Axle Line Capacity up-gradation by Process Planning

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Abstract:* The demand of automobile components is increasing at a faster rate due to heavy demand of vehicles. Thus the capacity up-gradation is the basic need of manufacturing and assembly units of automobile components. The axle is the most important part of the vehicle. To increase the capacity of axle assembly, first the capacity assessment of the existing equipments was done. It was needed to introduce some more equipment either in the existing assembly line (extension line) or may be put parallel to the existing line (parallel line). These two lines are compared in terms of investment cost, number of manpower, flexibility, ease of implementation etc. and the parallel line layout is recommended. The planning was also made for assembly of 100 axles/shift for multi models LCV, MCV and HCV.

Keywords:* Axle; Extension line; parallel line; process planning; capacity up-gradation; process layout; line balancing; Light Commercial Vehicle LCV;MediumCommercialVehicleMCV;HeavyCommercialVehicleHCV.

1. INTRODUCTION

The capacity up-gradation is the basic need of each and every industry. This can be achieved by process planning, either by new set up or by implementing the different techniques and sorting out the bottlenecks of the existing set-up in the company. The capacity up-gradation planning is done for the fulfillment of the forecasted market demand. Planning helps in identifying the resource problem and minimizes redundancies of effort [1-11]. The major problem being faced by almost all automobile industries is the line balancing of the multi-model [12-14]. An efficient line balancing technique seeks to generate a balanced workload at multiple stations, while simultaneously reducing equipment and labors requirement [11]. Line balance helps to reduce the bottlenecks, quick identifying the constraints, reduce work overload, improve workflow etc.

This study is being carried out for the up-gradation of Axle Line of an automobile company. This company manufactures multi Axles for Heavy Commercial Vehicle (HCV), Medium Commercial Vehicle (MCV) & Light Commercial Vehicle (LCV). Its working hour is 450 min/shift. Existing capacity of the plant was 60/shift i.e. the vehicle can be produced after every 7.5 min. Thus the cycle time for 60/shift is 7.5 min. and for 100/shift will be 4.5 min. Such a large increment from existing 60/shift to

100/shift of axle assembly requires in depth study of the existing set-up. First of all, the capacity assessment of all the existing equipment was done. With this, the bottleneck for 100/shift have been identified. If the cycle time is less or equal to 4.5 minutes, the equipment will be able to produce 100 /shift. For that some additional facilities may be required e.g. machine equipments, material handling, jigs/fixture, assembly tools, line side storage & supply. Any assembly automobile company is being divided into following sub groups-

a) Axle Line
b) Transmission line
c) Engine Line
d) Cabin Line
e) Chassis Line

In this study emphasis is given on the capacity up-gradation of Axle line from 40/shift to 100/shift.

2. AXLE AND AXLE LINE ASSEMBLY

Axle is the most important component of the vehicle. It is considered as its legs and it carries complete weight of the vehicle. The weight carrying portions of the axles, whether it may be front or rear, is considered as beam supported at the ends, loaded at two intermediate points and subjected to the following loads [15-16]:

- The vertical load at the spring centers due to the weight of the vehicle.
- A fore and aft load at the wheel center due to driving or braking effort.
- The torque reactions due to drive or brakes.
- A side thrust at the radius of the tier due to centrifugal force when rounding a curve.

The multi axle consists of three axles - Front axle, Rear Axle and Tag Axle (Dummy axle). The axle line is divided in five-sub groups-

1)Washing Station
2)Slat conveyor
3)Hub line
4)Differential Line
5)Painting Line

Slat conveyor is the main line of the Axle line Assembly [17-22]. Higher Axle Loads and Higher Speeds are contrary to each other. The problems that industry faces include not only multi-period problems, but also managing the assortment for multiple generations of products. It is futile to attempt both (High Speeds and High Axle Loads) on existing mixed traffic network. In order to determine the direction of the organization, it is necessary to understand its current position and the possible avenues through which it can pursue a particular course of action. Strategies to create additional capacity and increasing average speeds by optimum use of existing network and selectively constructing new conventional lines [23-26]. For capacity up gradation, two options will arise either the new conveyor will be set up parallel or it is to be extended after modification. By considering these two options of slat conveyor line, cost/axle was calculated.

3. CAPACITY ASSESSMENT OF THE EXISTING EQUIPMENT

Capacity assessment of the existing equipments was done for the requirement of the additional facilities. For the calculation of output per shift the required data were noted from the company and calculation were made. A typical calculation for 6×2 vehicle is shown for different equipment. The process of calculation for different equipments is described:

3.1 Capacity assessment of the Slat Conveyor

i. Based on Manpower

Throughput time of Slat Conveyor for 6×2 model = 107 min.
Pitch of the fixture=0.25 meter
Distance between the Station = 2.5 meter
Length of the conveyor=17.5 meter
No. of the effective Station = {(17.5/2.5)-1} = (7-1) = 6
Therefore, the maximum number of manpower = 6×2=12 (two persons at each station).
Utilization of the manpower /vehicle=Throughput time/No. of Manpower=107/12=8.9
Output /shift=Total working time per shift/Utilization of manpower per vehicle
=450/8.9= 50.56

ii Based on Speed

Speed of the Conveyor= 1m/min.
Number of the axle for 6×2 model =3
Pitch between the vehicles= No. of axle × pitch between fixtures = 3×2.5 meter =7.5 meter
Length of the effective station = 2.5 meter
Therefore time for assembly of one vehicle =7.5 minutes

Table 1: Capacity Assessment of the Slat conveyor

Parameters\ model	**10:59**	**10:70**	**10:90**	**MCV**	**HCV**	**6X2**
THROUGHPUT TIME (In mins.)	36	35	37	54	78	107
Pitch of the conveyor (m)	0.25	0.25	0.25	0.25	0.25	0.25
Pitch of the Fixture (m)	2.5	2.5	2.5	2.5	2.5	2.5
No. of the Effective Station	6	6	6	6	6	6
MANNING						
Max No. of Manpower	12	12	12	12	12	12
Utilization of Manpower/ Vehicle (mins.)	3.0	2.9	3.1	4.5	6.5	8.9
Out Put / Shift	150	155	145	100	69	51
SPEED						
Max. Speed (m/min.)	1	1	1	1	1	1
Pitch of one vehicle	5	5	5	5	5	7.5
Time for one Vehicle	5	5	5	5	5	7.5
Max. Out Put / Shift	90	90	90	90	90	60

Maximum output per shift = Total working time per shift/time taken to assemble one
Vehicle = 450/7.5 = 60
Similarly, for other types of models, calculations were made and the results were included in Table 1.

3.2 Capacity of the washing machine

There are two washing machines
i Main Washing machine for Slat conveyor
ii Washing machine for Hub and Drum Line
i Main Washing Machine
No. of trays used for washing one 6 ×2 vehicle = 5
Cycle time for one tray= 1.5 min. (As per specification of the washing machine)
Time taken to start the washing machine= 0.14 min.
Total Time involved for washing machine= 1.5 ×5+0.14=7.64 min.
Maximum capacity of the washing machine = Time per shift /total time for the machine
=450/7.64=58.9
Similarly, the calculation is done for different models of main washing machine and Hub-Drum Washing machine and the results are shown in Table 2(a) and Table 2 (b) respectively.

Table 2(a): Capacity Assessment of the Main Washing Machine

Parameters\ model	10:59	10:70	10:90	MCV	HCV	6X2
No. of Tray Used for one Vehicle	4	4	4	4	4	5
Cycle Time (min.)	1.5	1.5	1.5	1.5	1.5	1.5
Starting Time (min.)	0.14	0.14	0.14	0.14	0.14	0.14
Total Time / Vehicle (min)	6.1	6.1	6.1	6.1	6.1	7.6
Maximum Capacity of Washing	73.3	73.3	73.3	73.3	73.3	58.9

Table 2(b): Capacity Assessment of the Hub – Drum Washing Machine

Parameters\ model	10:59	10:70	10:90	MCV	HCV	6X2
No. of Tray Used for one Vehicle	4	4	4	4	4	6
Cycle Time (min.)	1.5	1.5	1.5	1.5	1.5	1.5
Total Time / Vehicle (min)	6.0	6.0	6.0	6.0	6.0	9.0
Maximum Capacity of Washing	75.0	75.0	75.0	75.0	75.0	50.0

The capacity assessments for the other equipments were also done. A summary sheet for the different models is prepared and is shown in Table 3. From Table 3, it is observed that the capacity of unloading Gantry for Hub-Drum Washing machine was approaching for 100/shift, but the capacity of other equipments was much below the required 100/shift.

Table 3: Summary Sheet of Capacity of the equipments

Sl.No.	Parameters\ model	10:59	10:70	10:90	MCV	HCV	6X2
1	Capacity Assessment of the Slat Conveyor -- Man- Power	150	155	145	100	69	51
	Speed	90	90	90	90	90	60
2	Capacity of Washing Machine						
	Main Washing Machine	73	73	73	73	73	59
	Hub- Drum Washing Machine	75	75	75	75	75	50
3	Capacity of Press for Diff. Line	369	369	223	223	75	75
4	Capacity of Press for Integrated Hub Line(HCV as Base Model)	398	395	388	157	86	53
5	Fixture for Shim Selection	0	0	381	0	54	36
6	Capacity of Greasing Application(Manual)	125	125	125	121	69	46
7	Capacity of Painting Only (Manually)	134	134	134	134	108	69
8	Capacity of Paint Booth	122	122	122	122	99	63
9	Capacity of Loading Gantry for Hub-Drum Washing	152	152	152	152	114	76
10	Capacity of Unloading Gantry for Hub- Drum Washing	148	195	195	139	139	102
11	Capacity of Loading Gantry for Main Washing	97	97	97	97	97	79
12	Fixture For Differential Case & Case - Crown Wheel Assly (Separate Fixture)	126	126	95	95	36	36
13	Fixture for Differential Final Assly (separate fixture)	89	89	89	89	59	51

Therefore, it can be concluded that from the existing equipments, it was impossible to upgrade for 100/shift. For achieving the required goal, it is utmost important to include some additional equipments. Due to the addition of the equipment, there will be change in axle layout. The equipments may be either added in the existing line, making it as an extension or may be put parallel to the existing line and it may be called as a parallel line. Then there is a need for estimation of cost for these two lines.

4.0 EXTENSION LINE VS. PARALLEL LINE

The existing Axle Assembly line can be sub divided in two groups:

i) Main Line
ii) Sub Assembly Line

Main Line can be further divided into three groups:

a) Main Washing machine
b) Slat conveyor
c) Painting

There are two sub assembly lines:

a) Hub Drum Line
b) Differential Line

At the time of change of Axle Line Layout, the length of the Slat conveyor can be increased and this option may be called as an extension line. If another Slat conveyor is set up parallel to the existing slat conveyor then this option may be called as parallel line.

4.1 Estimation of the cost

The calculation of the cost is done for above two proposed assembly line (extension line and parallel line). The cost comprises:

i) Cost of plant and machinery
ii) Cost of power consumption
iii) Cost of manpower
iv) Cost of consumables

4.1.1 Cost of Plant and Machinery

The cost of Plant and Machinery consists of:
i) Land & Building Costs
ii) Equipment Costs
iii) Assembly costs
iv) Material Handling Cost
v) Jigs and Fixture Cost
vi) Cost for Quality control facilities
vii) Line Side Storage
viii) Stores Investment etc.

Since the cost of the existing equipment is much higher than the price at the time of purchase. Therefore, for the calculation of the cost of plant and machinery a multiplying factor of 1.5 is taken.

4.1.2 Cost of power consumption

For the calculation of cost of power consumption the connected load/unit is known from the specification of the equipment.
Working hour per day = 16
Load Factor=0.3
Quantity of the equipment=y (say)
Rise of units per day=Connected load per unit × Load Factor × Working hours per day × Quantity of the equipment
Cost of power per day = Rise of units per day ×cost per unit.
Cost of power per shift = Cost of power per day/2
The calculation of the cost of power consumption was made.

4.1.3 Cost of Manpower

Manpower consists of two types
i) Permanent
ii) Temporary (casuals, apprentice, etc.)

Let 'X' is the total manpower involved in assembly. Let the permanent member is 'Y' and the temporary member is 'Z'.
Cost of manpower is calculated as no. of manpower × Rate per annum in Lacs.
Cost of manpower per day = Total cost of manpower per annum / 365
Cost of manpower per shift = Cost of manpower per day / 2
The calculation of the cost of manpower was made.

4.1.4 Cost of Consumables

Cost of consumables is the variable cost and it varies with the number of vehicles produced. The cost of consumables per vehicle will remain unchanged either for parallel or extension line assembly.
For the above calculation, the following assumptions were taken: Depreciation rate for building is taken as 3.34%.
Depreciation rate for plant and machinery is taken as 7.24%.
Interest on total investment is taken as 10.0%.
Rate of maintenance cost for buildings = 1%.
Rate of maintenance cost for plant and machinery = 5%.
Rate of insurance cost on investment = 0.14%

The summary sheets of the above cost calculation are shown in Table 4.

4.2 Calculation of the Manpower

Apart from the calculation of the cost, number of manpower also plays a critical role in making decision for the type of the axle line layout. The number of manpower calculation was done separately as follows:
Throughput time on Slat conveyor for 6 ×2 model=107 min.
Output of the slat conveyor=40/shift
Working hour per shift = 450 min.
Cycle Time = Working hour per shift / Output per shift
=107/40=11.25
Similarly for the calculation of manpower on different station are shown in Table 5.
In parallel conveyor, one line is set for the production of 60/shift LCV/MCV and other for 40/shift HCV/6X2 models. The manpower was allocated as per maximum throughput time. The 6 ×2 vehicle have three axles and thus, 40 number of 6 ×2 vehicles is equivalent to 60 vehicles having two axles. The highest throughput time for vehicle, which has two axles, is HCV (20:16) model. For extension the manpower for same production will be according to 120/shift HCV (20:16 model).

Table 4: Axle Aggregate Cost Summary

Sl. No	**Category**	**Unit**	**Existing**	**Parallel**	**Extension**			
	Peak Volumes		16000	60000	60000			
	Cost Head		Total Per Annum	Per Axle	Total Per Annum	Per Axle	Total Per Annum	Per Axle
	Investment							
1.	Land Cost	Rs.			0.0		0.0	
2.	Building	Rs.	9808000		15952000		11460000	
3.	Plant & Machinery	Rs.	25051038		38475096		39711540	
	Total Investment		34859038		54427096		51171540	
A	Depreciation							
A.1	Depreciation for Building	%	3.34 %		3.34%		3.34 %	
		Rs.	327587.0	20.47	532796.8	8.8	382764	6.38
A.2	Depreciation for Plant & Machinery	%	7.24 %		7.24%		7.24 %	
		Rs.	18136	113.3	27855	46	2875	47

			95.2	6	97	.4	11.	.9
	Total Depreciation	Rs.	2141282.4	133.83	3318393.8	55.3	3257879	54.3
B	Interest							
B1.	Interest on Total Investment	%	10%		10%		10%	
		Rs.	3485903.8	217.87	5442709.6	90.7	5117154	85.2
	Fixed Cost	Rs.	5627186.2	351.70	8761103.4	146	8375033	139
C	Power Per Annum	Rs.	2308680	144.29	4087195	68.1	3309293	55.1
D	Manpower Per Annum	Rs.	7118653.3	444.92	7950738.2	132	8974766	149
E	Indirect Consumable Per Annum	Rs.	596903.1	37.31	2238386.5	37.3	2238386.	37.3
F	Maintenance Cost Per Annum	Bldg. %	1%		1%		1%	
		P & M %	5%		5%		5%	
		Rs.	1350631.9	84.41	2083274.8	34.7	2100177	35
G	Insurance Cost on Investment	%	0.14%		0.14%		0.14%	
		Rs.	45804.9	2.86	71552.2	1.19	67079.1	1.12
	Variable Cost	Rs.	11421928	713.87	16433071	273	1669170	278
	Total Annual Cost	Rs.	28469787.	1779.4	41625321.1	693	4175644	695
	Cost / Axle Set (2 Nos.)	Rs.	890		347		348	

4.3 Comparison between Extension and Parallel Line

For the comparison between the parallel and extension, following parameters were taken:

a. Aggregate cost per axle.
b. Number of manpower.
c. Investment
d. Incase front, rear or tag Axle off loaded in future.
e. Flow of Aggregates
f. Stoppage of current production Line

The merits and demerits of both options are discussed below:

Merits of the Parallel Conveyor:-

1) Saving of the Manpower (Table 5)
2) Production will not stop while implementation.
3) Speed to the Pitch ratio in parallel is less while working, therefore ease of working on the Conveyor.
4) Incase Front, Rear and Tag Axle are offloaded then assets can be fully utilized.

Demerits of the Parallel Conveyor:

- Larger area as compared to the Extension line.

Demerits of the Extension:

1) More manpower is required.
2) Production stopped while implementation.
3) Speed to pitch ratio is high therefore difficulties may take place while assembly
4) Drainage modification may be required.
5) Further, in extension, additional Paint booth as well as Washing machine was needed. It will increase the problem of material handling.

The above-mentioned points discussed are given a weighted score. Rating was given to each point according to the easiness, pros and cons of implementation. The type, which has scored more, has been taken into consideration. As per basis of KT matrix (Table 6) parallel conveyor was proposed.

Table-5: Calculation of the manpower

	Existing	Option 1 (Parallel)		Option 2 (Extension)	
		MCV	6x2	Total	Total (HCV)
Capacity	60	60	40		120
Cycle Time / Vehicle (in Mins.)	7.50	7.50	11.25		3.75
Throughput Time (in Mins.)					
	Main Washing Machine	8.91	8.82	12.25	
	Slat Conveyor	78.08	56.53	115.09	
	Painting	9.36	7.86	14.41	
	Differential Washing	7.12	6.17	8.12	
	Differential Line	35.89	15.05	33.71	
	Hub & Drum Washing	7.02	6.48	10.71	
	Hub Line	34.15	16.67	55.21	
	Knuckle Assly	8.12			
	Shock Abs. Bkt. Welding	5.47	5.47		
TOTAL TPT	194	123	250		194
Manpower on 2 Shift Basis					

(Per Day)					
	Main Washing Machine	6	2.4	2.2	4.6
	Slat Conveyor	22	15	20.5	35.5
	Painting	4	2	3	5.0
	Differential Washing		1.6	1.4	3.0
	Differential Line	10	4	6	10.0
	Hub & Drum Washing	2	1.7	1.9	3.6
	Hub Line	10	4.4	9.8	14.2
	Knuckle Assly	2			
	Shock Abs. Bkt. Welding	2	2	2	4.0
Total		58	33	47	80

In parallel layout, there may be two options existing

i) Hub drum line and differential line are in between both conveyors.

ii) Hub drum line and differential line are aside of both conveyors.

With the hub drum line and differential line aside of both conveyor, the distance from the slat conveyor may increase. Due to this, there may be material handling problem. Therefore, for the parallel line layout the option in which Hub drum line and differential line are in between both conveyors were taken into consideration. For this option there can be two possibilities:

(i) When the Hub drums line and differential line are also parallel to each other.

(ii) When the Hub drum line and differential line are face to face.

For the option, when hub drum line and differential line are parallel to each other, then there may be criss-crossing of material handling and overhead supply. The best option of layout is when hub-drum line and differential lines are face to face and in between both the slat conveyor. The parts are to be continuously supplied to the line as per its utilization. The deciding factor for the supply is the types of parts and the number of parts used per vehicle. The line side storage also depends on the ratio of the different model to be assembled on that particular day.

output of the vehicle = N/shift, and suppose the demands for the 10:50, 10:70 and 11:10 model are in the ratio of x: y: z. Let the number of parts used for 10:50, 10:70 and 11:10 models are p, q and r respectively.

Then the number of parts supplied per shift

$$'S' = x/(x+y+z) \times N \times p + y/(x+y+z) \times N \times q + z/(x+y+z) \times N \times r$$

$$= N/(x+y+z) \times \{p \times x + q \times y + z \times r\}$$

Let the capacity of the Bin or Trolley='w', then the supply frequency per shift = S/w

Table 6: KT Matrix

Rating Basis : 1~3 Poor, 4~6 just below requirement , 7~8 Meets Need, 9~10 Exceeds Need							
Sl. No.	**Parameter**	**Context**	**Weightage**	**Option 1 (parallel conveyor)**		**Option 2 (Extension of Conveyor)**	
				Rating	Score	Rating	Score
1	Aggregate Cost/ Vehicle (Base Front and Rear Axle of 20.16)	comprehensive cost which includes Capital Cost (Interest & Depreciation), Manpower, Power, Consumables etc.	9	8	72	8	72
				347		348	
2	No. Manpower	No. of Manpower required for 60/shift - MCV & 40/Shift – 6X2	9	8	72	5	45
				80		103	
				Less manpower required		More manpower required	
3.	Investment	Total Investment required (Including Plant & Machinery & Bldg.)	8	6	48	7	56
				Rs. 544 Lacs		Rs. 512 Lacs	
				Parallel conveyor can be commissioned without stopping production		Drain Modification is required	
4	Incase front and Tag Axle off loading in Future	Utilization of Assets	8	6	48	4	32
				New conveyor, Washing M/c, Paint Booth & Presses		Extended conveyor can not be given to vendor	

				may be given to vendor			
5	Flow of Aggregate	Feasibility for the overhead supply Layout	8	7	56	7	56
				Hub and Diff. Line will be in Between Two conveyor, Hence feeding two conveyor is smooth			
				Hub line and Diff. Line working flow will be good		Restriction in implementing diff. line for LCV & HCV as available width was 4m only	
7	Stoppage of current production line	No vehicle loss during implementation	7	6	42	3	21
				Independent implementation without disturbing existing production		Production Shut down required min. one week	
	Total				338		282

If the S/w value is very less, then the frequency can be set for few days or even for a week. If the value of S/w is more than it can be set for number of times per shift according to need.By using above formulation, the line side storage & Frequency of supply/shift for different models were calculated.In process layout, how the work was done and how much work will be done at a particular station is mentioned. The line balancing helps in maximum utilization of the manpower. The time taken to do a particular work was taken from the company, which is determined with the help of MDAT software (MOST Data Acquisition Tool). This software is based on MOST (Maynard Operation Sequence Technique). Since there are number of sub-operation, the time allocated to the worker may not be equal to the cycle time. In this study, the process layout with line balancing for MCV 60/shift & 6 ×2- 40/shifts was prepared. The Line Layout prepared is summarized as follows:

There are two parallel lines for HCV model:

i) Main Line
   a) Main Washing Machine
   b) Slat Conveyor
   c) Painting

ii) Sub Assembly Line
   a) Hub Drum Line
   b) Differential Line

Hub Drum line may be sub divided in two ways
i) Hub-Drum Washing Machine
ii) Hub-Drum Assembly

Differential Line may be sub divided in two ways
i) Differential Washing Machine
ii) Differential Assembly

Similarly, the assembly of MCV Line can be sub divided. Process layout chart are prepared. The components for assembly on slat conveyor are washed on the main Washing Machine and one operator is involved for the loading the component and other for unloading the component. At the Slat conveyor Knuckle Assembly, Brake Assembly, Torquing, Dust cover fitment, Tie rod fitment, Differential fitment, Shaft Fitment, Hub Drum Fitment etc. are done. The operators are involved for assembly. Workers are doing the assembly at both side of the conveyor and are denoted as Left Hand Side Worker (LH) and the Right hand side worker (RH). The Final assembly will go for painting. Here two workers are allocated to do the job. At Hub Drum line, the Bearing race fitment, Bearing Fitment, Oil Seal Pressing, Bolt Pressing Shim Selection and Greasing application were done. At Differential Line, the differential Case Assembly, Retainer Assembly, Carrier Retainer assembly and Final differential assembly were done. There were two equipments, which are common to HCV and LCV Line. These are

i) Hub Drum Washing Machine
ii) Differential Washing Machine

At Hub Drum Washing Machine, the Hub and Drum are washed and supplied to the different line. At Differential Washing Machine, the different components used for Differential Assembly are washed and are supplied to the Differential Line. The summary sheet of the process chart for HCV 40/shift and LCV/MCV 60/shift are shown in Table 7 & Table 8 respectively. From these summary Tables one may be able to know how the work is done and how much work will be done at a particular station.

CONCLUSIONS

The capacity up gradation is the basic need of all automobile manufacturing and assembly units of automobile components. The axle is the most important part of the vehicle. To increase the capacity of axle assembly from existing 60/shift to 100/shift of an assembly unit, the equipments either added in the existing assembly line (extension line) or may be put parallel to the existing line (parallel line) and also the capacities of the individual equipments are calculated and from that additional required quantity of equipments are proposed.

REFERENCES:

[1] John P. Tanner & Associates, “Manufacturing engineering, an introduction to the basic function”, Orlan, Florida, 1991.
[2] www.atlantic.cc.wm/timesheet-benefits.htm/
[3] K.R.Phaneesh, “Production and Operation Management”, Sudha Publications, 2002.
[4] Edward J. Phillips, “Manufacturing Plant Layout, Fundamentals and fine points of Optimum facility design”, P.E. Society of Manufacturing Engineers One SME Drive Michigan,1997.
[5] Richard Muther, “Practical plant layout’, McGraw-Hill Book Company, 1955.
[6]. Joseph Harrington, “Understanding the manufacturing process”, Marcel Dekker, Inc., New York,
[7] Arthur C. Ansley, “Manufacturing Methods and Processes”, Chilton Book Company,
[8] Maynard, H.B., Stegemerten G.J. & Schwab, Methods-time Measurement New York: McGraw-Hill, 1948.
[9] Bryan B. Christopher son, www.managers.net.com.
[10] Dirk J Rauglas, www.propalanner.net.
[11] Tanner, T.P., Planning To Minimize Manufacturing Corpn. Production Engineering, June 1986.
[12] Ravi Shanker, “Industrial Engineering and Management”, Golgotha Publication Pvt. Ltd, New Delhi 1971
[13] Harold T. Amrine, John A. Ritchey, Oliver S, Hulley, “Manufacturing Organization and Management” Second Edition, Prentice Hall of India Private Limited, New Delhi, 1971.
[14] Vijay S, Seth, “Facilities Planning and Material Handling, Methods and Requirements”, Marcel Dekker Inc., New York, 1995.
[15] Kirpal Singh,” Automobile Engineering, Vol-1”, Standard Publishers Distributers, 2001.
[16] Jay Kopycinsk, “www.minitruckinweb.wm”, A Premedia Publication.
[17] Sadhu Singh, “Machine Design” Khanna Publishers, Third Edition, Delhi, 1999.
[18] Hicks, Philip E, “Introduction to Industrial Engineering and Management Science”, Mc Graw Hill, NewYork, 1977.
[19] Ed. T.J.Bently, “The Management Service Handbook, Institute of management Services”.
[20] Dennis A Whitmore, “Work Measurement, Institute of Management Services”
[21] Krick, E.V., “Methods Engineering Design and Measurement of Work Methods,” Wiley, New York, 1962.
[22] Maynard, H.B. “Industrial Engineering Handbook”, Third Edition, Mc Graw Hill, New York, 1971.
[23] Herbert Meyr, “Supply chain planning in the German automotive industry”, Institute of Transport Economics and Logistics, 2004.
[24] A. Gürhan Kök Fuqua, School of Business Duke University, Marshall L. Fisher, The Wharton School University of Pennsylvania, Ramnath Vaidyanathan, The Wharton School, “Assortment Planning: Review of Literature and Industry Practice”, 2006.
[25] Patrick J. Montana and Bruce H. Charnov, “Barron's Management book fourth edition”
[26] M. Lorenzen, "Strategic Planning for Academic Library Instructional Programming." In: Illinois Libraries 86, Page no. 2, 2006