Enhancement in productivity through balancing of assembly line

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Abstract: This act of balancing the assembly line (ALB) is complex of need to be checked for rebalancing periodically to achieve goals/objectives of any organization. Assembly line can be balanced with help of various models depending on the product and product mix of the enterprise. The assembly line under empirical study is manufacturing shock absorber and has 9 Nos. of working stations with varying tasks allocated to each station. The assessment of performance can only be based through statistical study approach so-that all the stations including all the variance are covered for results to be as accurate as possible. In this case study, the problem of reconfiguration is not redesigning the line which may include retention of the workers, sweeping changes in layout design or reallocating space for storage. By reconfiguration over here, it is assumed that line efficiency is to be enhanced either by reducing the no of stations or by regrouping the cycle times which will maximize the utilization and reduce blocking-starvation problem as far as possible.

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1. INTRODUCTION

An assembly line is a moving conveyor that passes a series of work station in a uniform time internal called the cycle time. At each work station, work is performed on a product either by adding parts or by completing assembly operations. The work performed at each station is usually made up of many bits of work at the "micro" level that can be described by motion time analysis. Convenient grouping of these bits of work are called work units. Generally they are grouping that cannot be subdivided on the assembly line without paying a penalty in extra motions.
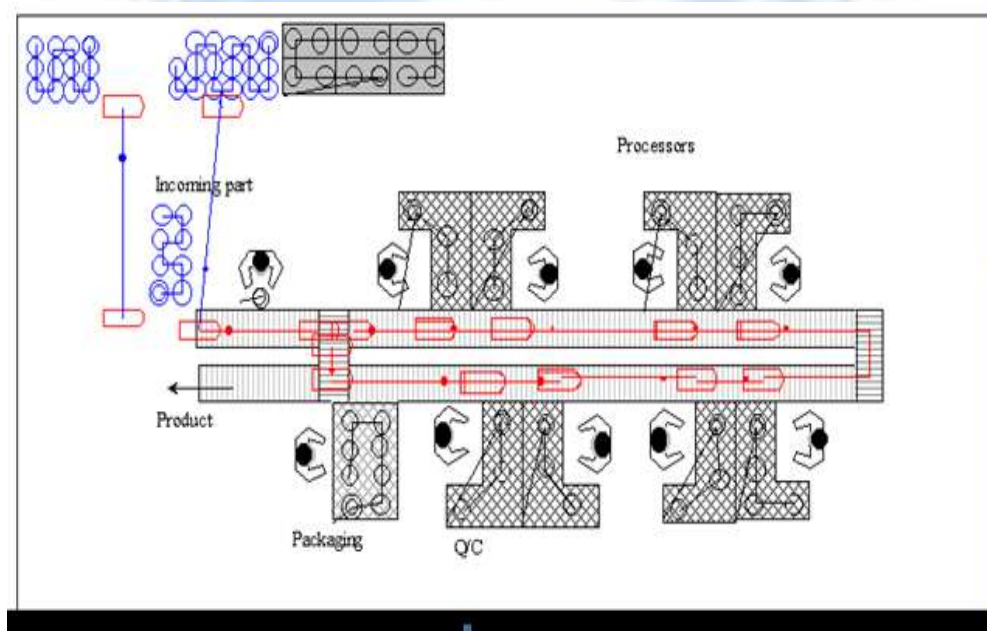
2. LITERATURE RIVIEW

Chakravarty and Shtub (1985) research on mixed-model line balancing; i.e., the problem of combining line balancing with lot sizing in a multi-product environment. Recent developments in the area of multi-echelon production/inventory systems

are applied, and algorithms are developed which determine the number of work stations required along the line, the tasks assigned to each station, and the cycle time.

Ghosh and Gagnon (1989) present a literature review and analysis of the assembly line balancing and scheduling of assembly systems.

Farnandes (1992) suggested that the two major problems are encountered in planning and operating a mixed-model production line: line balancing and sequencing of products into the line.

Farber (2005) found the mixed model production lines mean that more than one model being processed in the same production line in an arbitrary sequence.

Hirotani et al. (2006) finds that in a traditional assembly line each worker is usually assigned to a particular task, with the most demanding task determining the production rate.

3.   PROBLEM STATEMENTS

In this study, the commencement of experiment need to be raised on certain input values as well as output values. On, investigation it was found that the data is available but it is not formulated as no-body was interested to analyze and fish out the problems associated with the line for a long time solution. E.g. the utilization & non utilization being two main factors to start with the study and this important aspect are all together missing.

1.   Causes of massive inventory built up not identified.
2.   The reasons for idleness in the line have not been identified so-that can't the problem can be sorted out.

The total cycle time data is also not available i.e. the stations which is having maximum cycle time has not been specified. This data regarding total cycle time and the highest cycle time is of great importance so as to identify the no. of stations required for a particular set of production.

3.1Objectives
The objective of this study is to manage inventory effectively:

1.   To identify Utilization and non utilization time wastes in the production.
2.   To analyze this wastes from lean considerations.
3.   To recommend the appropriate lean tools and their implementation process.
4.   To suggest the improvements in the inventory management leading to cost benefits.

4.   Overview of Industry

The demand of automotive vehicles is increasing day by day that's why the demand for rims are also raised. M/s Bhagwati Techno Fab (P) Ltd. is the leading industry in the area of rim fabrication for four wheeler commercial auto vehicles. This industry, fabricate the parts through sheet metal process for leading automobile vehicle manufacturing industries like ECEL, ACE, VE Commercial Vehicle Ltd. Etc.

5.   Problem Formulation

On the maiden visit to M/s Bhagwati Techno Fab Ltd. (Manufacturing automotive parts), there were many surprises, which were not affecting the operating management. The people walk day-in and day-out on the shop floor and are still unaware of the problems which remain hidden and are a cost to the company. Data is collected for total monthly production on the basis on 22 days working spread over period of 8 hours on double shift basis. This average data is more or less consistent in each month that means the averages are sufficient enough to consider it as a base for the study purpose. The aisles were full of trolleys loaded with WIP and further every nook and corner was having no. of trays filled with WIP. Also, many of the trays didn't carry the material identification including the quantities lying therein. This did represent the waste which was generated by the principle of inventory management like 'First in last out' i.e. inventory getting dumped one above the other. This type of planning attitude must provide for obsolescence and scrap. This further reveals that there was good amount of overproduction which is again type of waste that is producing more than the requirement. The principles of 5S have been used to identify, analyze and evaluate the existing manufacturing system. The fact regarding over production has been established as per production data: planned v/s actual. A total of 14 models were identified for overproduction and this is 10% of the existing models. The period under study is from NOV'2013 to APR'2014 and model wise-month wise planned v/s actual production data of these 14 models is as per Table 2 and graphically presented in Figure 8.

Table 2:   Production Data: Planned v/s Actual

| Model No.	NOV'13		DEC'13		JAN'14		FEB'14		MER'14		APR'14	
	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual	Plan	Actual
26-A-2-011A	425	155	175	185	290	0	90	200	110	0	240	310
8V-262301200	350	150	280	210	0	35	100	0	510	330	0	48
8V163900100	230	230	300	210	80	300	180	50	75	58	100	115
7400537	110	180	0	75	150	110	150	228	165	30	115	50
7201769	200	250	200	175	150	250	420	370	410	230	475	300
7600056	225	350	400	405	530	200	450	140	225	320	210	957
7302272	115	170	300	240	400	450	200	430	250	480	130	115
960400001700	310	250	0	180	265	250	400	250	470	350	670	145
960400002000	245	330	320	410	600	870	200	560	225	170	150	200
200182400100	570	375	600	505	280	180	400	295	100	390	480	520
960400013628	150	180	150	110	210	100	405	300	480	580	525	140
960400001900	250	320	475	230	520	225	440	300	200	205	435	145
960400000100	470	190	320	225	130	140	200	90	400	150	140	165
9604000001600	200	190	200	100	400	570	240	185	265	190	110	200
Grand Total	3650	3120	3520	3160	3605	3110	3635	3208	3615	3293	3670	3210
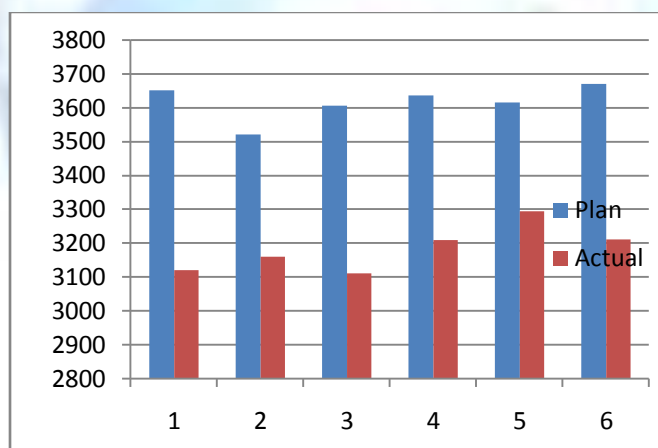
Figure 8:   Planned v/s Actual Production

As per installed capacity of plant, the production should be of wheel rims about 210-220 parts per day. But from calculation of above data reveals that the daily average production of wheel rim is just 140 (approx.). That is much far away from the situation. Hence, the required area where the improvement is needed is found out with the help of this data.

To enhance the productivity of the plant, a case study has been attempted. To achieve the required goal, the process for rim assembly has been studied. It was observed during the process study which is used for fabrication wheel rim, that there is a wide gap between actual production and the available capacity of the plant. The main problem is to find out the area where improvement is needed to balance the capacity with the actual production rate. This gap also results in creating the gap between demand and supply of the product not to meet customer satisfaction.

Table 3: Actual production month wise

Months	Plan Production	Actual production
NOV, 2013	200	250
DEC., 2013	200	175
JAN., 2014	150	250
FEB., 2014	420	370
MAR., 2014	410	230
APR., 2014	475	300
Total	1855	1575

Average plan production per month = $\sum X_i / n = 1855/6 =$ 309.2 say 310 Nos.
Average actual production per month = $\sum X_i / n = 1575/6 =$ 262.5 say 260 Nos.
Average difference between plan and actual = App. 50 Nos. (83% Utilization of resources)

The very first observation regarding working efficiency is integrated of intentional slow down and this may be obvious because of change of hands. The various types of losses were found during the survey at initial stage of proposed study and listed below:

1. Equipment failure loss: In the sheet metal process, the loss that lowering the efficiency of the machineries is the equipment failure loss. It occurs when the machineries unexpectedly fail. This losses also includes loses due to equipment function deterioration.
2. Setup and adjustment loss: In Industry this loss occurs mainly at the shift and rest time of the operators. In this, most of the time is wasted in setup of lathe machine or drawing process which is manually performed. There are some operators who don't start to operate the machine at the scheduled time. Hence, this is also can being corporate as a loss that is generated by operator.
3. Startup loss: The startup loss is the one that occurs until the startup. In the industry at the beginning of the machine there is small time loss to warm up the machine.
4. Minor stoppage and idling loss: The minor stoppage loss is the one in which minor trouble causes the machine to refrain from operation. When breakage occurs during operation on Lathe machine and other machines, unplanned stoppage for cleaning and lubrication is one of the minor stoppage and idling loss occur on the factory.
5. Speed Loss: The speed loss is the loss caused when the machine run more slowly than the designed speed. Most of the machines in the factory are running under their designed speed. Under design speed running can be generated due to inefficient operator.
6. Defect and rework loss: The defects in the sheet metal fabrication industry are not re worked but discarded as waste. In general the defects are likely to be considered as waste which should be disposed of returning the customer which is loss to the company. The goal should be zero defects to provide better product right the first time and every time.

4.1 Research Objective
The idea with this case study is to optimize the current situation of the M/s Bhagwati Techno Fab (P) Ltd. with best manufacturing strategies. The research objective for present case study is listed below:

- To investigate the current situation of the production of the case company.

- Causes of massive inventory built up not identified.

- The reasons for idleness in the line have not been identified so-that can't the problem can be sorted out.

- To suggest the ways to improve the situation.

- To enhance the productivity & utilizing the recommended suggestions.

6. ANALYSIS

This work deals with the end to end perspective of enhancing the line efficiency of an Automotive Products (Rim) manufacturing industry. The initial observations revealed low output levels, large setup change time and waiting for material. The main focus is on enhancing the output through multi model assembly line problem (MALBP). The efficiency of the line can be enhanced by reducing the no. of workstations, reducing the cycle time and also reducing the waiting time because of either bad scheduling or because of blockage and starvation. This balancing problem is being addressed through reduction in no. of workstations thereby, reducing the manpower and the implied cost. The process precedence is in sequence and follows the straight line.

Average production per day = $\sum X_i / N = 2297/30 = 76.56$ Say 77 Nos./day

Table 4: Utilization data as observed on each station

Sr.	Total observations	Stations									Total utilization	Parts Produce
		1	2	3	4	5	6	7	8	9		
1	10	4	5	5	6	5	4	3	5	4	41	74
2	11	3	5	6	6	5	4	4	6	4	43	76
3	10	4	6	5	5	6	3	3	7	3	42	74
4	12	4	5	6	6	5	4	4	6	3	43	78
5	13	4	6	5	5	6	4	4	6	4	44	75
6	12	4	6	5	5	5	3	3	5	4	40	77
7	12	4	5	6	5	5	3	4	5	3	40	76
8	10	3	5	6	6	5	3	4	5	3	40	78
9	10	3	5	6	6	6	3	4	5	3	41	79
10	10	3	5	5	6	6	4	4	6	3	42	80
11	10	4	5	5	6	6	4	4	6	3	43	75
12	10	4	5	5	6	6	3	4	6	4	43	74
13	10	4	5	6	5	6	4	4	6	4	44	76
14	11	4	5	6	5	5	3	3	6	4	41	75
15	14	3	5	6	5	5	4	3	6	3	40	74
16	13	3	5	6	5	6	3	3	5	4	40	76
17	12	4	5	6	6	6	4	3	5	3	42	74
18	13	3	6	5	6	6	3	3	5	4	41	77
19	12	4	6	5	5	6	4	3	5	3	41	78
20	10	3	6	5	6	6	3	4	6	4	43	79
21	10	4	6	5	5	6	4	3	6	3	42	78
22	11	5	6	5	6	5	4	4	6	4	45	75
23	14	3	6	5	5	5	3	3	5	3	38	76
24	12	3	5	6	6	5	3	4	6	4	42	76
25	13	4	5	6	5	5	4	3	6	4	42	79
26	11	3	5	6	6	5	4	3	5	4	41	77
27	12	3	5	6	5	5	4	4	6	4	42	78

28	13	3	6	6	5	5	3	4	5	3	40	77
29	12	3	6	6	6	5	4	3	6	3	42	78
30	10	4	6	6	5	6	4	3	6	4	44	78
Total	343	108	164	170	169	169	113	112	177	115	1252	2297

Where X_i is the production per day and n represents the number of days from the above observation, it was cleared that the non utilization being quite high. The main priority of this sampling worked out separately and allocations of the major reasons for this low utilization. The time lost against tea and late starts which comprises of almost 5-10% has been ignored. The details of non utilization time with breakup are given in Table 5.

Table 5: Non Utilization observed data with break-up history

Sr. No.	Non Utilization	Break-up			
		Setup change	Percentage	No-material	Percentage
1	49	22	24.4	27	30.0
2	56	25	25.3	31	31.3
3	48	20	22.2	28	31.1
4	65	26	24.1	39	36.1
5	73	26	22.2	47	40.2
6	68	25	23.1	43	39.8
7	68	27	25.0	41	38.0
8	50	22	24.4	28	31.1
9	49	21	23.3	28	31.1
10	48	21	23.3	27	30.0
11	47	22	24.4	25	27.8
12	47	23	25.6	24	26.7
13	46	23	25.6	23	25.6
14	58	25	25.3	33	33.3
15	86	29	23.0	57	45.2
16	77	28	23.9	49	41.9
17	66	25	23.1	41	38.0
18	76	27	23.1	49	41.9
19	67	26	24.1	41	38.0
20	47	23	25.6	24	26.7
21	48	21	23.3	27	30.0
22	54	24	24.2	30	30.3
23	88	30	23.8	58	46.0
24	66	26	24.1	40	37.0
25	75	28	23.9	47	40.2
26	58	25	25.3	33	33.3

27	66	27	25.0	39	36.1
28	77	27	23.1	50	42.7
29	66	26	24.1	40	37.0
30	46	23	25.6	23	25.6
Total	1835	743	24.1	1092	35.4

The combined data on utilization and non utilization has been depicted in Table 6. The columns of the Table 6 have been put in graphical form for instantaneous understanding wide Figure 10, Figure 11 and Figure 12.

Table 6: Comparison of utilization and non utilization data

| Sr. No. | Utilization percentage (X) | Non utilization breakup | |
		Setup change percentage (Y)	No material percentage (Z)
1	45.56	24.44	30.00
2	43.43	25.25	31.31
3	46.67	22.22	31.11
4	39.81	24.07	36.11
5	37.61	22.22	40.17
6	37.04	23.15	39.81
7	37.04	25.00	37.96
8	44.44	24.44	31.11
9	45.56	23.33	31.11
10	46.67	23.33	30.00
11	47.78	24.44	27.78
12	47.78	25.56	26.67
13	48.89	25.56	25.56
14	41.41	25.25	33.33
15	31.75	23.02	45.24
16	34.19	23.93	41.88
17	38.89	23.15	37.96
18	35.04	23.08	41.88
19	37.96	24.07	37.96
20	47.78	25.56	26.67
21	46.67	23.33	30.00
22	45.45	24.24	30.30
23	30.16	23.81	46.03
24	38.89	24.07	37.04
25	35.90	23.93	40.17
26	41.41	25.25	33.33
27	38.89	25.00	36.11
28	34.19	23.08	42.74
29	38.89	24.07	37.04
30	48.89	25.56	25.56
Total	1538.2	520.6	787.7
Average	51.3	17.4	26.3
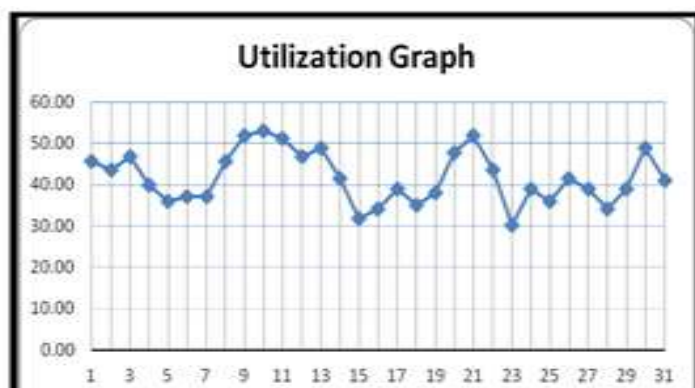
Figure 10: Graph for Utilization
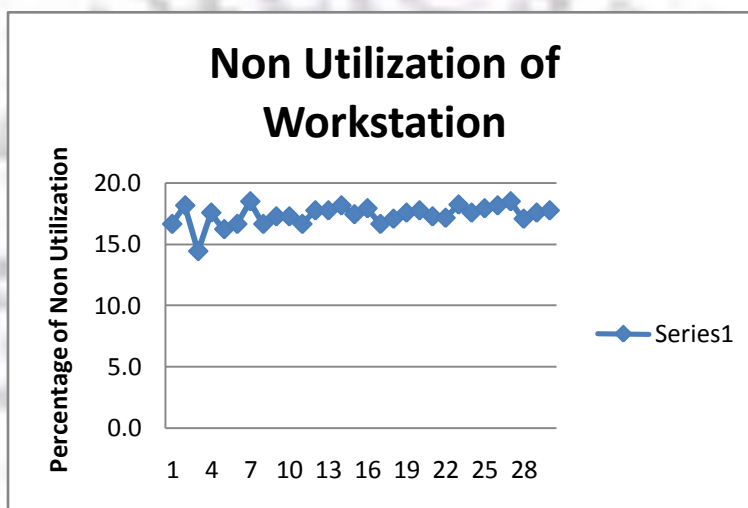
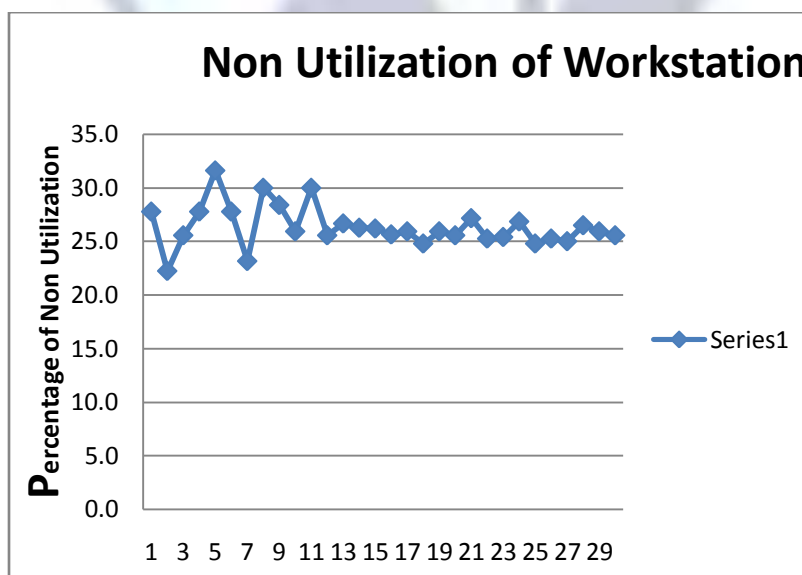**Figure 11: Non Utilization Graph due to Setup Change**

Figure 12: Non Utilization Graph due to No Material on workstation

7.   Results and Discussion

Almost all the industries have the different assembly lines for variety of products. But in some cases the line remains same with small adjustment in the setup of the machine parts. This is most common in automotive products manufacturing industries. The present study has been done on Rim manufacturing industry. The said industry manufactures rim for automotive vehicles. All the steps to manufacturing the rim for various types are same excluding the shape and size of the rim. In the present case, the rim was manufactured by passing it from 9 different workstations (As mentioned in Chapter 4). Under the present circumstances, the rate of production was very low. So-that, the new strategies need to be worked out. As in the present case, the complete data has been picked up from base to arrive at existing levels of utilization and the cycle time. The study had to be continued over a period of 30 days to find out the details of factors contributing to no value addition. The present level of production volumes i.e. 95 Nos./shift can be achieved through 2 stations only. The targeted production of 190 Nos. can be achieved by having 8 stations as against 9 stations in the present conditions. The deployment of 8 stations can easily contribute to 190 Nos./shift which is almost two times the existing production volumes. The saving of one workman can contribute approximately 1.8 Lakhs per annum at the rate of Rs 15000/- per month per workman. Also, the higher volumes of production shall lead to better utilization of resources, high cash inflow and improved profits.

7.1 Future Scope

In current scenario of economic globalization, liberalization, keen competition and increasing customer awareness quality is a buzzword for survival and growth of any organization whether in manufacturing or production sector. The problems occurring in the industries are vast and require a mix of various problem solving techniques to help in effectively solving them. Over the past few decades, Balancing of Assembly line has been a great challenge for the researchers. With the help of ALB, the reduction in number of workstation and efficient utilization of plant resources can be determined very easily. The R&D and production engineers can easily apply it into the research field because of:

(i)   The proposed solution by ALB can be implemented at an affordable cost, and
(ii)   It is readily amendable to computerization.

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