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WORK CONTENT REDUCTION OF CHASSIS ASSEMBLY LINE USING MOST: A CASE STUDY

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Abstract

To sustain in this competitive globalized industrial environment, a company needs to increase productivity by reducing or eliminating the idle and/or downtime, improving the working methods, standardize the time as well as enhance the overall capacity planning. Nowadays Maynard Operation Sequence Technique is used in all the Manufacturing industries for calculating and reducing the work content. By using this technique, we can find the non-value added activities, Method Improvement, Off-Lining activities and Off-Loading activities, unnecessary movement of the operator at the work-station etc.

Keywords -MOST (Maynard Operation Sequence Technique), Productivity, Assembly Line, VA, NVA activities

1. INTRODUCTION

Chassis Assembly Line consists of a sequence of workstations where human workers performed assembly tasks. Chassis Frame of vehicle variants were assembled as they move along the line. At each workstation, a portion of the total work was performed on each Chassis frame. Chassis frame enters into the starting of the line at regular intervals. Chassis frame travels through successive workstations and workers add components that progressively build the final assembled Chassis frame.

Chassis Assembly line was having 22 numbers of workstations. These workstationswere divided and identified with the names. These workstationswere combined into the seven different groups. These groups were assigned different tasks and different numbers of operators. Some workstations on the chassis assembly line need more time that on the others. These variations in time causes under-utilized of some operators. Therefore, there was a need of line balancing to increase the production rate with maximum utilization of the input sources. To calculate the time required by the operator to complete a specified task for the defined method at the defined pace of performance some techniques like Time Study is used. However, in this work, a new technique i.e. Maynard Operation Sequence Technique (MOST) were used.

To increase the productivity of the Chassis Assembly Line, there was a need to reduce the Work Content of the Line. Reduction of the existing Work Content results into the increase in production. So for Work Content reduction Maynard Operation Sequence Technique is used. By using this technique, we find the non-value added activities, unnecessary movements of the operator at the workstation, Method Improvement, Off-Lining activities and Off-Loading activities etc. The planned production rate of the Chassis Assembly Line was 120 vehicles per shift. However, actual production rate was 110 vehicles per shift with manpower of 54. The ratio of the vehicles produced in a shift per operator was 2.04.

Measuring work accurately is a fundamental and essential ingredient in any and every organization. As a proven work measurement tool, the MOST technique is an ideal choice for creating those all-important structured time standards that are the backbone of all business sectors. MOST is not only a faster work measurement technique; it ensures a much more detailed method description than say, Time Study, or estimating. It is a more precise approach to work measurement and productivity improvement. A progression of MTM, MOST provides precise analyses that highlight the opportunities to reduce complicated or excessive movement and therefore time, human effort and cost.

2. LITERATURE REVIEW

Maynard operation sequence technique (MOST) is a predetermined motion time system is used primarily in industrial settings to set the standard time in which a worker should perform a task. To calculate this, a task is broken down into individual motion elements, and each is assigned a numerical time value in units known as time measurement units, or TMUs, where 100,000 TMUs is equivalent to one hour (Maynardet al2012). All the motion element times are then added together with any allowances, which resulted into the standard time. It is more common in Asia whereas the original and more sophisticated Methods Time Measurement technique, better known as MTM, is a global standard.

The most commonly used form of MOST is BasicMOST, which was released in Sweden in 1972 and in the United States in 1974. Two other variations were released in 1980, called MiniMOST and MaxiMOST. The difference between the three is their level of focus—the motions recorded in BasicMOST are on the level of tens of TMUs, while MiniMOST uses individual TMUs and MaxiMOST uses hundreds of TMUs. This allows for a variety of applications—MiniMOST is commonly used for short (less than about a minute), repetitive cycles, and MaxiMOST for longer (more than several minutes), non-repetitive operations. BasicMost is in the position between them, and can be used accurately for operations ranging from less than a minute to about ten minutes.(Zandin, Kjell B (2003), Work Measurement Systems. New York City).

Cornejo (2019) applied MOST in Mini Rotary Shear Line (MRS) process. He identified non-value added activities and the bottleneck of the problem. Major contributor of non-value added activities were ineffective raw material storage, preparation of materials and downtime due to borrowing.The downtime was reduced by 19.61% and the productivity increases by 9.18% in the section.

Rahman (2018) applied MOST in the sewing section of a garment industry, with the aim of identifying the non-value added activities and minimizing the bottlenecks to improve productivity and reduce product cycle time, production cost per product. This resulted into reduced the total activity time from 139 seconds to 109 seconds and improved daily productivity from 600 pieces to 1600 pieces.

lngale et al (2014) emphasized the technique of work measurement by using Basic MOST. This study was carried out in a pump manufacturing industry. The existing manufacturing line is not meet with the customer demand, with available resources. By the combined approach of VSM and Basic MOST application, new modified process has been proposed. This study shows improvement in EWT of line by synchronization of VSM and BASIC MOST about 40% and improvement in lead-time by 15%.

Bondbare et al (2016), applied MOST method on cable assembly line for productivity improvement. Earlier, the production was 750 units with 20 workers but after applying the MOST, increase in production was found as 900 units with 14 workers.

Ankit et al (2015) carried out their research on assembly of diesel engine manufacturing unit. By using MOST method in sub assembly department reduction of 27.66 % of total assembly time and in assembly department reduction of 18.20 % of total assembly time was achieved.

Belokar et al (2012) implemented MOST to increase the efficiency and the cost effectiveness of the work and reduce worker's fatigue through identification and minimization of the Non- Value Added (NVA) activities. As a result of their study, the authors managed to save 18% of the working time and define a new set of reduced standard time.

Saravanan Tanjong Tuan et al (2014) conducted study in the rear window assembly section to capture the workflow activities using systematic and descriptive workflow data block for the value adding, value engineering and methods engineering analysis by using MOST. Subsequently, new methods and work standards were developed in advance for capacity planning, workplace layout design and manning analysis. Thus through the process redesign and process flow analysis, material handling and workflow were improved. Consequently, it has been possible to reduce the production cycle time to cater the higher level of demand with shorter tact time maintaining the current level of manpower.

Yadav T. K (2013) conducted study inCylinder head assembly flow with the help of MOST. Time of the whole cylinder head assembly flow was below the 425.52 sec and reduces the workstation and area of workstation with manpower.

Mishra A. et al (2014) in their work, comparative case study of the MOST and "Traditional Time Study" was carried out for Fitment of particular parts,and Assembly Line-3. It had been found that appreciable decrease in time taken MOST in accomplishment of task in both the cases. A total decrease of 16.8% was observed inFitment of particular parts and 32.2% in Assembly Line-3 with the application of MOST as compared to Traditional Time Study.

Jain R. et al (2016) demonstrates the application of MOST technique through a case study of process improvement for improving labour productivity at bathroom appliances industry in casting section. The observational MOST study improved the casting process time by 17.69% compared to stopwatch technique. The MOST study was well accepted by the labourers compared to the stopwatchtechnique during implementation of observational MOST technique.

3. EXISTING SYSTEM DATA COLLECTION

Chassis Assembly Line was a sequence of workstations connected by a material handling system where each workstation performs a set of task using a predefined assembly process. Company having large volume of production of standardized equipment and components having a continuous flow prefer to use conveyor type assembly line. Here the work centers were sequenced in such a way that at each stage a certain element of total job was carried out, so that at the end of conveyor line the final Chassis frame assembly done. This final assembled Chassis frame were then dispatch by using the hoist to Final Line in which the final assembled chassis frame and Body structure was combined assembled to get the final finished product.

To calculate the Time required by the operator to complete a specified task for the defined method at the defined pace of performance, some techniques like Time Study is used. However, in this work, a new technique i.e. MAYNARD OPERATION SEQUENCE TECHNIQUE (MOST) was used. The software name as M-DAT i.e. MOST Data Acquisition Tool was used for calculating work content. The reasons behind using MAYNARD OPERATION SEQUENCE TECHNIQUE (MOST) over Time Study are as follows:

1. During taking observations on each stage of chassis one or two observations are enough to measure the work accurately while in Time Study Technique work must be measured repeatedly (minimum 10 cycles) by stopwatch to arrive at averages.
2. Rating factor is inbuilt (in index Time) in MOST while in Time Study Technique Accuracy of time standard depends solely on 'Rating' decided by time study engineer.
3. The time calculated of each activity does not deviate from analyst to analyst as standard calculation sheets with standard motion sequences and index values are available, while Time Study may vary from analyst to analyst depending upon analyst's skill and experience.
4. Time can be measured up to 0.36 secs. i.e. 1 TMU, while in Time Study Technique Time can be observed up to 2 to 3 secs.
5. Detailed analysis and description of the operation/ method is available, while in limited description of the operation / Method is given in the time study element.
6. Restudy of the operation is faster by means of working in office, while in Time Study Technique Restudy of the operation is not faster. It takes the same time as the earlier

study.

7. Also the time required for new product can be calculated in advance, while in Time Study Technique time cannot be calculated advance.

In M-DAT software, all data i.e. movements of the operator are feed. After providing all the data, we get the final output i.e. total work content of the activity.

3.1 Assembly Line Details

Specifications of Chassis Assembly Line were as follows:

1) No. of Work Stations= 22
2) No. of Operators= 54
3) Conveyor length= 120.23 m
4) Pitch = 5.4 m
5) TACT =3.75 min
6) Conveyor speed= 1.44 m/min.
7) TACT= Effective Working Time (450 mins) / No. of Vehicles produced (120) = 3.75 min.
8) Assembly conveyor speed range available 0.6 m/min to 3 m/min.

So by using Maynard Operation Sequence technique, all the time required for all the operation of the chassis assembly is calculated. Appendix A summaries of all activities and time required to perform these activities.

Table 1.1 Summary of Stage wise Group Work Content and Manpower

Sr. No.	Operation Description	Present Work Content In Man-Mins. (a)	Group wise Manpower as per Work Content
1	Stage No : A To C and 01 to 04 (Multi-Link assembly & Chassis Loading)	44.62	14
2	Stage No : 05 Front axle drop Stage No : 06 IFS mounting Stage No : 07 to 09	26.40	8
3	Stage No : 10 Fuel lines Stage No : 11 Brakes	27.25	9
4	Stage No : 12 Engine drop on chassis frame Stage No : 13 Propeller shaft fitment Stage No : 14 Exhaust System mounting	26.68	9
5	Stage No : 15, 16 Lubrication Stage No : 17 Tyre mounting	13.33	4
6	Stage No : 18 Chassis Rectification Stage No : 19 Chassis Buy-off	(4.46)	10
	Total	**138.28**	**54**

4. WORK CONTENT REDUCTION

To increase the productivity of the Chassis Assembly Line, there was a need to reduce the Work Content of the Line. Reduction of the existing Work Content results into the increase in production. So for Work Content reduction Maynard Operation Sequence Technique is used.

By use of this technique, the non-value added activities, unnecessary movement of the operator at the work-station, Method Improvement, Off-Lining activities and Off-Loading activities etc. were find out.

4.1 Off-Line Activities

Some activities can be performed out of the line. These activities have no effect on the Line activities. In addition, no special skills for the operator were required to perform these activities. These activities performed off-line by contract person. The activities that were chosen for off-liningwere independent of the line activities and yet they were essential part of the assembly. By off-lining the activities the number of operations performed on the line reduces which results into reduction in the time and work content. Following were some basic criteria for selection of the activities to be off-lined.

1. Non-interdependency of the activity with the activities on the line.
2. Minimal level of skills from the operator's point of view.
3. Activities in which tools and fixtures usage is at a very basic level.

If the above given criteria were applied to the list of activities performed on the line, some of the activities were found suitable for off-lining. For Chassis Frame assembly off-lining activities were as follows:

1. Placing a Rear Coil Spring Pad to LH and RH side of the Chassis Frame.
2. Front Bumper Plate mounting to Chassis Frame.
3. Spare Wheel Mounting Winch fitment to Chassis Frame.
4. Rear Shock Absorber opening on Hydraulic fixture.
5. Fitment of Fuel Hose and Exhaust pipe.
6. Fitment of Fuel Line Routing clip to Chassis Frame.

7. Fitment of Brake Line Routing clip to Chassis Frame.
8. Placing a Front Coil Spring Pad to LH and RH side of the Chassis Frame.
9. Rear Footstep Cover fitment to onto Footstep of the Chassis Frame.

The total Work Content reduced by off-lining is 6.24 man-mins. Summary of the Off-Lining activities and their respective work content reduction are given in the appendix B.

4.2 Method Improvement

Some activities were not performed by using proper method or proper processes. The way of performing processes or operations were not so accurate. This increases the time i.e. work content required to perform the activities. This can be reduced by using proper or special tool for specific operations. Critical examination when conducted on existing method helps to identify unnecessary activities and cost associated with the existing jobs.

Such activities get added to the jobs due to various reasons and were not readily apparent to those who are responsible for causing them. They were brought to light when existing production methods was analyzed critically and impartially. Also by changing the way of performing operations, work content can be reduced. Method Improvement activities for the Chassis Frame assembly were as follows:

1. Loose fitment of Short and Long Links with LH and RH side of Chassis Frame.
2. Loose fitment of Short and Long Links with Rear Axle LH and RH side of Chassis Frame.
3. Loose fitment of Pan Hard rod on Chassis Frame.
4. Tightening of Multi-Links nuts of the LH and RH side of Chassis Frame.
5. Fitment of Upper Arm with LH and RH side of Chassis Frame.
6. Steering Gear mounting to Chassis Frame.
7. Front Stabilizer Bar mounting to Chassis Frame.
8. Spare wheel mounting on Chassis Frame.
9. Loose fitment of Lower Arm with LH and RH side of Chassis Frame.
10. Placing Coil Spring Pad & Spring positioning on Spring Tower with LH and RH side of Chassis Frame.
11. Coil Spring pressing IFS of LH and RH side of Chassis Frame.
12. Tightening of IFS bolts of the LH and RH side of Chassis Frame.
13. Assemble Link Stabilizer Bar to Lower Arm assembly of the LH and RH side of Chassis Frame.
14. Tightening of Stabilizer Bar mounting bolts.
15. Routing of Fuel Main Line - Tank to Filter.
16. Routing of Fuel Return Line- Tank to FIP.
17. Hose Fuel Tank Neck fitment.
18. Hose Ventilator Fuel Tank to Fuel Neck fitment.
19. LSPV assembly to Chassis Frame.
20. Fitment of Front Side 3-way Tee to Chassis Frame.
21. Brake Hose connection to Front wheel and LH and RH side of Chassis Frame.
22. Tube TMC to LSPV (3rd part) connection and Bypass.
23. Tube to Rear RH Wheel connection Tee to RH wheel.
24. Fitment of Steering Arm to LH and RH side of Chassis Frame Knuckle.
25. Brake vacuum Leakage Test.
26. Engine Drop to Chassis Frame.
27. Tightening and Torquing Engine mounting nuts front end.
28. Engine Rear end fitment & torqueing.
29. Connection of Fuel Return Line on FIP.
30. Fitment of Column Intermediate to Steering Gear.
31. Rear Axle parking cable mounting on LH and RH side of Chassis Frame.
32. Chassis Number punching (Auto).
33. Fitment of Propeller Shaft Front End.
34. Fitment of Propeller Shaft Rear End.
35. Assembly of Exhaust Pipe Front and Middle Pipe to Engine.
36. Muffler and Tail Pipe assembly fitment to Front Exhaust.
37. Rear Axle Oil filling.
38. Oil filling in Transmission.
39. Breather Pipe fitment on Differential.
40. Pressure Hose & Return Hose connection on Steering Gear.
41. Power Steering Hose fitment on Power Steering Pump.
42. Fitment of Fuel Gauge to Tank.
43. Tyre fitment onto Chassis Frame.

The total Work Content reduced by Method Improvement is 13.06 man-mins. Summary of the Method Improvement activities and their respective work content reduction is given in appendix C.

4.3 Off-Loading Activities

In order to reduce the total number of operations and the Work Content, some operations should be off-loaded i.e. some operations should be done at the vendors end. The activities to be off-loaded depend on following aspects:

1. Criticality of operations.
2. Secrecy of operations.
3. Cost benefit associated with off-loading.

These off-loaded parts come as DOL (Direct On-Line) items. They were directly unloaded on line whenever required.

The total Work Content reduced by Off-Loading is 1.62 man-mins. Summary of the Off-Loading activities and their respective work content reduction is given in appendix D.

Table 1.2 Summary of Work Content Reduction of Chassis Assembly Line

S. No.	Operation Description	Present work content in Man-mins. (a)	Proposed work content due to			Net Proposed WC reduction. (e)=(b+c+d)	Proposed work content in man-mins.
			Method Improvement (b)	Off-Loading (c)	Off-Lining (d)		
1	Stage No : A To C and 01 to 04 (Multi-Link assembly &Chassis Loading)	44.62	2.60	0.00	5.27	7.87	36.75
2	Stage No : 05 Front axle drop Stage No : 06 IFS mounting Stage No : 07 to 09	26.40	3.09	0.00	0.97	4.06	22.34
3	Stage No : 10 Fuel lines Stage No : 11 Brakes	27.25	2.04	0.86	0.00	2.90	24.35
4	Stage No : 12 Engine drop on chassis frame Stage No : 13 Propeller shaft fitment Stage No : 14 Exhaust System mounting	26.68	4.38	0.76	0.00	5.14	21.54
5	Stage No : 15, 16 Lubrication Stage No : 17 Tyre mounting	13.33	0.95	0.00	0.00	0.95	12.38
6	Stage No : 18 Chassis Rectification Stage No : 19 Chassis Buy-off	(4.46)	0.00	0.00	0.00	0.00	0.00
	TOTAL	138.28	13.06	1.62	6.24	20.92	117.36

5. RESULTS

Based on analysis of the Chassis Assembly Line system, the work content of all the activities performed on the line was calculated. The existing work content of all the activities was 138.28 man-minutes, which includes some non-value adding activities. This work content is reduced by using Maynard Operation Sequence Technique (MOST). The total work content is then reduced by 20.92 minutes by Method Improvement in process, Off-Lining the activities and Off-Loading the activities.

Chassis Assembly Line had some activities that can be performed out of the line. These activities have no effect on the Line activities. In addition, no special skills for the operator were required to perform these activities. These activities performed off-line by contract person. The activities that were chosen for off-lining were independent of the line activities and yet they were essential part of the assembly. By off-lining the activities the number of operations performed on the line reduces which results into reduction in the time and work content. By critically examination of the chassis assembly line, some activities were off lined and work content were then reduced by 6.24 man-minutes.

Some activities were not performed by using proper method or proper processes. The way of performing processes or operations were not so accurate. This increases the time i.e. work content required to perform the activities. This can be reduced by using proper or special tool for specific operations. Critical examination when conducted on existing method helps to identify unnecessary activities and cost associated with the existing jobs. By changing the way of performing operations, work content were reduced. The total Work Content reduced by Method Improvement is 12.94 man-minutes.

In order to reduce the total number of operations and the Work Content, some operations should be off-loaded i.e. some operations should be done at the vendors end. These off-loaded parts come as DOL (Direct On-Line) items. They were directly unloaded on line whenever required. The total Work Content reduced by Off-Loading is 1.62 man-minutes.

Table 1.3 Percentagewise Work Content Reduction of Chassis Assembly Line

		WORK CONTENT IN MAN-MINUTES	PERCENTAGE
1	Existing work content	138.28	100%
2	Work Content Reduction	20.92	15%
3	Proposed work content	117.36	85%

6. CONCLUSIONS

This study of the Chassis Assembly Line using MOST technique shows the great significance in competitive advantages in terms of satisfying the customer demand, well balancing the process flow as well as ensuring the economic benefits. The time and effort required in establishing the time values for various operation was very less when compared with the stopwatch method. This proves the effectiveness of the MOST. The study has been carried out by disintegrating the large operations into simple and small elemental activities and then assigning index values to those elemental activities to get the theoretical cycle time. The work content of all the activities performed on the line is calculated. The total work content is then reduced using MOST technique by 20.92 minutes, the result with a reduction of 15%, by Method Improvement in process, Off-Lining the activities and Off-Loading the activities. The scope of this study with the application of the MOST can be explored from a wider perspective through implementation in a single or mixed model assembly lines having large number of workstations. Thus, with the detailed description, which establishes the time needed to perform an activity, MOST is a clear pointer to where a method can be improved. It provides traceable and concise time calculations that indicate the opportunities for saving time, money and human efforts.

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Appendix A- Summary of stage wise operations and work content

S. No.	Operation Description	PRESENT WORK CONTENT IN MAN-MINS. (a)
	Stage No : A To C and 01 to 04 (Multi-Link assembly & Chassis Loading)	
1	Coil spring pad placement LH/RH	0.26
2	Coil spring placement on chassis LH/RH	0.91
3	Loose fitment of short & long links with chassis LH/RH	2.11
4	Loose fitment of short & long links with rear axle LH/RH	3.07
5	Loose fitment of Pan hard rod on chassis	0.68
6	Loose fitment of Pan hard rod on axle	0.75
7	Rear axle lifting and drop on chassis.	1.15
8	Disengage tackle from rear axle & move to home position.	0.36
9	Tightening of multi-links.	5.32
10	IPMS data entry	0.25
11	Preparation of Traveler card	0.27
12	Build sheet mounting	0.25
13	Front bumper plate mounting to frame	0.71
14	Loading chassis frame on conveyor	2.33
15	Spare wheel mounting winch fitment	1.33
16	Fitment of Upper arm to Frame LH & RH	3.90
17	Steering gear mounting to frame	2.74
18	Front Stabilizer bar mounting on frame	1.52
19	Rear shock absorber fitment to axle (LH & RH)	0.95
20	REAR shock absorber opening on hydraulic fixture.	0.31
21	Rear shock abs fitment to frame (LH & RH)	0.74
22	Fitment of insulator engine to frame LH & RH	1.86
23	Rear stabilizer bar fitment	4.45
24	Fuel tank assy on frame	2.62
25	Tightening of REAR shock abs Upper & Lower end mounting nuts	1.61
26	Traveler card filling (0.24 x 7 groups)	1.68
27	Fitment of fuel line Routing clip	0.43
28	Fitment of brake routing clips on frame	1.18
29	Rear footstep mounting. Bracket fitment on chassis	0.88
1	Sub Total	44.62
	Stage No : 05 Front axle drop	
30	Spare wheel mounting on chassis	1.17
31	Locking & removal of chain from coil spring.	0.58
32	Material coll. For lower arm mounting.	0.11
33	Lower arm mounting to frame (loose) LH & RH	3.70
34	Place coil spring pad & spring positioning on spring tower LH & RH	0.83
	Stage No : 06 IFS mounting	
36	Coil spring pressing IFS RH & LH	3.37
36	Tightening of IFS bolts (LH & RH side)	4.78
37	Assemble link stabilizer bar to lower arm assy (LH & RH side)	1.69
38	Tightening of Stabilizer bar mounting bolts	1.13
39	Front shock absorber mounting RH & LH(2 wd) lower end	2.48
40	Traveler card filling	1.28
41	Rear footstep fitment onto chassis Rear footstep cover fitment onto footstep	1.81
	Stage No : 07 to 09	
42	Chassis Inversion.	2.89
43	Loosening & tightening of Spare wheel	0.39
44	Traveler card filling (Opn No:412980)	0.19
2	Sub Total	26.40
	Stage No : 10 Fuel lines	
45	Routing of fuel main line - Tank to filter	0.71
46	Routing of Fuel return line tank to FIP	0.70
47	Connection pipe to frame	0.89
48	Hose fuel tank neck fitment	0.74
49	Hose ventilator Fuel tank to Fuel neck fitment	0.43
50	Clipping of vertical brake pipe	0.24
51	LSPV assy to frame	0.96
52	Traveler card filling (Opn. No.503200 - 582650)	0.34
	Stage No : 11 Brakes	
53	Fitment of front side 3-way Tee to frame	0.85
54	Brake hose connection to Front wheel & Chassis Frame(LH & RH)	2.84
55	Fitment of tube 3 way tee to front RH wheel connection	1.30
56	Fitment of tube TMC to front side tee	0.62
57	Fitment of tube 4 way square to Front LH wheel connection - Tube along IFS cross member (Only 2 wd)	1.29

58	Fitment of tube TMC to LSPV 1st part & Bypass	1.86
59	Tube TMC to LSPV (3 rd part) connection & Bypass	2.31
60	Tee 3 way assembly to gear carrier	1.38
61	Hose LSPV to Rear 3 way tee to chassis	1.20
62	Tube Front LH wheel to Tube along IFS c /s member.	0.87
63	Tube to rear RH wheel connection tee to RH wheel	1.49
64	Tube to rear LH wheel connection tee to LH wheel	1.46
65	Traveler card filling (Opn. No.593220 - 753350)	1.66
66	FITMENT OF STEERING ARM TO KNUCKLE (LH & RH)	2.36
68	Brake vacuum Leakage Test	0.75
3	Sub Total	27.25
	Stage No : 12 Engine drop on chassis frame	
69	Engine Drop to frame	1.19
70	Engine Front end fitment	0.48
71	Tighten & Torque Engine mounting nuts front end	2.65
72	FITMENT OF NVH BAREARIER FIP BOTTOM	0.53
73	Engine rear end fitment &torqueing	0.52
74	Connection of Fuel return line on FIP	0.86
75	Fitment of column intermediate to steering gear manual	0.98
76	Front shock absorber mounting RH & LH(2 wd) top end	1.59
77	Speed sensor fitment for electronic cluster	0.76
78	Traveler card filling	0.39
	Stage No : 13 Propeller shaft fitment	
79	Rear axle parking cable mounting on chassis (LH & RH) Footstep harness clip fitting and routine	2.11
80	Chassis Number punching (Auto)	2.41
81	Fitment of propeller shaft front end	2.05
82	Fitment of propeller shaft rear end	4.86
83	Fitment of center bearing for split propeller shaft	0.82
	Stage No : 14 Exhaust System mounting	
84	Assemble exhaust pipe front & middle pipe to engine	1.72
85	Muffler & Tail pipe assy fitment to Front exhaust	2.37
86	Tightening of Spare wheel	0.39
4	Sub Total	26.68
	Stage No : 15, 16 Lubrication	
89	Rear axle oil filling	1.51
90	Oil filling in transmission	1.65
91	Breather pipe fitment on differential	0.25
92	pressure hose & return hose connection on steering gear	0.77
93	clipping for final line for body drop	0.40
94	Clipping pressure hose on steering gear	0.30
95	Power steering hose fitment on power steering pump	0.80
96	Fitment of fuel gauge to tank	1.16
	Stage No : 17 Tyre mounting	
97	Traveler card filling (Opn. No.893481- 913490)	0.47
98	Tyre fitment onto chassis	6.02
5	Sub Total	13.33
	TOTAL	138.28

Appendix B- Summary of Off-Lining Activities and Respective Work Content Reduction

S. No.	OFF-LINING ACTIVITIES	PROPOSED WORK CONTENT REDUCTION DUE TO OFF-LINING IN MAN-MINS.
	Stage No : A To C and 01 to 04 (Multi-Link assembly & Chassis Loading)	
1	Coil spring pad placement LH/RH	0.26
2	Front bumper plate mounting to frame	0.71
3	Spare wheel mounting winch fitment	1.33
4	REAR shock absorber opening on hydraulic fixture.	0.31
5	Fuel tank assembly on frame	0.17
6	Fitment of fuel line Routing clip	0.43
7	Fitment of brake routing clips on frame	1.18
1	**Sub Total**	**4.39**
	Stage No : 05 Front axle drop	
8	Place coil spring pad & spring positioning on spring tower LH & RH	0.16
2	**Sub Total**	**0.16**
	Stage No : 06 IFS mounting	
9	Assemble link stabilizer bar to lower arm assembly (LH & RH side)	0.74
10	Rear footstep cover fitment onto footstep	0.95
3	**Sub Total**	**1.69**
	TOTAL	**6.24**

Appendix C- Summary of Method Improvement Activities and Respective Work Content Reduction

S. No.	METHOD IMPROVEMENT ACTIVITIES	PROPOSED WORK CONTENT REDUCTION DUE TO METHOD IMPROVEMENT IN MAN-MINS.
	Stage No : A To C and 01 to 04 (Multi-Link assembly & Chassis Loading)	
1	Loose fitment of short & long links with chassis LH/RH	0.55
2	Loose fitment of short & long links with rear axle LH/RH	0.32
3	Loose fitment of Pan hard rod on chassis	0.20
4	Tightening of multi-links.	0.43
5	Fitment of Upper arm to Frame LH & RH	0.23
6	Steering gear mounting to frame	0.22
7	Front Stabilizer bar mounting on frame	0.64
1	**Sub Total**	2.59
	Stage No : 05 Front axle drop	
8	Spare wheel mounting on chassis	0.12
9	Lower arm mounting to frame (loose) LH & RH	1.02
10	Place coil spring pad & spring positioning on spring tower LH & RH	0.07
	Stage No : 06 IFS mounting	
11	Coil spring pressing IFS RH & LH	0.38
12	Tightening of IFS bolts (LH & RH side)	0.29
13	Assemble link stabilizer bar to lower arm assembly (LH & RH side)	0.52
14	Tightening of Stabilizer bar mounting bolts	0.15
15	Rear footstep fitment onto chassis	0.43
2	**Sub Total**	2.98
	Stage No : 10 Fuel lines	
16	Routing of fuel main line - Tank to filter	0.31
17	Routing of Fuel return line tank to FIP	0.35
18	Hose fuel tank neck fitment	0.05
19	Hose ventilator Fuel tank to Fuel neck fitment	0.25
20	LSPV assembly to frame	0.17
	Stage No : 11 Brakes	
21	Fitment of front side 3-way Tee to frame	0.04
22	Brake hose connection to Front wheel & Chassis Frame(LH & RH)	0.08
23	Tube TMC to LSPV (3rd part) connection & Bypass	0.66
24	Tube to rear RH wheel connection tee to RH wheel	0.03
25	FITMENT OF STEERING ARM TO KNUCKLE (LH & RH)	0.05
26	Brake vacuum Leakage Test	0.05
3	**Sub Total**	2.04
	Stage No : 12 Engine drop on chassis frame	
27	Engine Drop to frame	0.26
28	Tighten & Torque Engine mounting nuts front end	0.40
29	Engine rear end fitment &torqueing	0.01
30	Connection of Fuel return line on FIP	0.59
31	Fitment of column intermediate to steering gear manual	0.07

	Stage No : 13 Propeller shaft fitment	
32	Rear axle parking cable mounting on chassis (LH & RH) Footstep harness clip fitting and routine	0.41
33	Chassis Number punching (Auto)	0.81
34	Fitment of propeller shaft front end	0.36
35	Fitment of propeller shaft rear end	0.64
	Stage No : 14 Exhaust System mounting	
36	Assemble exhaust pipe front & middle pipe to engine	0.16
37	Muffler & Tail pipe assembly fitment to Front exhaust	0.67
4	**Sub Total**	4.38
	Stage No : 15, 16 Lubrication	
38	Rear axle oil filling	0.12
39	Oil filling in transmission	0.49
40	Breather pipe fitment on differential	0.03
41	pressure hose & return hose connection on steering gear	0.02
42	Power steering hose fitment on power steering pump	0.12
43	Fitment of fuel gauge to tank	0.07
	Stage No : 17 Tyre mounting	
44	Tyre fitment onto chassis	0.10
5	**Sub Total**	0.95
	TOTAL	12.94

Appendix D- Summary of Off-Loading Activities and Respective Work Content Reduction

S. No.	OFF-LOADING ACTIVITIES	PROPOSED WORK CONTENT REDUCTION DUE TO OFF-LOADING IN MAN-MINS.
	Stage No : 10 Fuel lines	
1	Hose fuel tank neck fitment	0.83
	Stage No : 11 Brakes	
2	Tee 3 way assembly to gear carrier	0.79
	TOTAL	**1.62**