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A RATIONAL APPROACH TO REDUCE THE VERTICAL - START UP TIME & ENHANCE THE PROFITABILITY OF AN INTEGRATED STEEL MANUFACTURING COMPANY - A CASE STUDY

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ABSTRACT

The paper involves a scientific study for assessing the existing production level of a Pre-Fabricated Steel Shop and thereby reducing the Vertical Start-Up Time of a newly Commissioned Pre-Fabrication shop of an Integrated Steel Manufacturing Company. Apart From this, an enhanced Annual Business Plan for the FY'2012 was also to be prepared, considering the Potential improvement areas in the existing system. However to achieve this enhanced Annual production target for FY'2012, the Researcher was keen interested to conduct a methodical study of the existing system & Identify the Bottlenecks in the production line. A proper System Study has been conducted in this regard, by using Several Industrial Engineering Tools & Techniques. Few of them are Line Balancing, Resource Allocation techniques, etc. Arena Simulation Software has been also used to validate the existing system and forecast the future production based upon the suitable changes & suggestions to the existing system. Based on the Research conducted by the Team, it was found that the system with an existing production of only 3.5 MTPA has a Potential to Produce around 5.3 MTPA of Steel Products..

KEYWORDS: Financial Impact, Incentive plan, Steel Melting Shop, Vertical Start-up.

INTRODUCTION

This Research paper deals with a novel line balancing problem for flexible transfer lines composed of Plasma / OXY Cutting machine, Welding machine, Drilling machine, Shot Blasting machine, Painting machine & Contract works. The studied lines are paced and serial, i.e. a part to be machined passes through a sequence of workstations. In addition, accessibility has to be considered. Moreover, the workstation workload depends on the sequence in which the operations are assigned because of setup times related to the change and displacement of tools, rotation of the part, etc.

Manufacturers are increasingly interested in optimizing their production systems. In this paper, a special case of production systems is considered: machining transfer lines. Transfer lines are widely used in the automotive industry. In such a line, a repeatable set of operations is executed each cycle time. The line is composed of sequentially arranged workstations and a transport system which ensures a constant flow of parts along the workstations. These machining lines produce large series of identical or similar items.

The paper involves a scientific study for assessing the existing production level of a Pre-Fabricated Steel Shop of an Integrated Steel Manufacturing Company. Apart From this, to achieve an enhanced Annual Business Plan for the FY’2012 the researcher was assigned the task to identify Potential improvement areas in the existing system. To achieve this enhanced Annual production target, the researcher was interested to conduct a methodical study of the existing system & identify the bottlenecks in the production line. A proper system study has been conducted in this regard, by using several Industrial Engineering tools & techniques. Few of them are Line Balancing, Resource allocation techniques, etc. Arena simulation software has been also used to conduct a rigorous Queue Analysis and recognize the bottlenecks to the Existing production. Based on the Areas identified in the existing system suitable suggestions were proposed and future production was forecasted after implementing those effective changes. Based on this research work, it was found that the system with an existing production of only 3500 Tonnes per month has a potential to produce around 6000 Tonnes per month of steel products. The detailed flow process chart is as shown below:

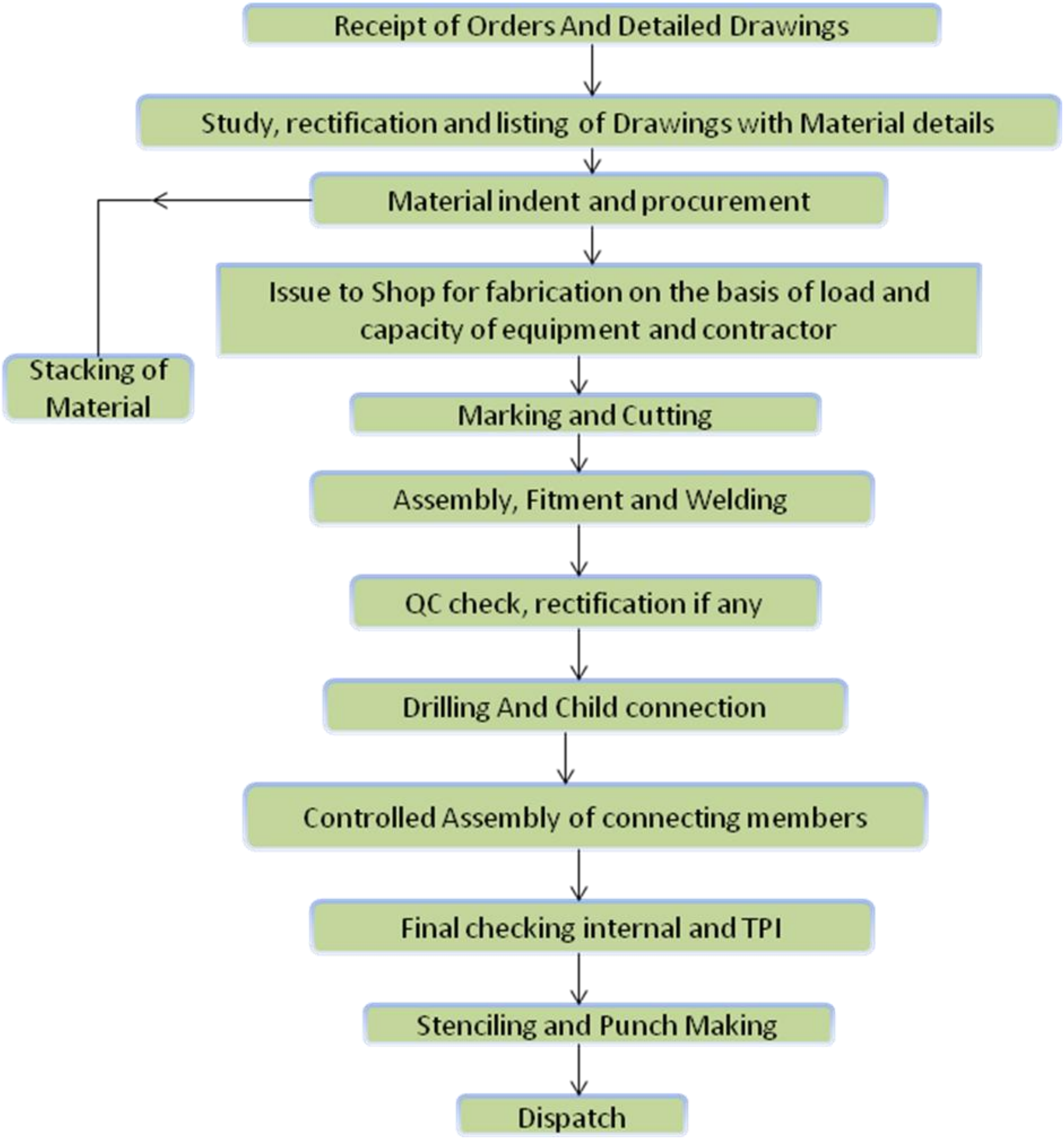


Fig. 1

In existing system, there are total four bays of this Pre-Fabrication Unit whose plant layout is shown in Fig.2. Eeach bay consist two EOT Crane (Electronic overhead Travelling Crane). Bay no. 1 & 4 is dedicated for production and Bay no. 2 & 3 is for fabrication work by contractor. AB & BC bay is utilized for raw material stock or raw material handling. Bay 1 consist one cutting bed, two welding m/c, one drilling m/c, one short blasting m/c. Bay 4 consist one cutting bed, two welding m/c, one drilling m/c, one blasting and painting m/c. In bay BC, steel plates stocked for use as raw material for I – beam. In addition, most of the raw material plates required is stocked at open yard at outside area and I-Beams produced in Bay 1 & 4 are also further fabricated in open area by different contractors.

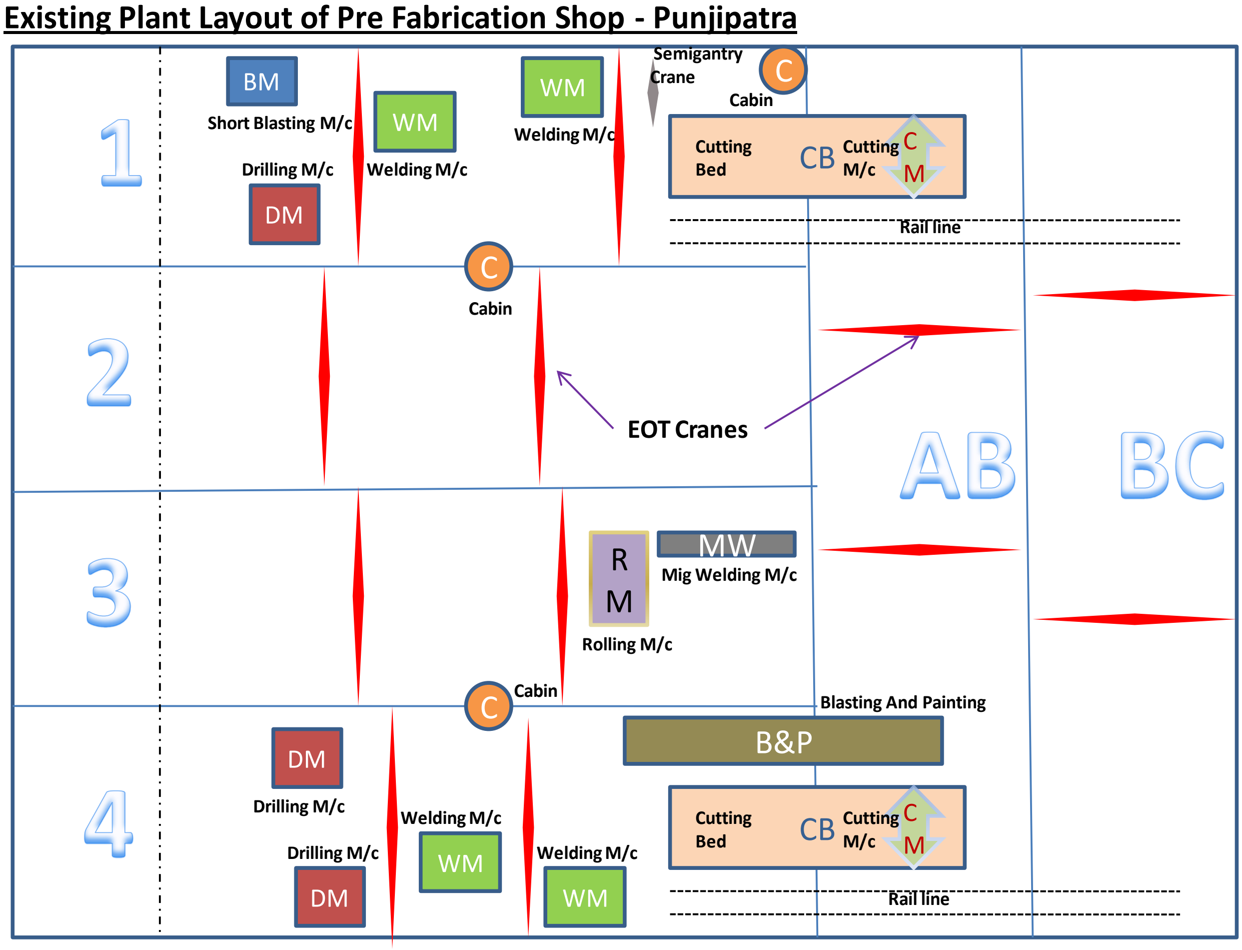


Fig. 2.

2. Literature review

The line balancing problem was defined for the first time in 1954 and modeled mathematically in 1955 (Bautista &Pereira, 2009). The assembly line balancing problem is defined as the grouping of the tasks required to assemble the final product to the stations which are arranged in a serial fashion and linked together by a transport system. Once the permanent manufacturing conditions have been achieved, the production items flow along the line at a constant rate, and each workstation has an equal allotted time to finish their tasks. Usually, the objective of the balancing problem is the minimization of the idle time of the line via the minimization of the number of required workstations, the minimization of the cycle time, or a combination of both. (Jannet, Van, Fokkert, 1997).

Buxey and Wild discriminate two types of assembly lines. The first is single model flow line; the second is mixed and multi-model flow line. The major difference between them is that single model flow line only processes one kind of job, while different kinds of jobs are processed in mixed and multi-model flow lines (Merengo, Nava, Pozzetti, 1995).

This paper mainly focuses on paced lines, where transfer equipment moves periodically. In manufacturing field, according to the complexity of processing, which mainly refers to the steps that every job has to be processed, Assembly workshop is divided into four classes (Usubamatov & Abdulmuin, 2009): single stage with single processing workstation, single stage with multi-stations, multi-stages flow-shop, multi-stages job-shop. The assembly line in this paper mainly deals with Flow-shop, which means that processing times may differ from each other whereas processing routs remain the same. In such an assembly line, there is one problem that could not be avoided: the uncertainties brought by human effects should not be neglected when analyzing and predicting the assembly lines. The processing time varies even when the same worker deals with the same kind of job, which should be considered in order to balance and simulate the assembly line accurately (Essafi, 2010). Monte Carlo simulation could be applied to collect statistic data, turning assembly line simulation problems with stochastic parameters into ones in certain environment. Most of the simulation software support assembly line simulation and corresponding result analysis, such as Arena, Flexsim and etc. However, there is little research on assembly line problem with overlapped operation and stopped line operation.

Simulation for Cycle Time Reduction

Simulation has become one of the widely used study techniques these days because of its powerful problem solving capabilities for complex systems that cannot be easily analyzed using the traditional study techniques available. The application of simulation and statistical analyses is for the process improvement of a paint shop within a heavy manufacturing plant. The explicit objectives of this study were the evaluation of cycle time relative to loading time, unloading time, and shift patterns. Arena is a hierarchical SIMAN based modeling system that can be tailored and used in the various application areas. (Penker, Barbu & Gronalt, 2007).

Developing a discrete event simulation model can solve the mixed model production line problem in a refrigerator company. The purpose of the model is to determine the bottlenecks before changing the traditional line to a mixed model production line. Model was developed in Arena Simulation Package for analysis of manufacturing process and work flow process to improve system performance. The basic steps involved in the simulation modeling and analysis are (Anderson & Ferris, 1994).

Problem formulating: During this phase it should be determined if the simulation is the appropriate tool to analyze the study under consideration. These steps involve a formal problem statement and project objectives.

Project planning: This phase is focused on planning, organizing, directing and controlling the project. Planning includes the development of a work break down structure. Organizing includes acquiring resources and creating a linear responsibility chart.

System definition: This process began with classifying the system. Systems can be discrete, continuous, or combined with respect to the system events. The system considered in our thesis is discrete event system where state of the system is changed at specified time. Another important component is to decide what components and events to model, also the type of input data needs to be collected and analyzed to measure system performance.

Input data collection and analysis: This phase of simulation is often considered the most difficult. Data may be collected from historical records or can be collected in real time. In order to observe data in a simulation model, it must preferably first be fit to a distribution. The distribution is then used to generate values to drive the simulation model. In order to determine the best distribution fit for the observed data chi square and KS test are used.

Model translation: Model translation requires selecting a computer programming language or a general purpose simulation soft ware package. We use Arena Simulation Software for model translation.

Validation: The process of ensuring that the simulation model represents the reality at a given confidence level. The validation process consists of both face validation and statistical validity. Face validity is the continuous process of ensuring that the model, at least on the surface, represents the reality. Statistical validation consists of comparison of the simulation model with the actual system. In statistical validity, some measures of output performance are collected. The same system loading conditions observed during the data collection process must be recreated in the simulation model.

Experimentation and analysis: Once a valid base model has been developed it is necessary to develop new ideas. These alternatives are examined in an effort to improve the performance of the existing system.

Recommendations and conclusions: This is the final phase of the project after the analysis has been carried out. The required changes and suggestions need to be made so as to obtain the desired objective.

3. Research methodology

The methodology for the research is to study the existing system and translate this system to a model. The Model has been developed considering the material flow process (shown in Fig.1). & existing plant layout (Shown in Fig.2). After validating the model, a Queue Report has been generated to spot out the bottleneck to the existing Production line. Apart from this, a scientific study has been done in order to define the Maximum Potential of Facilities installed within this shop. Finally a line balancing approach has been adopted to evenly distribute the workload on these machines such that they can be efficiently utilized. Finally Suitable Changes has been suggested to enhance the overall production level of this unit and the impact of additional facilities on the production has also been forecasted..

Assumptions:

However following assumptions has been undertaken by the researcher in course of completion of this work:

1. All the machining centers operate at an 90% efficiency level.
2. The Maximum efficiency level of Contract workers is 85%.
3. No machining center breakdowns are considered because breakdowns are taken into account in the efficiency factor.
4. All the machines / facilities / Contract workers operate in 3 Shifts. Viz. A, B & C Shifts.
5. Orders are taken only during the first shift.
6. The jobs are being manufactured on First Come First Serve (FIFS) basis.
7. The time required for tool changes is considered negligible with the help of an automatic tool changer (ATC).
8. All the raw materials are available at the beginning of each production cycle and thus there are no inter-arrival times for raw materials.
9. The demand of all kinds of product is predetermined, and the online sequence of entering the assembly line is also predetermined.

4. Detailed Analysis

Based on the 92 Hrs. of Time study (conducted during 10th Feb'12-19th Feb'12), rigorous observation & Assorted data provided by Department, the researcher developed a Simulation Model on ARENA 12 Software to identify the areas where queue develops & thereby restricts the overall production. The Concerned logic for the running Simulation Model is as shown below in Fig. 3

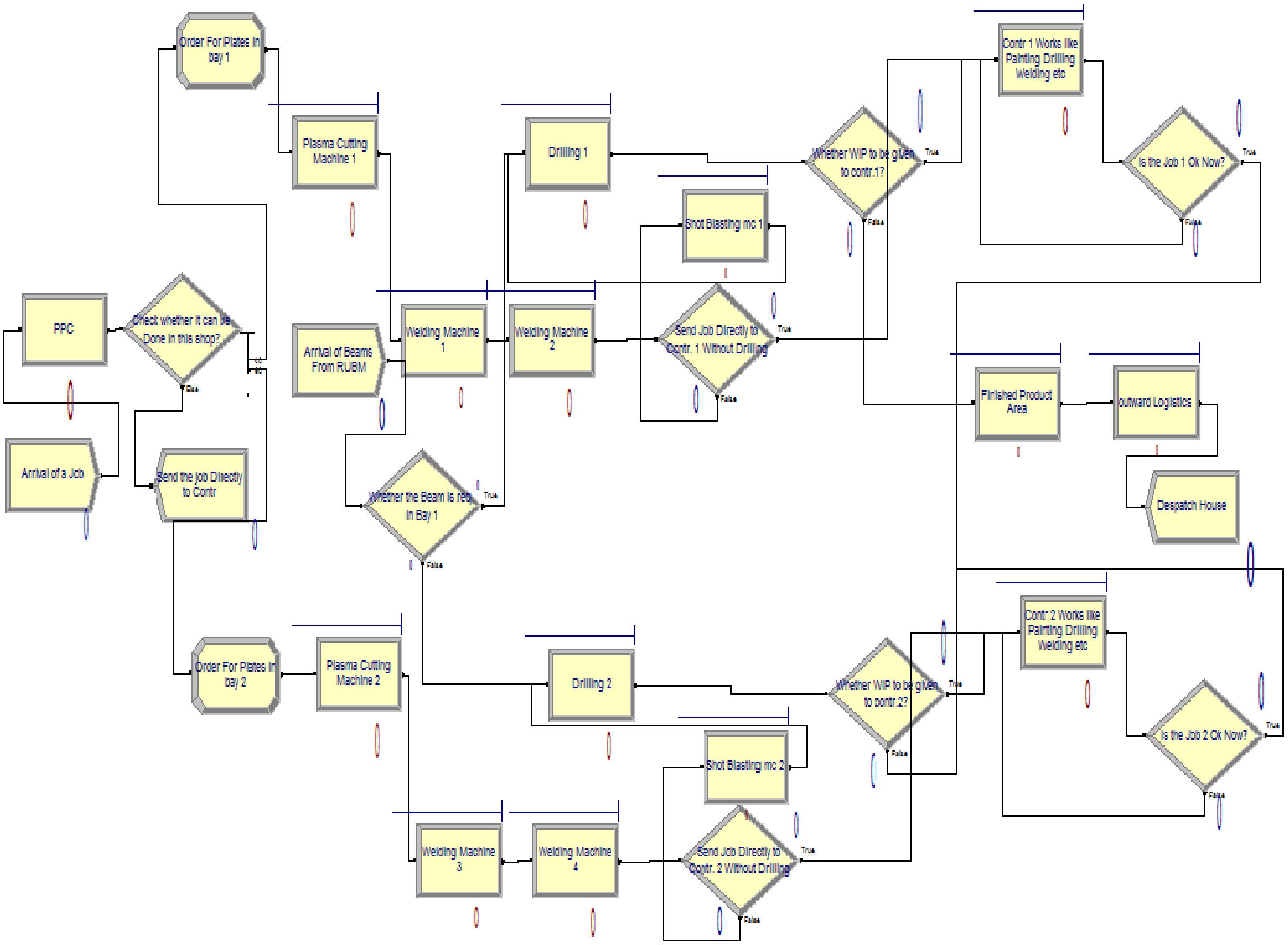
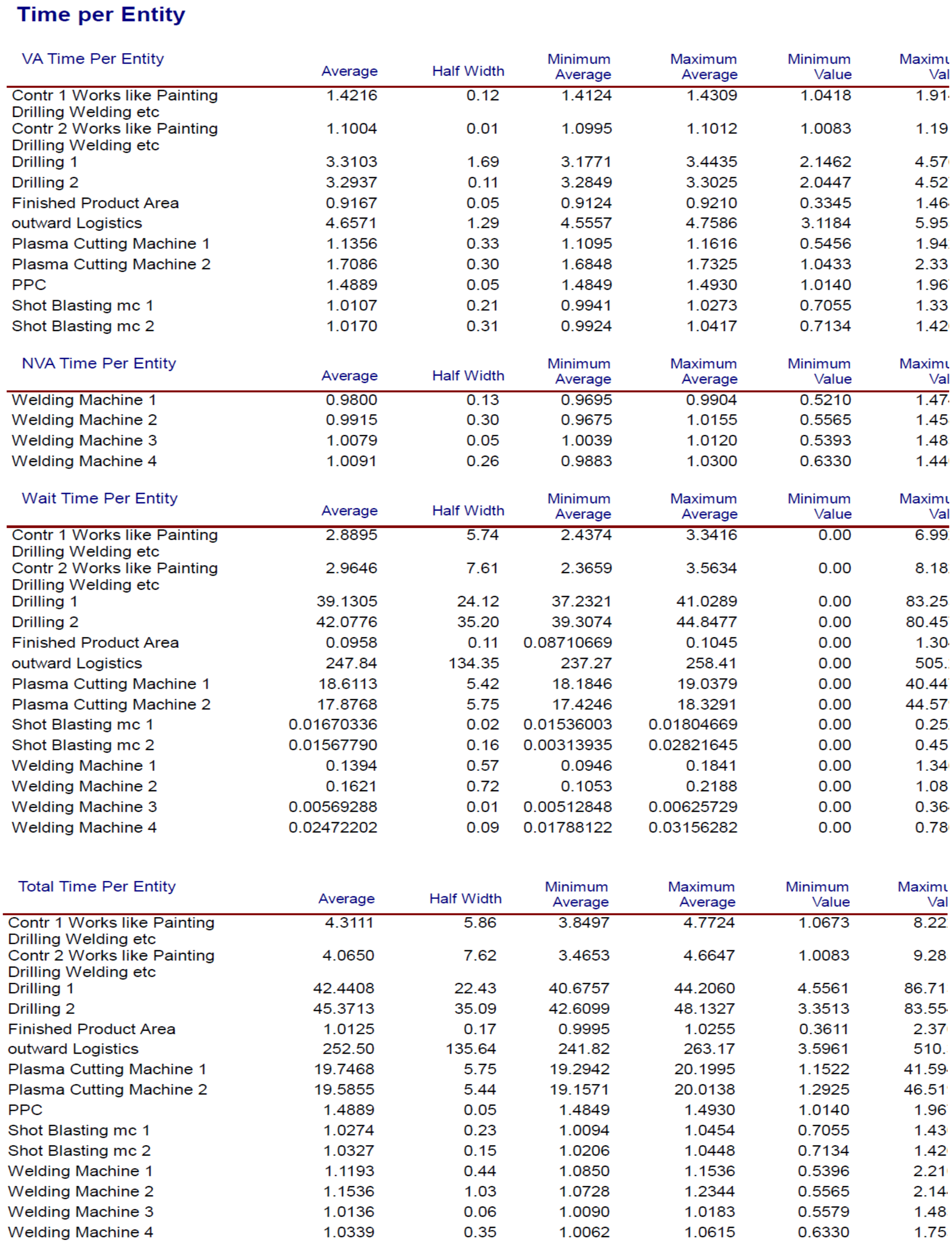


Fig. 3 (Source : Arena 12 Simulation Software)

However for validation of this model, two replications were taken. Results of the same are as follows:



Time per Entity

VA Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu Val
Contr 1 Works like Painting Drilling Welding etc	1.4216	0.12	1.4124	1.4309	1.0418	1.91
Contr 2 Works like Painting Drilling Welding etc	1.1004	0.01	1.0995	1.1012	1.0083	1.19
Drilling 1	3.3103	1.69	3.1771	3.4435	2.1462	4.57
Drilling 2	3.2937	0.11	3.2849	3.3025	2.0447	4.52
Finished Product Area	0.9167	0.05	0.9124	0.9210	0.3345	1.46
outward Logistics	4.6571	1.29	4.5557	4.7586	3.1184	5.95
Plasma Cutting Machine 1	1.1356	0.33	1.1095	1.1616	0.5456	1.94
Plasma Cutting Machine 2	1.7086	0.30	1.6848	1.7325	1.0433	2.33
PPC	1.4889	0.05	1.4849	1.4930	1.0140	1.96
Shot Blasting mc 1	1.0107	0.21	0.9941	1.0273	0.7055	1.33
Shot Blasting mc 2	1.0170	0.31	0.9924	1.0417	0.7134	1.42

NVA Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu Val
Welding Machine 1	0.9800	0.13	0.9695	0.9904	0.5210	1.47
Welding Machine 2	0.9915	0.30	0.9675	1.0155	0.5565	1.45
Welding Machine 3	1.0079	0.05	1.0039	1.0120	0.5393	1.48
Welding Machine 4	1.0091	0.26	0.9883	1.0300	0.6330	1.44

Wait Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu Val
Contr 1 Works like Painting Drilling Welding etc	2.8895	5.74	2.4374	3.3416	0.00	6.99
Contr 2 Works like Painting Drilling Welding etc	2.9646	7.61	2.3659	3.5634	0.00	8.18
Drilling 1	39.1305	24.12	37.2321	41.0289	0.00	83.25
Drilling 2	42.0776	35.20	39.3074	44.8477	0.00	80.45
Finished Product Area	0.0958	0.11	0.08710669	0.1045	0.00	1.30
outward Logistics	247.84	134.35	237.27	258.41	0.00	505.
Plasma Cutting Machine 1	18.6113	5.42	18.1846	19.0379	0.00	40.44
Plasma Cutting Machine 2	17.8768	5.75	17.4246	18.3291	0.00	44.57
Shot Blasting mc 1	0.01670336	0.02	0.01536003	0.01804669	0.00	0.25
Shot Blasting mc 2	0.01567790	0.16	0.00313935	0.02821645	0.00	0.45
Welding Machine 1	0.1394	0.57	0.0946	0.1841	0.00	1.34
Welding Machine 2	0.1621	0.72	0.1053	0.2188	0.00	1.08
Welding Machine 3	0.00569288	0.01	0.00512848	0.00625729	0.00	0.36
Welding Machine 4	0.02472202	0.09	0.01788122	0.03156282	0.00	0.78

Total Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu Val
Contr 1 Works like Painting Drilling Welding etc	4.3111	5.86	3.8497	4.7724	1.0673	8.22
Contr 2 Works like Painting Drilling Welding etc	4.0650	7.62	3.4653	4.6647	1.0083	9.28
Drilling 1	42.4408	22.43	40.6757	44.2060	4.5561	86.71
Drilling 2	45.3713	35.09	42.6099	48.1327	3.3513	83.55
Finished Product Area	1.0125	0.17	0.9995	1.0255	0.3611	2.37
outward Logistics	252.50	135.64	241.82	263.17	3.5961	510.
Plasma Cutting Machine 1	19.7468	5.75	19.2942	20.1995	1.1522	41.59
Plasma Cutting Machine 2	19.5855	5.44	19.1571	20.0138	1.2925	46.51
PPC	1.4889	0.05	1.4849	1.4930	1.0140	1.96
Shot Blasting mc 1	1.0274	0.23	1.0094	1.0454	0.7055	1.43
Shot Blasting mc 2	1.0327	0.15	1.0206	1.0448	0.7134	1.42
Welding Machine 1	1.1193	0.44	1.0850	1.1536	0.5396	2.21
Welding Machine 2	1.1536	1.03	1.0728	1.2344	0.5565	2.14
Welding Machine 3	1.0136	0.06	1.0090	1.0183	0.5579	1.48
Welding Machine 4	1.0339	0.35	1.0062	1.0615	0.6330	1.75

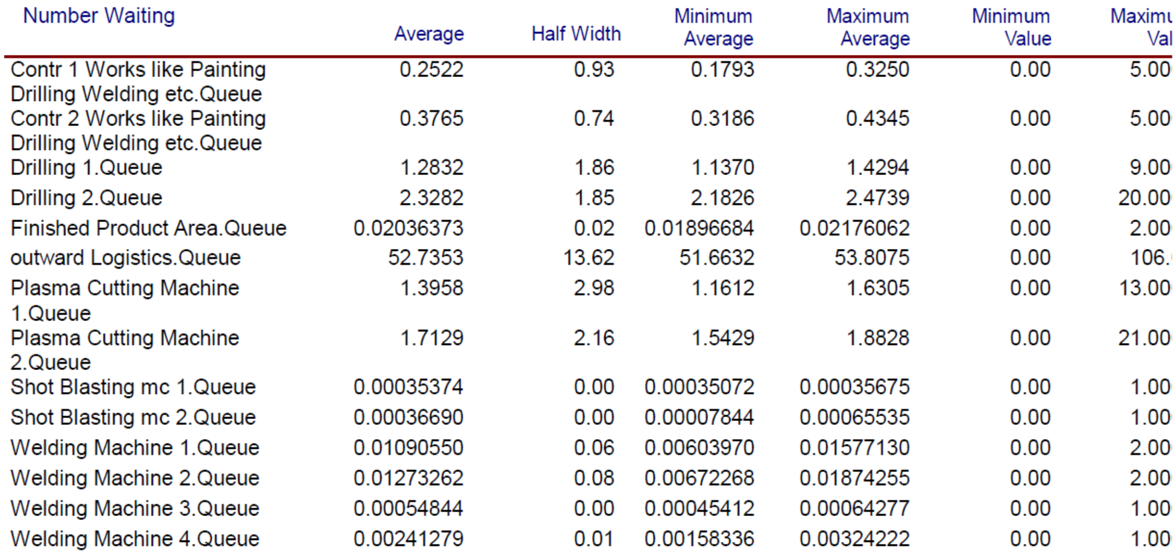
Table. 1 (Source : Arena 12 Simulation Software)

After getting the replication results from ARENA 12 software, we Compared it with the time study data for different sections and is tabulated below:

	Simulation Model. (Replication Results)			Existing System. (From Time Study)		
Entity Description	Avg. Time (In Hrs.)	Min. Time (In Hrs.)	Max. Time (In Hrs.)	Avg. Time (In Hrs.)	Min. Time (In Hrs.)	Max. Time (In Hrs.)
Contr 1 Works like Painting ,etc.	4.31	3.85	4.77	4.38	3.80	4.95
Contr 2 Works like Painting ,etc.	4.07	3.47	4.66	3.92	3.33	4.50
Drilling 1	42.44	40.68	44.21	42.59	39.66	45.51
Drilling 2	45.37	42.61	48.13	43.77	40.86	46.67
Plasma Cutting Machine 1	19.75	19.29	20.20	20.58	20.81	20.35
Plasma Cutting Machine 2	19.59	19.16	20.01	19.37	18.60	20.14
Shot Blasting mc 1	1.03	1.01	1.05	1.03	0.90	1.15
Shot Blasting mc 2	1.03	1.02	1.04	1.10	1.02	1.17
Welding Machine 1	1.12	1.09	1.15	1.11	1.01	1.20
Welding Machine 2	1.15	1.07	1.23	1.15	1.03	1.26
Welding Machine 3	1.01	1.01	1.02	1.02	1.01	1.02
Welding Machine 4	1.03	1.01	1.06	1.32	1.00	1.64
Finished Product Area	1.01	1.00	1.03	1.01	1.00	1.02
outward Logistics	252.50	241.82	263.17	255.00	240.00	270.00
PPC	1.49	1.48	1.49	1.50	1.45	1.55

Table. 2 (Source : Arena 12 Simulation Software & Time Study)

After the Validation of the model developed on ARENA 12, the researcher carried out a queue analysis of the existing system. Based on the results from this Simulation (shown below), it was analyzed that the maximum number of queues developed in Beam welding area , Drilling area & Dispatch area. Thereby the researcher emphasized mainly in the production bays to identify the actual reasons of delay. Apart from that further emphasis was laid on dispatch resources to overcome the reasons of lower productivity of this Pre-fabrication Plant.



Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximu Val
Contr 1 Works like Painting Drilling Welding etc.Queue	0.2522	0.93	0.1793	0.3250	0.00	5.00
Contr 2 Works like Painting Drilling Welding etc.Queue	0.3765	0.74	0.3186	0.4345	0.00	5.00
Drilling 1.Queue	1.2832	1.86	1.1370	1.4294	0.00	9.00
Drilling 2.Queue	2.3282	1.85	2.1826	2.4739	0.00	20.00
Finished Product Area.Queue	0.02036373	0.02	0.01896684	0.02176062	0.00	2.00
outward Logistics.Queue	52.7353	13.62	51.6632	53.8075	0.00	106.
Plasma Cutting Machine 1.Queue	1.3958	2.98	1.1612	1.6305	0.00	13.00
Plasma Cutting Machine 2.Queue	1.7129	2.16	1.5429	1.8828	0.00	21.00
Shot Blasting mc 1.Queue	0.00035374	0.00	0.00035072	0.00035675	0.00	1.00
Shot Blasting mc 2.Queue	0.00036690	0.00	0.00007844	0.00065535	0.00	1.00
Welding Machine 1.Queue	0.01090550	0.06	0.00603970	0.01577130	0.00	2.00
Welding Machine 2.Queue	0.01273262	0.08	0.00672268	0.01874255	0.00	2.00
Welding Machine 3.Queue	0.00054844	0.00	0.00045412	0.00064277	0.00	1.00
Welding Machine 4.Queue	0.00241279	0.01	0.00158336	0.00324222	0.00	1.00

Table. 3 (Source : Arena 12 Simulation Software & Time Study)

Based on this queue analysis, it seems to be clear that Manpower is none of the reasons for lower production of this unit. Apart from that, the facilities such as Welding machines & Shot blasting machine is quite capable for producing higher percentage of products as compared to existing production.

After identifying the major bottleneck in the system, the researcher moved in a bit detail inside the production bays to assess the maximum processing potential of these facilities. Based on the input data provided, capacity assessment of each facility in the production line has been done in order to evaluate the maximum tonnage of job processed on these machines.

The Technique being utilized in this kind of calculation is described below:

1) Capturing the activities to be carried on that particular machine.
2) Analysis of Different Parameters related to production from that facility. Viz. Avg. tonnage to be processed each time, Loading & Unloading Time of job, Processing Time, etc.
3) Based on the data analysis in section (2) , Calculate the total processing time of a single job on that concerned facility.
4) Calculate the monthly available working hours on that facility. This factor is based upon the Management working Policy & Maintenance Practices.
5) Find the number of Jobs Processed on that machine per month. i.e. (5) = ((4) * Utilization Factor of Facility) / (3).
6) Collect 30-35 samples of job processed on that facility to evaluate the Average tonnage of a single job to be processed.
7) Finally, calculate the Average Tonnage of jobs processed on that facility in a particular month. i.e. (7) = (5) * (6).

This approach has been used to assess the Max. Potential Tonnage that can be produced from that facility per Month. Following below is a summary of the assessment done on all the facilities in the production line:

S.Nos.	Facility Name	Existing Situation	
		Nos. of Facilities	Max. Tonnage / Facility
1	OXY / Plasma Cutting M/C	1	2100
2	T & I-Welding M/C (Corimplex M/C)	2	3100
3	FICEP-1 & 2 M/C	2	1976
4	Crane – 1	1	2450
4	Crane – 2	1	1450

Table. 4

Detailed Break-up of the job / activities carried on these facilities are shown below:

S.Nos.	Description	Actual Tonnage Produced
1	Actual Production From OXY / Plasma Cutting M/C	2100
1A	Actual Production From OXY Cutting M/C	1575
1B	Actual Production From Plasma Cutting M/C	525
2	Actual Production From T & I-Welding M/C	3100
2A	Actual Production From T-Welding M/C	2067
2B	Actual Production From I-Welding M/C	1033
3	Actual Production From FICEP-1 & 2 M/C	1976
3A	Actual Production From FICEP-1 M/C	451
3B	Actual Production From FICEP-2 M/C	1525
4	Actual Production From Crane – 1	4900
4A	Actual Child Part Plates Shifted	700
4B	Actual Web/ Flange Plates Part Shifted from Cutting m/c to grinding area	2100
4C	Actual Web/ Flange Plates Part Shifted from grinding area to T-Welding M/c	1400
4D	Actual Max. Web/ Flange Plates Part Shifted from grinding area to I-Welding M/c	700
5	Actual Production From Crane – 2	2900
5A	I Beam Stacking Area to FICEP M/c-1	662
5B	I Beam Stacking Area to FICEP M/c-2	2238

Table. 5

From the above analysis, it was clear that the facilities are not equally loaded with jobs. Apart from this, it was also taken into account that for 100% of Tonnage production, 60% should be the main part, 20 % and 10% should be the child beam part and child plate part respectively. Also the ratio of Built-up beam & Rolled-up beam should be around 45% & 30% wrt to total production. Based upon these consideration, even if some facilities are quite capable to produce much more are being prohibited to run for keeping the WIP inventory low.

In order to calculate the Total Production **(P)** of this Shop, researcher derived the following equation for computing the same**:**

P = $\prod$ (N , $\sum$ (M.P / R_M , CP / R_C))

Such that,

MP = min (m_1 / R_1 , m_2 / R_2) and

CP = min (c_1 / r_1 , c_2 / r_2)

Where,

N is the number of bays,

MP is main part tonnage,

CP is child part tonnage.

m_1 = Total Potential of Production of Build-up Beams from Beam welding line from each Bay. (In Tonnes)

m_2 = Total Potential of Processing Build-up & Rolled-up Beams on FICEP m/c from each bay. . (In Tonnes)

R_1 = % tonnage of total Production to be processed in Beam welding line,

R_2 = % tonnage of total Production to be processed on FICEP m/c.

c_1 = Total Production of Child Part Plates from each bay. (In Tonnes)

c_1 = Total Production of Child Beam Part from each bay. (In Tonnes)

r_1 = % tonnage of Child Part Plates in total Production,

r_2 = % tonnage of Child Beam Plates in total Production,

Also,

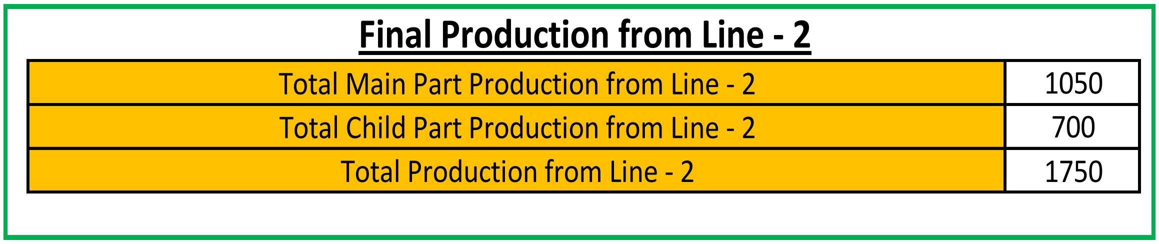
m_1 = min (Potential of Main part Tonnage From OXY Cutting M/C, Potential of Main part Tonnage From T & I-Welding M/C, Potential of Tonnage of Web/ Flange Plates Part Shifted by Crane - 1 from Cutting m/c to grinding area)

m_2 = min (Potential of Main part Tonnage From FICEP-1 & 2 M/C , Potential of Main part Tonnage Shifted by Crane – 2)

c_1 = min (Potential of child plate Tonnage From Plasma Cutting M/C , Potential of child plate Tonnage Shifted by Crane – 1)

c_2 = min (Potential of child Beam Tonnage From FICEP-1 & 2 M/C , Potential of child Beam Tonnage Shifted by Crane – 2)

Based upon the above calculation, the overall Production per bay from existing system will be as shown below:

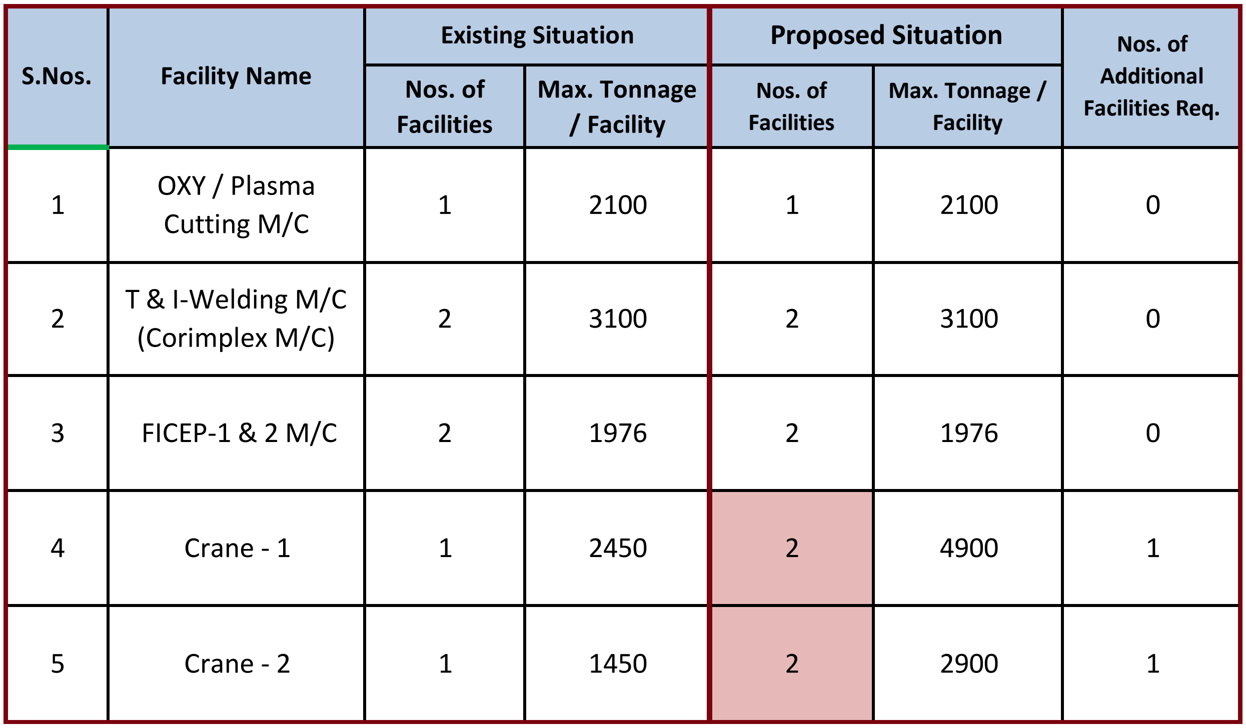


Final Production from Line - 2

Total Main Part Production from Line - 2	1050
Total Child Part Production from Line - 2	700
Total Production from Line - 2	1750

Table. 6

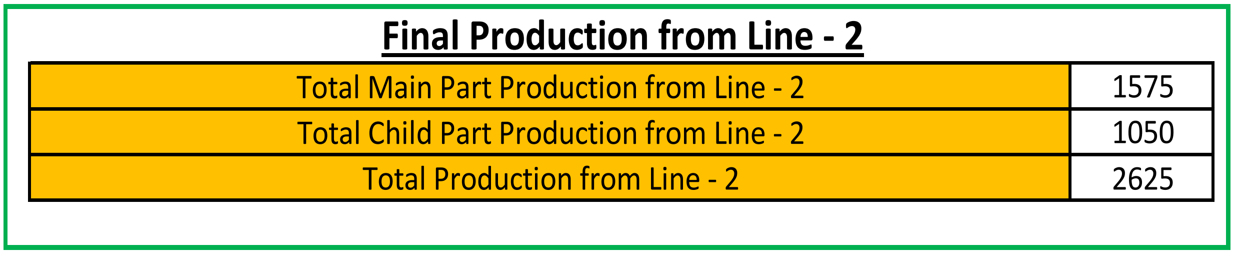
This model implies that, the overall production from the 2 bays of the shop floor is around 3500 Tonnes per Month. This proves that the results from simulation are justified & the real bottleneck exists in the production line. Now the researcher adopts the concept of Line Balancing in this area to enhance the overall production of the Manufacturing line. As per the calculation, the researcher came to know that actual problem were the Cranes which were not sufficient to shift the WIP jobs between different facilities in the shop Floor.



S.Nos.	Facility Name	Existing Situation		Proposed Situation		Nos. of Additional Facilities Req.
		Nos. of Facilities	Max. Tonnage / Facility	Nos. of Facilities	Max. Tonnage / Facility	
1	OXY / Plasma Cutting M/C	1	2100	1	2100	0
2	T & I-Welding M/C (Corimplex M/C)	2	3100	2	3100	0
3	FICEP-1 & 2 M/C	2	1976	2	1976	0
4	Crane - 1	1	2450	2	4900	1
5	Crane - 2	1	1450	2	2900	1

Table. 7

After the provision of additional facilities, the total production from proposed system came to be around 2625 tonnes / month and is shown in details below:



Final Production from Line - 2

Total Main Part Production from Line - 2	1575
Total Child Part Production from Line - 2	1050
Total Production from Line - 2	2625

Table. 8

Thereby it was concluded that, after the provision of 2 EOT Cranes, the Overall Production came to be around 5250 Tonnes / Month.

5. Conclusion

Based on the above Research Work, it was concluded that with the provision of additional 2 EOT Cranes in Each Bay, the overall production increases by around 50%. However the project Team evaluated the space availability option for installation of these EOT Cranes and indicated the higher management that there is sufficient space for the same in the shop floor. Apart from this, the results from ARENA Simulation also indicated that, the wait cost for the entities & Idle time of resources get reduced by 16% & 23% respectively which in turn increases the overall profitability of the concern.

6. Future Work

Future work will include the cost evaluation for suggested changes in the system. Apart from this further system study should be continued to monitor the savings from the implementation of various changes in the existing system and explore another fruitful suggestions. However there is a scope of MANPOWER study in this area to so that optimum number of men can be proposed.

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