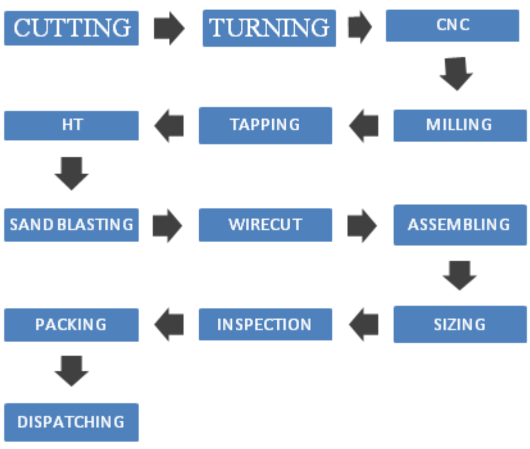


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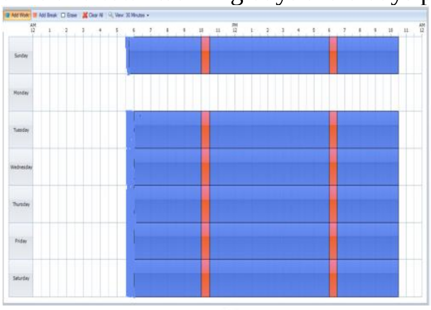
Fig 1.1 General manufacturing process
Fig 1.2 Extrusion Dies

## II. SIMULATION AND OPTIMIZATION OF MANUFACTURING ASSEMBLY LINE:

The collection of data through the interview, direct observation and reviewed documents available in company.

This the scenario of working hours of company presents as the calendar in process simulation software, research methodology adopted as follows to solve the problem. The work will run for 17 hours per day, red colour represents the break time and total working days are 6 days per week.



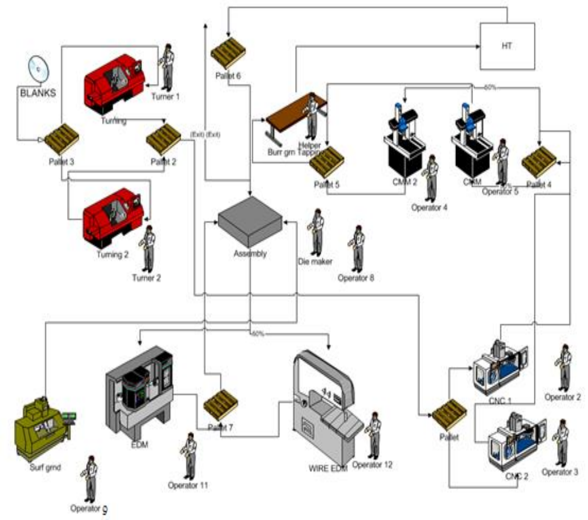



**Fig:2.1 Working Days Calendar**
**Fig 2.2 CURRENT PLANT LAYOUT**
Built in simulation software)

### A. Model Description (manufacturing)

Raw blanks arrive from cutting, using a Periodic Arrival pattern and receive an initial turning the blanks to size and then set in activity of under turning. After the work done under turning section the components set to move to CNC mill operation, from here same components are moved to conventional milling, here machining operations are completed. Then moved to burr grinding and tapping operations here helpers are performed the required activities. Finally dies are shifted to heat treatment operation.

### B. Model Description (assembly)

In assembly model blanks arrive from after heat treatment turning operation is performed, the usage of a Periodic Arrival pattern and obtain an initial turning the blanks to be sized. After the turning work achieved underneath turning phase the components set to distributed to CNC wire-cut operation, and EDM operation. Then moved to assembling (joining) the die set, next die maker final as the die profile sizing by using surface grinding.

Activity States (Single Cap) (Avg. Reps)

| Replication | Name | Scheduled Time (Hr) | % Operation | % Setup | % Idle | % Waiting | % Blocked | % Down |
|---|---|---|---|---|---|---|---|---|
| Avg | Burr grn Tapping | 102.00 | 37.23 | 0.00 | 59.26 | 3.51 | 0.00 | 0.00 |
| Avg | CNC 1 | 102.00 | 98.06 | 0.00 | 1.94 | 0.00 | 0.00 | 0.00 |
| Avg | CNC 2 | 102.00 | 82.97 | 0.00 | 1.41 | 0.00 | 0.00 | 15.62 |
| Avg | Con Mill 2 | 102.00 | 57.82 | 0.00 | 13.94 | 0.00 | 0.00 | 28.24 |
| Avg | Con Mill 1 | 102.00 | 58.69 | 0.00 | 41.31 | 0.00 | 0.00 | 0.00 |
| Avg | Turning 1 | 102.00 | 78.04 | 0.00 | 20.00 | 1.96 | 0.00 | 0.00 |
| Avg | Turning 2 | 102.00 | 80.35 | 0.00 | 19.65 | 0.00 | 0.00 | 0.00 |

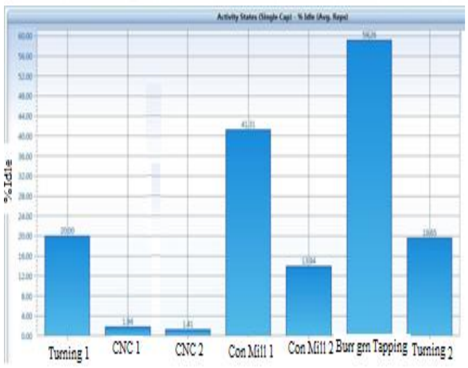
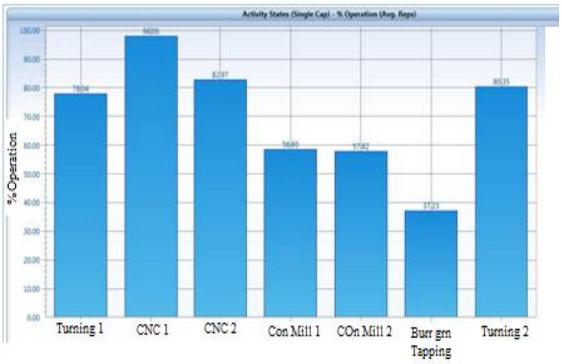



**Fig: 2.2.1 Simulation results of manufacturing (Before Optimization) .Fig 2.2.2 % idle**




| Activity States (Single Cap) (Avg. Reps) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Replication | Name | Scheduled Time (Hr) | % Operation | % Setup | % Idle | % Waiting | % Blocked | % Down |
| Avg | WIRE Cut | 102.00 | 22.25 | 0.00 | 71.87 | 0.00 | 0.00 | 5.88 |
| Avg | Die making | 102.00 | 24.52 | 0.00 | 25.73 | 0.01 | 0.00 | 49.75 |
| Avg | EDM | 102.00 | 53.48 | 0.00 | 44.81 | 0.00 | 0.00 | 1.72 |

**Fig: 2.2.3 Simulation results of Assembly (Before Optimization) Fig: 2.2.4 Table Activity data**

## III .PROBLEM IDENTIFIED IN MANUFACTURING

The current layout of machines does not facilitate high productivity. At the same time some machines are located close to each other, others are scattered either within the workshop or between different locations.

Here the turner and lathe machine utilization is 80% for the shift, loss of utilization per shift 20%. That loss of productivity as per the observation due to the moment of worker for shifting blanks from the main entrance that is other corner of plant.

The turned blanks have to be shifted further operation to CNC machining, here turning machines are one corner of the plant and CNC machines are other corner of the plant

*-Machine utilization*

Milling machine operator 4 & 5 and milling machine utilization is 58%, CNC2 machine and operator 3 utilization 82%

**Bottlenecks identified in assembly**

-The waiting (idle) time for the operator 8 is 55%
-The waiting (idle) time for the operator 9 is 53%
-The waiting (idle) time for the die maker is 75%

## A.OPTIMIZED PLANT LAYOUT

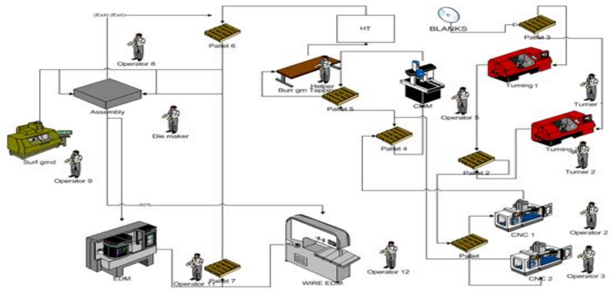


**Fig 3.1 Optimized simulation model**

## B.SIMULATION RESULTS OF MANUFACTURING (AFTER OPTIMIZATION)

| Activity States (Single Cap) (Avg. Reps) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Replication | Name | Scheduled Time (Hr) | % Operation | % Setup | % Idle | % Waiting | % Blocked | % Down |
| Avg | Burr grn Tapping | 102.00 | 42.95 | 0.00 | 52.37 | 4.68 | 0.00 | 0.00 |
| Avg | CNC 1 | 102.00 | 98.08 | 0.00 | 1.92 | 0.00 | 0.00 | 0.00 |
| Avg | CNC 2 | 102.00 | 97.26 | 0.00 | 2.74 | 0.00 | 0.00 | 0.00 |
| Avg | Con Mill 1 | 102.00 | 64.77 | 0.00 | 35.23 | 0.00 | 0.00 | 0.00 |
| Avg | Turning 1 | 102.00 | 98.04 | 0.00 | 1.96 | 0.00 | 0.00 | 0.00 |
| Avg | Turning 2 | 102.00 | 80.13 | 0.00 | 19.87 | 0.00 | 0.00 | 0.00 |

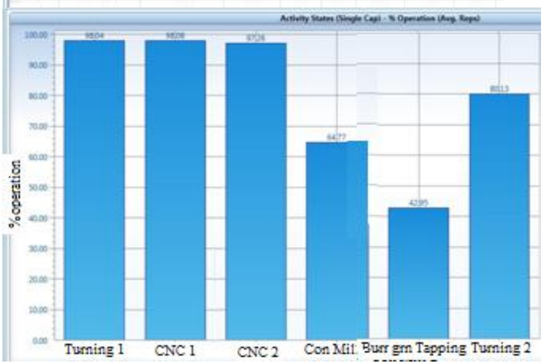



**Fig: 3.2 Table activity state data**
**Fig 3.3 % Operation**

## C.SIMULATION RESULTS OF ASSEMBLY (AFTER OPTIMIZATION):

| Activity States (Single Cap) (Avg. Reps) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Replication | Name | Scheduled Time (Hr) | % Operation | % Setup | % Idle | % Waiting | % Blocked | % Down |
| Avg | Die making | 102.00 | 46.57 | 0.00 | 53.43 | 0.00 | 0.00 | 0.00 |
| Avg | EDM | 102.00 | 54.16 | 0.00 | 44.13 | 0.00 | 0.00 | 1.72 |
| Avg | WIRE Cut | 102.00 | 20.04 | 0.00 | 74.08 | 0.00 | 0.00 | 5.88 |

**Fig: 3.4 Activity state data**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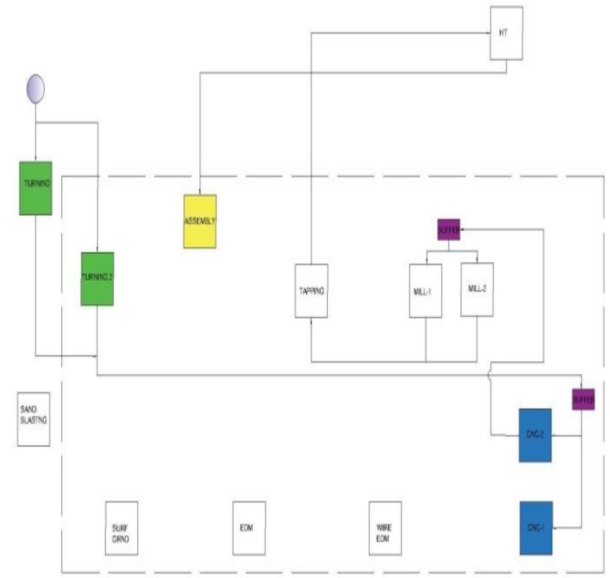


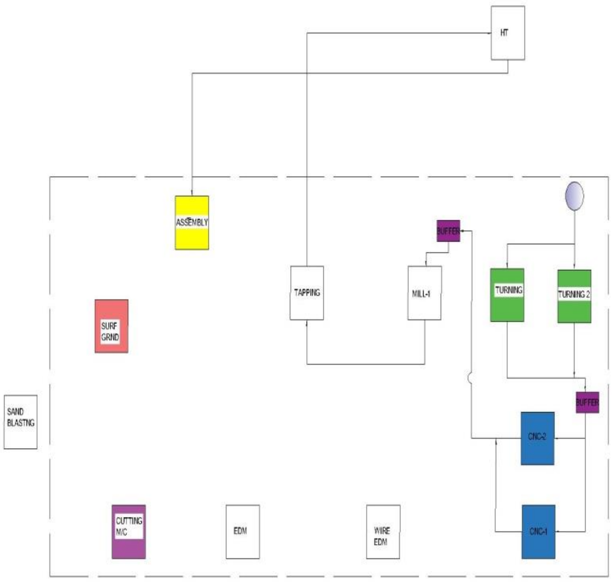



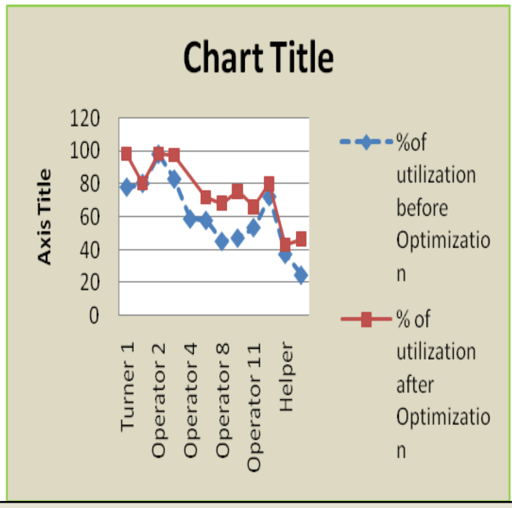

**Fig : 3.5 Current plant layout (actual)**
**Fig: 3.6 Optimized plant layouts (modified)**

## IV RESULT AND DISCUSSION

There are two sets of simulation results are reported in tabular form. In first set represents the results of simulation of the present situation of scenario. Comparing the utilization of each manufacturing activity line, are using the present simulation reference and varying the layout, machine attempting time of operator and decreasing the activity, break down time obtain the second set of results. Observation the second set have been built on the manufacturing line utilization. For both sets six replication are been used to build confidence of results obtain. By improving the direct labour productivity 7.7%, and the Machinery productivity 15.4%, Productivity values were found the final Raw materials productivity improvement 57.12%.

Table 4.1 Resource utilization table

| SL.No | Name | %of utilization before Optimization | % of utilization after Optimization | % of improvement after Optimization |
|---|---|---|---|---|
| 1 | Turner 1 | 78.04 | 98.02 | 19.98 |
| 2 | Turner 2 | 80.35 | 80.35 | 0 |
| 3 | Operator 2 | 98.06 | 98.07 | 0.01 |
| 4 | Operator 3 | 82.97 | 97.26 | 14.29 |
| 5 | Operator 4 | 58.69 | eliminated | - |
| 6 | Operator 5 | 57.82 | 71.6 | 13.78 |
| 8 | Operator 8 | 45.09 | 68.11 | 23.02 |
| 9 | Operator 9 | 47.06 | 75.25 | 28.19 |
| 10 | Operator 11 | 53.48 | 65.82 | 12.34 |
| 11 | Operator 12 | 72.25 | 79.91 | 7.66 |
| 12 | Helper | 37.23 | 42.83 | 5.6 |
| 13 | die maker | 24.52 | 46.2 | 21.68 |



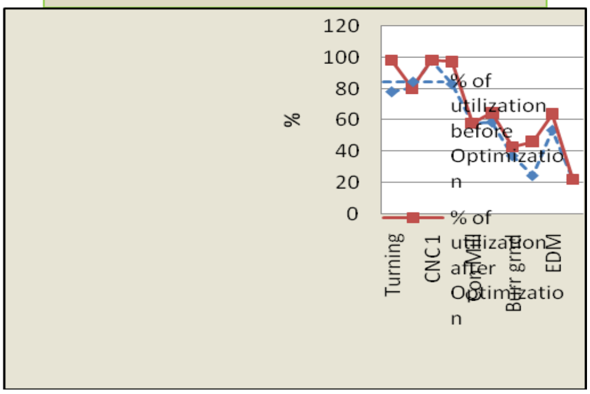




Fig.4.1 Resources utilization graph
Fig.4.2 Activity utilization graph

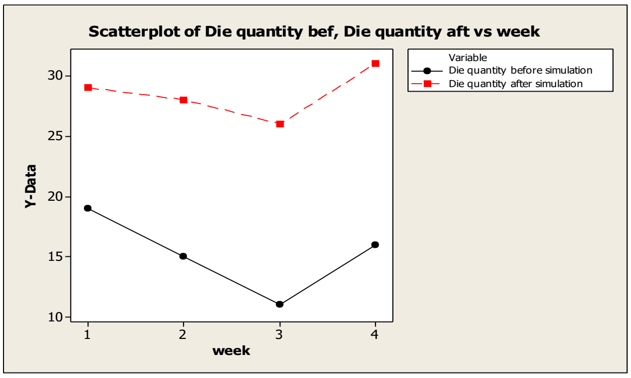



Fig.4.3 No. of dies produced per week

By improving the direct labour productivity 7.7%, and the Machinery productivity 15.4%, Productivity values were found the final Raw materials productivity improvement 57.12%.

## V.CONCLUSIONS

In this case study resource (worker) and activity (machine) performance in dies manufacturing system observed by building simulation model. The simulation is done by using process simulator software. Simulation models were built for the manufacturing and assembly sections separately and finally a full model is prepared for the purpose of conducting the computer based simulation.

The problems identified are the productivity of the existing system is low because of occurrence of bottlenecks, and waiting time identified at manufacturing assembly section. In assembly section die making is one of the problems. Better Utilisation of the Worker and machine performance can improve the productivity target. Otherwise, the company continues like this situation for a long time and it will be difficult for organisation to compete in today's global market. Therefore, to improve the existing performance of the company, resource like human and machine utilization improvement is a mandatory.

- Building and adapting on effective maintenance strategy to protect the production machines and extend their running life.
- By modification of layout can improve the production significantly.
- By eliminating one of the milling machine and same process performed on CNC machine can save Setup time Loading, Unloading and waiting time, labor cost etc.

- For improve the assembly section performance adding one operator to sizing where bottlenecks are identified.
- The overall productivity per month improved from 65 to 110 numbers.

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