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Implementation of Line Balancing Method for Manufacturing Line of Handle bar

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Abstract

Line balancing is one of the method. Which is help to leveling the work load across the work station , remove bottleneck station, remove excess capacity in the manufacturing line and optimal resources are being used to meet the customer requirements on time. If manufacturing line is not balanced properly and will leads to Short supply as against customer demand then the manufacturer has to pay heavy penalty or loss of business with customer will happen.

Prevent this kind of situation, Manufacturing line to be balanced in effective manner on the line balancing parameters like grouping of the workstation, leveling of work load, remove bottleneck station, remove excess capacity, remove excess work in progress, Effetely use no of manpower utilization ,man movement, material movements, Space utilization, manufacturing lead time, Throughput analysis ,customer demand. In this paper, we have implemented the various line balancing parameter in the handle bar manufacturing line and results were discussed .

Line balancing method will be useful for process planning, production, manufacturing, design and plant engineers in an industry.

Introduction

Many automobile parts are produced through the different manufacturing line like manual, semi automatic and automatic line in an industry at different volume rate. In each manufacturing line is having the set of stations . Which are mandatory to convert the raw material in to finished products and Line balancing is helps to ensure smooth out put of the line with optimum resources are being used for manufacturing.

We have selected handle bar manufacturing line in supangita engineers pvt limited at Bangalore and balanced on the line balancing parameters are as below

1. Grouping of the work station
2..leveling of work load
3.Remove bottleneck station
4.Remove excess capacity
5.Remove Excess work in progress
6.No of manpower
7.Man power Utilization
8. Man Movement
9.Material Movement
10.Space utilization
11.Manufacturing lead Time
12.Throughput analysis
13.Customer Demand Analysis

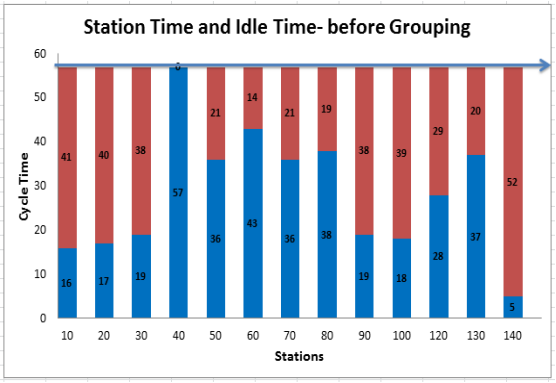
The implementation of Balancing method in handle bar manufacturing line results were discussed and compared (before and after line balancing).

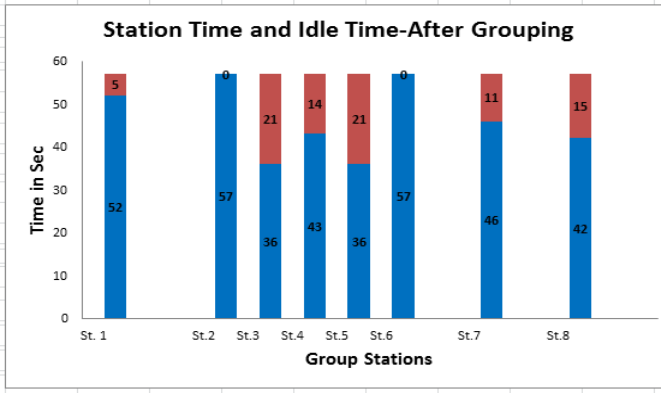
Line Balancing Method-Grouping Of work Station

Grouping of Station means that the set of work station will be grouped based on cycle time. Which is help to effectively utilize operator and reduce no of operator. We have consider large candidate method for grouping station

Large candidate method rules as follows

1.Arrange the cycle time as per the sequence of operation
2.Combine the next proceed operation
3.Those cycle time should not exceed the highest cycle time (bottle neck station)
4. Station time is combine as close to or less than highest cycle time
5. If required , Eliminate the non value added time or design station times are same and less than bottleneck station time.





GROUPING STATION BENEFITS :

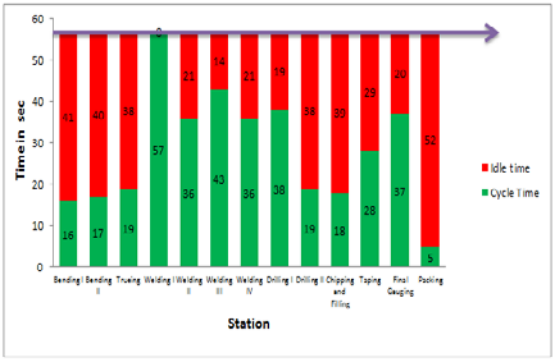
Parameters	Grouping station	
	Before	After
No of Operator	14	8
Idle Time	51.58%	36.82%
Operator utilization	48.41%	63.17%
Cost of operator per Pc	Rs 13.05	Rs 8.57

Line Balancing Method-Leveling of work load

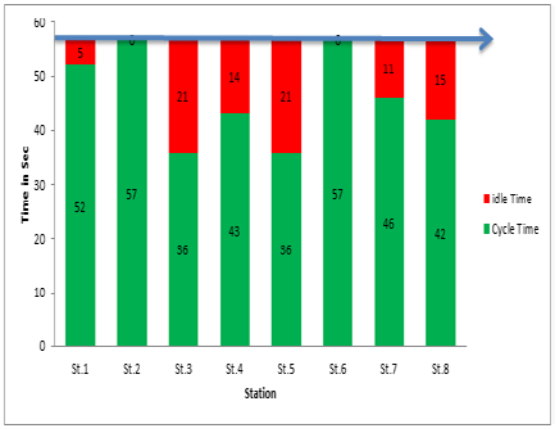
Leveling of work load Means that station times of different group will be make it almost same or close to same station time. It's help to equalize the work load for different group station and also for operators.

Leveling will be done with help of Grouping Station. We found that the grouping station is not equalize. If required , Eliminate the non value added time or design station times are same.

LEVELING WORK LOAD BEFORE LINE BALANCING STATION TIME AND IDLE TIME:



LEVELING WORK LOAD AFTER LINE BALANCING STATION TIME AND IDLE TIME:



BENEFITS OF LEVELING WORK LOAD

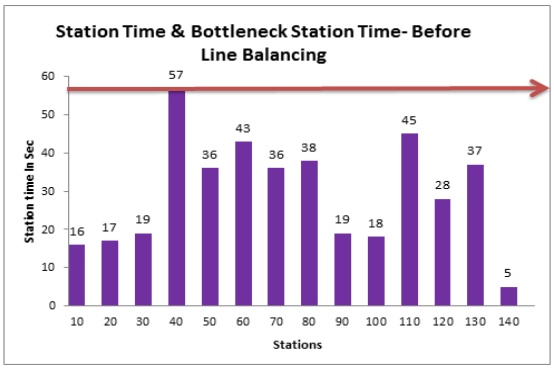
Parameters	Leveling Work Station	
	Before	After
No of station	14Nos	8 Nos
No of Operator	14 Nos	8 Nos
Total Station time	369 sec	369 Sec
Total Idle Time	331 sec	87Sec

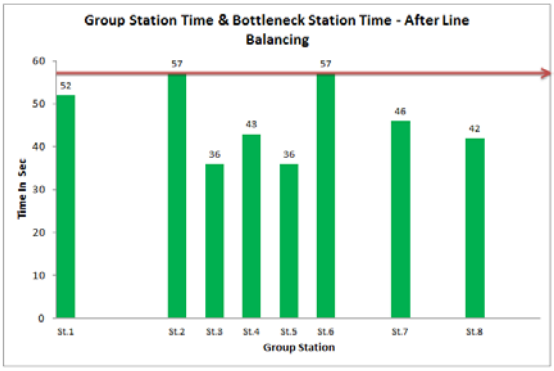
Line Balancing Method-Remove Bottleneck Station

Bottleneck station Means that station which is operating with high cycle time and its decide the line output. Remove the bottleneck station

in the manufacturing line with help of grouping station.

If required , Eliminate the non value added time or design station times are same.



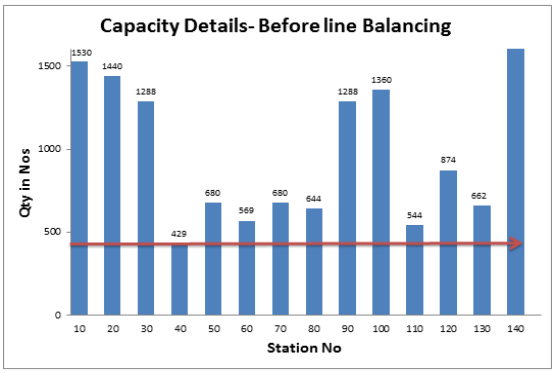


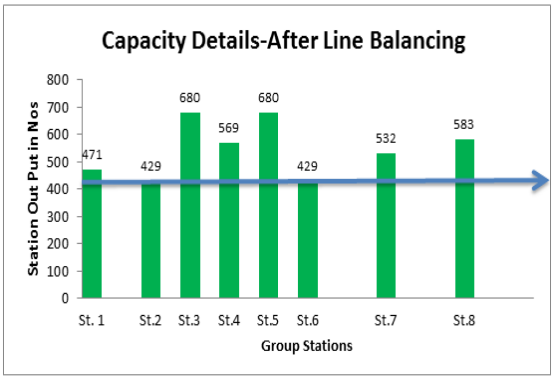
Parameter	Before line balancing	After line balancing
Bottleneck Station time	57 Sec	57 sec
Station operating time	5 to 57 sec	36 to 57 sec
Remarks	All Station time design same as 57 sec or less than 57 sec	

Line Balancing Method-Remove Excess Capacity

Capacity is the max quantity will be comes out from the manufacturing line. The capacity of the line will be decided by the bottleneck station time.

Remove the excess capacity in the manufacturing line with help of grouping station and try to minimize the excess capacity to the bottleneck station capacity.





Parameters	Before line balancing	After line balancing
Bottle neck capacity	429 Nos per shift	429 Nos per shift
Excess capacity	1101 Nos	251 Nos
Remarks	After balancing still 251 nos excess quantity to reduced to 429 Nos	

Line Balancing Method-Remove Excess Work In Progress

Work in progress (WIP) is the quantity of the parts or sub assembly available in the manufacturing line. Which are being processed or are between processing operations. WIP is inventory that is in the state of being transformed from raw material to finished product.

Excess work In progress of the each stage will be calculated by the following simple formula.

Excess WIP

= Total Capacity Qty –Bottleneck station Output Qty.

= Total Capacity Qty -work Inprogress

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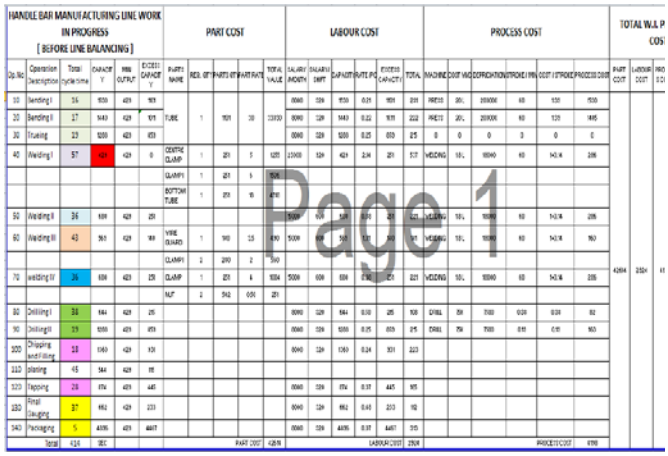
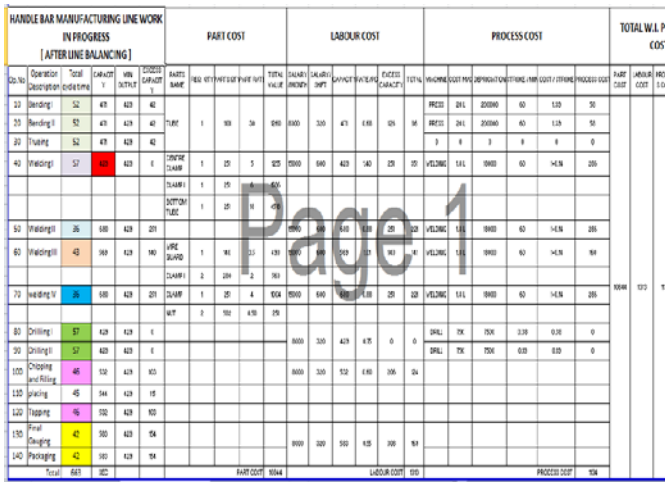
The bottleneck output qty will be come as min output of the line and The materials like part or assembly are being used for manufacturing Excess products will be considered as excess working progress in the manufacturing line and reduced as much as possible





Work in progress :

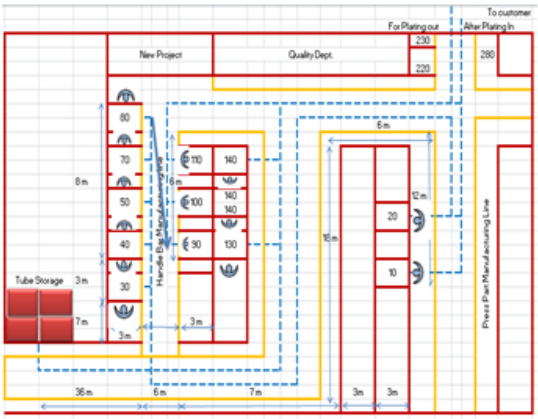
Parameter	Before line balancing	After line Balancin
Excess Capacity in Inventory	Max 1101 Nos	Max 251 Nos
Part cost	Rs 42614	Rs 10844
Labour Cost	Rs 2924	Rs 1313
Process Cost	Rs 4198	Rs 1134
Total WIP Cost for 3 Shifts	Rs 149208	Rs 39873
Remarks	After line balancing still excess WIP cost Rs 39873 Reduc to Zero Value (No WIP)	

Line Balancing Method-No of Man Power

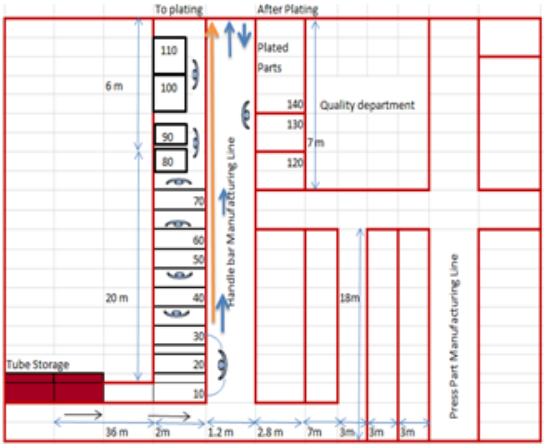
Handlebar is manufactured with help of semiautomatic manufacturing line . Hence man power is essential for loading & unloading, performing operation and also required them for checking, material feeding to line and product packing.

Grouping of station is help us to reduce the No of operator and Cost of labor in the manufacturing line.

Existing Layout



Proposed layout



Manpower Cost Details- Before line balancing

Op No	Operation Description	Manpower	Salary/ Month	Salary/ Shift	Manpower cost/ Day	Man power cost
10	Bending I	1	8000	320	960	
20	Bending II	1	8000	320	960	
30	Trueing	1	8000	320	960	
40	Welding I	2	23000	920	2760	
50	Welding II	1	15000	600	1800	
60	Welding III	1	15000	600	1800	1.16800 INR /1287 Nos
70	Welding IV	1	15000	600	1800	2.13.05 INR Pc
80	Drilling I	1	8000	320	960	
90	Drilling II	1	8000	320	960	
100	Chipping and Filling	1	8000	320	960	
110	Plating	NA	NA	NA	NA	
120	Taping	1	8000	320	960	
130	Final Gauging	1	8000	320	960	
140	Packing	1	8000	320	960	
	Total	14	140000	5600	16800	

Manpower Cost Details-After Line balancing

Operation	Operation Description	Manpower	Salary/ Month	Salary/ Shift	Manpower cost/ Day	Man power cost
10	Bending I	1	8000	320	960	
20	Bending II					
30	Trueing					
40	Welding I	1	15000	600	1800	
50	Welding II	1	15000	600	1800	
60	Welding III	1	15000	600	1800	
70	Welding IV	1	15000	600	1800	
80	Drilling I	1	8000	320	960	1.11040 INR /1287 Nos
90	Drilling II					
100	Chipping and Filling	1	8000	320	960	2.8.57 INR Per Pc
120	Taping					
130	Final Gauging	1	8000	320	960	
140	Packing					
	Total	8	92000	3680	11040	

Man power balancing benefits :

Parameter	Before balancing	After balancing	Remarks
No of man power	14	8	Manpower saved -6 Nos
Lobor Cost per piece	Rs 13.05	Rs 8.57	Cost per piece saved – Rs 4.48
Labour cost /day	Rs 16795.35	Rs 11029.6	labour Cost saved – Rs 5765.75 per day
Remarks	Because of the manpower balancing, The saving of the manpower cost is going to be INR 144143.75 per month.		

Line Balancing Method-

Man power Utilization

Man power utilization is related to the operator performance as against the standard cycle time or output. Normally man power utilization will be measured in two ways

Manual processing line

= Actual production Output / standard production output

Semi automatic line

Man power Utilization

= Operator Control Time / Total cycle time

Man Power ideal Time

= Operator Idle time / Total Cycle time

Average Man power utilisation

Sum of n station man power utilisation/ total n number of station

MAN POWER UTILIZATION : BEFORE LINE BALANCING

Station	OCT	MCT	WKT	Allowance	Total	Operator Utilization	Idle Time
10	7	8	0	1	16	43.75	56.25
20	7	9	0	1	17	41.17	58.82
30	14	4	0	1	19	73.68	26.31
40	14	40	0	3	57	24.56	75.43
50	6	28	0	2	36	16.66	83.33
60	18	22	0	3	43	41.86	58.14
70	14	20	0	2	36	38.86	61.11
80	4	32	0	2	38	10.52	89.48
90	4	14	0	1	19	21.05	78.94
100	17	0	0	1	18	94.44	5.55
120	8	18	0	2	28	44.44	55.55
130	29	0	6	2	37	78.37	21.62
140	5	0	0	0	5	100	0
					Avg.Total	48.41	51.58

No of Operator : 14

Operator Utilization : 48.41%

Idle Time : 51.58 %

Cost Per Operator /pc : Rs 13.05

MAN POWER UTILIZATION : AFTER LINE BALANCING

Station	OCT	MCT	WKT	Allowance	Total	Operator Utilization	Idle Time
St1	28	21	0	3	52	53.85	46.15
St2	14	40	0	3	57	24.56	75.44
St3	6	28	0	2	36	16.66	83.34
St4	18	22	0	3	43	41.86	58.14
St5	14	20	0	2	36	38.88	61.12
St6	8	46	0	3	57	14.04	85.96
St7	25	18	0	3	46	54.34	45.66
St8	34	0	6	2	42	95.23	4.76
					Avg.Total	42.42	57.57

No of Operator : 8 (based on LCM)

Operator Utilization : 42.42%

: 8/14 x48.41 =27.66

: 48.41-27.66=20.75

: 42.42 +20.75 =63.17 %

Idle Time : 57.57 %-20.75 %=36.82%

: 100-63.17=36.82

Cost Per Operator /pc : 8.57 Pc

Man power Utilization benefits

Parameter	Before line balancing	After line Balancing
No of operator	14	8
Idle time	51.58 %	36.82%
Operator utilization	48.41 %	63.17 %
Cost labour per piece	Rs 13.05	Rs 8.57
Remarks	Idle time of the operator should be kept it as minimum	

Line Balancing Method- Man Movement

Movements of men are essential to carried out the loading, operation , unloading ,receive the raw material from store, move the finished goods to FG area same time movements are essential for keep the materials, tools ,spare and machine safely.

Design the layout such way that the man movement should be kept as minimum . In our case , we have balanced the man movements with help of reducing the non value added movements in the existing layout.

MAN MOVEMENT DETAILS IN THE EXISTING LAYOUT :

Op.No	From	To	Distance	No of Unit/Day	Total Distance Traveled/ No
10	RM Store	Bending I	88 m	1287 Nos	0.146K.m
20	Bending I	Bending II	2 m		
30	Bending II	Trueing	39 m		
40	Trueing	Welding I	1 m		
50	Welding I	Welding II	1 m		
70	Welding II	Welding III	1 m		
80	Welding III	Welding IV	1 m		
90	Welding IV	Drilling I	8 m		
100	Drilling I	Drilling II	0.5 m		
110	Drilling II	Chipping & Filling	0.5 m		
120	Chipping & Filling	Plating	1.5 K.m		
130	Plating	Tapping	1.5 K.m		
140	Tapping	Final Gauging	1 m		
150	Final Gauging	Packing	3 m		
		Total	146 m		

Op.No	From	To	Distance	No of Unit /Day	Total Distance Traveled /No
60	Store	Clamp & Nut welding	38 m	1287 Nos	0.076 K.m
	Clamp & Nut Welding	Store	38 m		

Total Man movement in a manufacturing line per piece nos : 0.222 K.m

Man Movement in K.M per day production in the Mfg Line : 0.222*429 =95 k.m

MAN MOVEMENT DETAILS IN THE PROPOSED LAYOUT

Op.No	From	To	Distance	No of Unit/Day	Total Distance Traveled/ No
10	RM Store	Bending I	33 m	1287 Nos	0.045 K.m
20	Bending I	Bending II	1 m		
30	Bending II	Trueing	1 m		
40	Trueing	Welding I	1 m		
50	Welding I	Welding II	1 m		
70	Welding II	Welding III	1 m		
80	Welding III	Welding IV	1 m		
90	Welding IV	Drilling I	0.5 m		
100	Drilling I	Drilling II	0.5 m		
110	Drilling II	Chipping & Filling	1 m		
120	Chipping & Filling	Plating	1.5 K.m		
130	Plating	Tapping	1.5 K.m		
140	Tapping	Final Gauging	1 m		
150	Final Gauging	Packing	3 m		
		Total	45 m		

Op.No	From	To	Distance	No of Unit /Day	Total Distance Traveled /No
60	Store	Clamp & Nut welding	38 m	1287 Nos	0.076 K.m
	Clamp & Nut Welding	Store	38 m		

Total Man movement in a manufacturing line per piece nos : 0.121 K.m

Man Movement in K.M per day production in the Mfg Line : 0.121*429 =52 k.m

Man movements benefits

Parameters	Before line balancing	After line balancing
No of man Power	14	8
Man Movement required for manufacturing a product	0.222 K.M	0.122 K.M
Total Man Movement for Min Output	95 K.M	52 K.M
Distance travelled by operator / shift	6.78 K.m	6.5 K.M
Standard – Normal Man Walk distance / day Walk Distance / shift- 8 hrs		: 58 K.M / day : 20 K.M / 8 hrs

Line Balancing Method- Material Movement

Movements of material are essential to convert the material in to finished products by means of material adding process in each stage (Part welding). Material movements should be minimum as much as possible. If material movements are too long that will be leads to parts damage , space utilization will be poor and parts are scatted entire area of the plant

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MATERIAL MOVEMENT DETAILS IN THE EXISTING LAYOUT:

Op.No	From	To	Distance	No of Unit/Day	Total Distance Traveled/ No
10	RM Store	Bending I	88 m	1287 Nos	0.146 K.m + 3.0 K.m
20	Bending I	Bending II	2 m		
30	Bending II	Trueing	39 m		
40	Trueing	Welding I	1 m		
50	Welding I	Welding II	1 m		
70	Welding II	Welding III	1 m		
80	Welding III	Welding IV	1 m		
90	Welding IV	Drilling I	8 m		
100	Drilling I	Drilling II	0.5 m		
110	Drilling II	Chipping & Filling	0.5 m		
120	Chipping & Filling	Plating	1.5 K.m		
130	Plating	Tapping	1.5 K.m		
140	Tapping	Final Gauging	1 m		
150	Final Gauging	Packing	3 m		
		Total	146 m		

Op.No	From	To	Distance	No of Unit /Day	Total Distance Traveled /No
60	Store	Clamp & Nut welding	38 m	1287 Nos	0.076 K.m
	Clamp & Nut Welding	Store	38 m		

Note :

Plating will be carried out at Omax Pvt Ltd, Bommasandra, Bangalore.
Total Material movement in a manufacturing line per piece nos
= 0.146+0.076+3.0 K.m
= 3.222 K.m

MATERIAL MOVEMENTS DETAILS IN THE PROPOSED LAYOUT

Op.No	From	To	Distance	No of Unit/Day	Total Distance Traveled/ No
10	RM Store	Bending I	33 m	1287 Nos	0.045 K.m
20	Bending I	Bending II	1 m		
30	Bending II	Trueing	1 m		
40	Trueing	Welding I	1 m		
50	Welding I	Welding II	1 m		
70	Welding II	Welding III	1 m		
80	Welding III	Welding IV	1 m		
90	Welding IV	Drilling I	0.5 m		
100	Drilling I	Drilling II	0.5 m		
110	Drilling II	Chipping & Filling	1 m		
120	Chipping & Filling	Plating	1.5 K.m		
130	Plating	Tapping	1.5 K.m		
140	Tapping	Final Gauging	1 m		
150	Final Gauging	Packing	3 m		
		Total	45 m		

Op.No	From	To	Distance	No of Unit /Day	Total Distance Traveled /No
60	Store	Clamp & Nut welding	38 m	1287 Nos	0.076 K.m
	Clamp & Nut Welding	Store	38 m		

Note :
Plating will be carried out at Omax Pvt ltd, Bommasandra, Bangalore.
Total Material movement in a manufacturing line per piece nos
= 0.045+0.076+3.0 K.m
= 3.121 K.m

MATERIAL MOVEMENT- BEFORE LINE BALANCING

Material Movement - Before line Balancing

Op.No	Operation Description	Total cycle time	Capacity	Output / Hour	Bin or Space capacity	Input Material	No of Movements	Movement Time inHr	Fork lift		Trolley		Total
									Cost of Movement per Hour	Cost of Movement	Cost of Movement per Hour	Cost of Movement per Hour	
10	Bending I	16	1530	191	150	Tube-1 No	10	0.83	33.33	28	1	0.00	Movements
20	Bending II	17	1440	180	150		10	0.83		28		0.00	
30	Trueing	19	1288	161	150		9	0.75		25		0.00	
40	Welding I	57	429	54	80	Center clamp-1 No, Clamp I-1 No Bottom	2	0.50		0		0.50	
50	Welding II	36	680	85	80		Single piece Flow	0.00		0		0.00	107.00
60	Welding III	43	569	71	80	wire guard-1 Clamp-2	2	0.50		0		0.50	
70	welding IV	36	680	85	80	Clamp-1, Nut -2 Nos	2	0.50		0		0.50	Cost
80	Drilling I	38	644	81	80		Single piece Flow	0.00		0		0.00	
90	Drilling II	19	1288	161	80		Single piece Flow	0.00		0		0.00	
100	Chipping and Filling	18	1360	170	80		Single piece Flow	0.00		0		0.00	
120	Tapping	28	874	109	80	Trolley Load	11	1.28		42		0.00	359.50
130	Final Gauging	37	662	83	80		Single piece Flow	0.00		0		0.00	
140	Packaging	5	4896	612	80	Trolley Load	61	7.12		235		0.00	
	Total						101	6.00		358		1.5	

MATERIAL MOVEMENT- AFTER LINE BALANCING

Material Movement - After line Balancing

Op.No	Operation Description	Total cycle time	Capacity	Station Time	Reduced Capacity	Bin or Space capacity	Input Material	No of Movements	Movement Time inHr	Fork lift		Trolley		Total
										Cost of Movement per Hour	Cost of Movement	Cost of Movement per Hour	Cost of Movement per Hour	
10	Bending I	16	1530	52	471	150	Tube-1 No	3	0.25	33.33	8	1	0.00	Movements
20	Bending II	17	1440		471	150		3	0.25		8		0.00	
30	Trueing	19	1288		471	150		3	0.25		8		0.00	
40	Welding I	57	429	57	429	80	Center clamp-1 No, Clamp I-1 No Bottom	2	0.50		0		0.50	
50	Welding II	36	680	36	680	80		Single piece Flow	0.00		0		0.00	29.00
60	Welding III	43	569	43	569	80	wire guard-1 Clamp-2	2	0.50		0		0.50	
70	welding IV	36	680	36	680	80	Clamp-1, Nut -2 Nos	2	0.50		0		0.50	Cost
80	Drilling I	38	644	57	429	80		Single piece Flow	0.00		0		0.00	
90	Drilling II	19	1288		429	80		Single piece Flow	0.00		0		0.00	
100	Chipping and Filling	18	1360	46	532	80		Single piece Flow	0.00		0		0.00	
120	Tapping	28	874		532	80	Trolley Load	7	0.82		27		0.00	79.50
130	Final Gauging	37	662	42	583	80		Single piece Flow	0.00		0		0.00	
140	Packaging	5	4896		583	80	Trolley Load	7	0.82		27		0.00	
	Total							23	6.00		78		1.5	

Material movements Balancing benefits

Parameter	Before line Balancing	After Line Balancing
Total Material Movement in the line per Piece in K.m	3.222 K.M	3.122 K.M
No of times-Material Loading	107 times	29 times
Cost of Material Movement for 429 Nos	Rs 359.50	Rs 79.50
Cost of Material Movement for piece	85 paise	19 paise
Cost Of Movement per Day	Rs 1079	Rs 239
Remarks	Because of the material Movement balancing, The saving of the material movement cost is going to be INR 252000 per Year.	

Line Balancing Method- Space Utilization

Space utilization means that the spaces are used for the manufacturing the handle bar products should be most effective. Now days the space is going to be initial investment as high in the industrial area. Hence space has to effectively used for Manufacturing.

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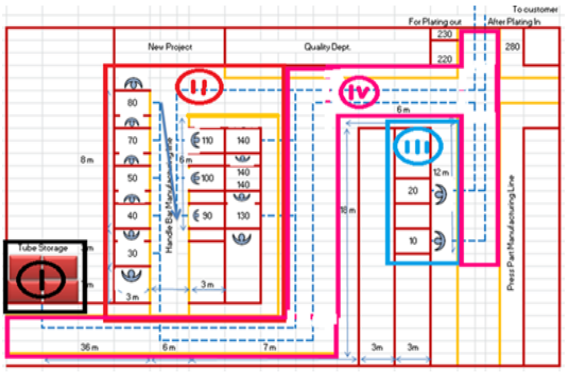


FLOOR SPACE UTILIZATION CALCULATION :

Location	Length[m]	Width[m]	Area [Sq.m]
RM Store(I)	6	6	36
Welding Area(II)	13	18	234
Pressing Area(III)	12	3	36
Gang Way(IV)	49	2	98
	16	2	32
	6	3	18
	18	2	36
Total area used for manufacturing the products			490 Sq.m

FLOOR SPACE UTILIZATION CALCULATION :

Location	Length[m]	Width[m]	Area [Sq.m]
RM Store(I)	6	6	36
Welding and Pressing Area(II)	26	6	156
Gang Way	42	2	84
Total area used for manufacturing the products			276 Sq.m

Space utilization Balancing benefits

Parameters	Before line Balancing	After Line Balancing
Total Area used for manufacturing the products	490 sq.m	276 sq.m
Cost Of land in the Bommasandra Industrial area at Bangalore-560099	[1Acre =4046.856 sq.m=Rs 2 Cr]	
Cost Of Space utilize	Rs 2421633	Rs 1364022
Remarks	The Space Cost saving is going to be Rs 1057611 as capital investment	

Line Balancing Method- Manufacturing Lead Time

Manufacturing Lead time means that the time required to manufacturer a first product from the manufacturing line. Manufacturing lead time will be vary with respect to the type of production and main aim to reduced the manufacturing lead time helps to quickly reach the market and also scope to get more new products for manufacturing and supply to customer.

Mfg Lead Time –Batch Production.

Batch Production means that a manufacturing process in which components or goods are produced in batches and not in a continuous stream. The manufacturing lead time of batch production will be calculated by using the following formula

Manufacturing lead Time = No X (Tset + Tcycle X Q + Tno)

No – No of operations having the product in Nos

T set – Set up Time required for each machine operation (Max Set Up Time) in Hrs or Mins

T Cycle – Cycle Time required for manufacturing the parts (Max Cycle Time) in hrs or Mins

Tno – Non Operating Time in hrs or Mins

Manufacturing Lead time –Mass Production

Mass Production is the production of large amounts of standardized product by machinery.

Manufacturing lead Time = No X (Tr + Max To)

No – No of operations having the product in Nos

Tr – Transfer Time required for Transferring the part from one station to Another station in Hrs or Mins

Max To – Cycle Time required for manufacturing the parts (Max Cycle Time) in hrs or Mins

Handle bar manufacturing Line- Manufacturing lead time before line balancing				
Operation	Operation Description	Total Cycle Time	Transfer time	Manufacturing Lead Time in Sec
10	Bending I	16	70	662 sec
20	Bending II	17	10	
30	Trueing	19	40	
40	Welding I	57	8	
50	Welding II	36	8	
60	Welding III	43	10	
70	Welding IV	36	10	
80	Drilling I	38	15	
90	Drilling II	19	5	
100	Chipping and Filling	18	5	
110	Plating	45	15	
120	Taping	28	25	
130	Final Gauging	37	12	
140	Packing	5	15	
Total		414	248	

Handle bar Manufacturing Line – Manufacturing lead time after Transfer time reduced				
Operation	Operation Description	Total Cycle Time	Transfer time	Manufacturing Lead Time in sec
10	Bending I	16	30	539 Sec
20	Bending II	17	10	
30	Trueing	19	8	
40	Welding I	57	8	
50	Welding II	36	10	
60	Welding III	43	10	
70	Welding IV	36	8	
80	Drilling I	38	5	
90	Drilling II	19	5	
100	Chipping and Filling	18	5	
110	Plating	45	5	
120	Taping	28	8	
130	Final Gauging	37	8	
140	Packing	5	5	
Total		414	125	

Robotic Welding Line –Manufacturing Lead Time (Cycle time and Transfer time Improved)				
Operation	Operation Description	Total Cycle Time	Transfer time	Manufacturing lead Time in sec
10	Bending I & II	20	17	348 Sec
20	Welding I & II	70	8	
30	Welding III & IV	46	8	
40	Drilling I	10	8	
50	Drilling II	10	8	
60	Filling and chipping	15	8	
70	Plating	51	5	
80	Taping	15	5	
90	Final Gauging	31	5	
100	Packing	3	5	
Total		271	77	

Manufacturing Lead time balancing Benefits

Parameter	Before line balancing	After line balancing	
		Transfer time Reduced	Cycle time and Transfer time Reduced
Cycle Time	414 sec	414 sec	271 sec
Transfer Time	248 sec	125 sec	77 sec
Manufacturing lead Time	662 sec	539 sec	348 sec
Reduced mfg Lead time	123 Sec		314 sec

Line Balancing Method- Throughput Analysis

Throughput Analysis (Manual Line) –Before Line Balancing

Throughput defined as the No of accepted parts will be coming out from the manufacturing Line is called as Throughput.

In order to find out the throughput, we need to know that the each stage output. The stage output means that the accepted output from the station. Throughput of line will be find out by multiply of all stage output ratio as against input.

Throughput

= S1 x S2 X S3 X S4 X S5 X S6 X S7 X S8 X S9 X S10 X S11 X S12 X S13 X S14

S 1 to 14 Referred as Stage.

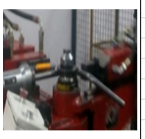
Input raw materials are processed in set of station. Which are required to convert the raw material to finished products. Each stage accepted output has to be note down and apply in above equation. Finally we can get the throughput of the manufacturing.

S1 = Accepted Qty/ Produced Qty for the station 1.

Throughput Analysis(Manual line)- Before Line Balancing													Month: Oct-15; Day: 15-10-2015
Operation No	10	20	30	40	50	60	70	80	90	100	120	130	140
Operation Name	Bending I	Bending II	Trueing	Welding I	Welding II	Welding III	Welding IV	Drilling I	Drilling II	Chipping and Filling	Tapping	Final Gauging	Packing
Capacity	1530	1440	1288	429	680	569	680	644	1288	1360	874	662	4896
Input Material	1530	1440	1288	429	680	569	680	644	1288	1360	874	662	4896
Accepted Material	1300	1296	1095	429	680	569	680	644	1288	1360	874	662	4896
Rejected Material	230	144	193	0	0	0	0	0	0	0	0	0	0
Output Ratio	0.85	0.9	0.85	1	1	1	1	1	1	1	1	1	1
Rework Material	230	144	193	0	0	0	0	0	0	0	0	0	0
Stage Output	1530	1440	1288	429	680	569	680	644	1288	1360	874	662	4896
Throughput per shift	Min Output : 429 Nos												
Throughput per day	Min Output : 1287 Nos												
Remarks	Throughput outputs in the stage of 10 ,20 and 30 will be 72 % . [say 1300/1530 x 1296/1300 x 1095/1296] and other Satges are 100 % as a throuput. This problem can be 100 % eliminate by introducing CNC bending machine												

Stage 10 ,20 and 30 has rework rate of 10-15 % per day . Ref the through put analysis report of year -2015 and 2016. This rejection is due to inadequate tool support leads to

bending profile change (Ref. the Process Photo Graph)

Process No	Process Name	Process Defect	Checking Method	Recommended Solution
10	Bending -I	 Mfg parts is not answering accepted Gauge-Bending Profile Changed	 Checked with Accepted Gauge	
20	Bending-II	 Mfg parts is not answering accepted Gauge-Bending Profile Changed	 Checked with Accepted Gauge	
30	Trueing	 Mfg parts is not answering accepted Gauge-Bending Profile Changed	 Checked with Accepted Gauge	Tube Bending Machine help to avoid the Tube bending Profile Change

Throughput Analysis (Robot Weld Line) – After Line Balancing

In this line , we have introduced a tube bending machine for the purpose of tube bending . which is help to avoid the three stage bending process and also reduce the rework rate to zero.

Throughput Analysis :

Throughput of line will be find out by multiply of all stage output ratio as against input.

Throughput

= S1 x S2 X S3 X S4 X S5 X S6 X S7 X S8 X S9 X S10

S 1 to 10 Referred as Stage.

Input raw materials are processed in set of robot weld station. Which are required to convert the raw material to finished products without any weld issue and consistency welding. Each stage accepted output has to be note down and apply in above equation. Finally we can get the throughput of the manufacturing.

S1 = Accepted Qty/ Produced Qty for the station 1.

Throughput Analysis(Robot weld line)- After Line Balancing									Month: Jan-16 / Day: 20-01-2016
Operation No	10	20	30	40	50	60	80	90	100
Operation Name	Bending I & II	Welding I & II	Welding III & IV	Drilling I	Drilling II	Chipping and Filling	Tapping	Final Gauging	Packing
Capacity	1224	350	532	2448	2448	1632	1632	790	8160
Input Material	1224	350	532	2448	2448	1632	1632	790	8160
Accepted Material	1224	345	515	2448	2448	1632	1632	790	8160
Rejected Material	0	0	0	0	0	0	0	0	0
Output Ratio	1	1	0.97	1	1	1	1	1	1
Rework Material	0	5	15	0	0	0	0	0	0
Stage Output	1224	350	520	2448	2448	1632	1632	790	8160
Throughput per shift	350 Nos per Shift								
Throughput per Day	1050 Nos per day per line								
No of line and Max output	2 and 2100 Nos								
Remarks	Throughput outputs in the stage of 20 and 30 will be 94 % . [say 345/350 x 530/345] and other Satges are 100 % as a throuput.This problem can be 100 % eliminate with help of proper foundation of the robot welding machine								

Stage 20 and 30 has rework rate of less than 0.95% (20 Nos per 2100 Nos Output) due to mounting bracket is not weld with handle bar . Ref the through put analysis report of year - 2015 and 2016. This rejection is due to high vibration at time of welding lead to create gap between electrode wire and work piece (Ref Process Photo Graph)

Process No	Process Name	Process Defect	Checking Method	Recommended Solution
10	Welding I & II	 Mounting Bracket is not welded with Handlebar assembly	Visual Inspection	Vibration observed at time of Welding leads to improper welding on the Bracket and leg area 
20	Welding III & IV	 Mounting Leg is not welded with Handlebar assembly	Visual Inspection	Proper foundation of the machine helps to avoid the vibration leads to achieve Zero Rejection on the Welding Stage

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Throughput Balancing Benefits

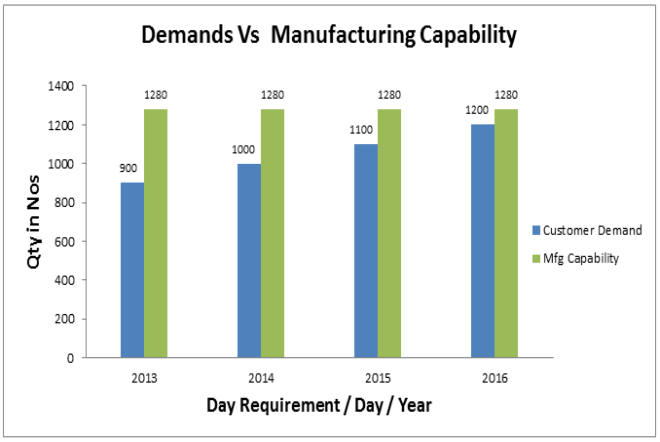
Parameters	Before Line Balancing	After Line Balancing
Throughput in %	72 % (stage 10,20 and 30)	94 % (Stage 20 and 30)
Output in Nos	1287 Nos (Designed :429 nos per shift)	2100 Nos (Designed : 350 Nos per shift)
Remarks	Inconsistence in the welding due to lack of manpower and frequently changing man power. Rework Quantity : 567 Nos	Consistence in the welding processes because of all welding processes governed by Robot Rework Quantiry : 20 Nos

Line Balancing Method- Customer Demand

Demand means that the rate of product wants by the consumer or customer or market from the manufacture. Normally demand mentioned in terms of quantity of products per day or week or month or year.

The manufacturing Capability in three shift should capable of meeting the demands otherwise go for new investment .

Year	2013	2014	2015	2016
Annual Qty	270000	300000	330000	360000
Month Qty	22500	25000	27500	30000
Days/Month	25	25	25	25
Non Operation day per month	5	5	5	5
Qty / Day	900	1000	1100	1200



Demand Balancing Condition :

Customer Demand ≤ Manufacturing Capability

Calculation :

Max .Customer Demand : 1200 Nos

Max. Manufacturing Capability : 1280 Nos

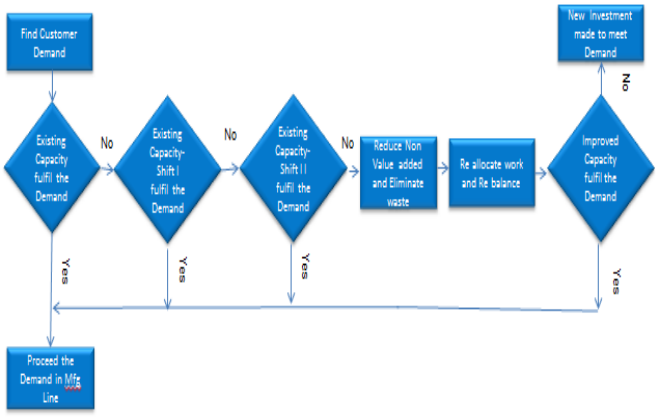
The Manufacturing capability will handle the customer Demand Products.

Customer Demand ≤ Manufacturing Capability

1200 NOS ≤ 1280 NOS

Demand is well balanced in the Handle Bar Manufacturing Line for Single product. The Handle bar manufacturing line (Manual Line) is capable of handle single product and for other variety of the product, we need to duplicate the line or go for the Robotic handle bar manufacturing Line.

Methodology adopted for line Balancing (Demand Balancing) as follows



Conclusion :

The detail discussions were made in the area of line balancing of handle bar manufacturing line

is useful for meeting the customer demand with help of optimum resource usage.

The line balancing method is not only applicable for single product and it can apply for multiproduct manufacturing line & other manufacturing process.

We have discussed few important line balancing method and same will help you to come out with Balanced manufacturing line in all aspects.

Future Work :

Grouping of work Station :

Still there is chance to reduce the idle time of operator from 36.82 % to Minimum as much as possible as they can.

Leveling of work Load :

Stations are operating in between 36 to 57 sec. all station time design or eliminate non value added time to less than 57 Sec.

Remove Excess Capacity :

Excess Capacity is observed 251 Nos has to reduced to Zero or as much as possible they can.

Work in Progress :

The current value of work in Processes is Rs 39873 has to reduced to Zero or as much as possible they can.

Man power utilization :

Check the possibility of man power idle time reduced from 36.82 % to Min or as much as possible they can.

Manufacturing lead time :

Final station cycle time and transfer time are 271 and 77 sec . Adjust the process parameter to bring the cycle time to min as much as possible.

Throughput analysis :

Throughput has affected in station no 20 and 30. Recommended action has initiate in the manufacturing and result to be checked.

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