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Productivity Improvement and Capacity Enhancement of an Automobile Industry: A Case Study

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***Abstract*: This paper presents the result of a study undertaken with the overarching objective of investigating the impact of productivity improvement approaches in automobile industries. Optimization of robotic arm/manipulators path in focused areas helps in eliminating non value added activities and results increase in productivity. Substantial reduction in material handling and operator manual work, reduction in manpower by using MOST (Maynard operation sequence technique) is obtained in detail.**

The tool Kaizen (continuous improvement) is applied as a way to progress towards lean manufacturing and as a formula to lead the activities of improvement. This work is mainly concentrated to find bottle neck areas in weld, paint and assembly shop of automobile industry under consideration. The main objective is to analyze delay time and line stoppages, also to minimize down time and develop several strategies to eliminate waste on shop floor. In this paper the TSP (Travelling salesman problem) and other lean manufacturing tools such as automation, Kaizen, MOST (Maynard operational sequence technique) has been used to increase the productivity and capacity of a shop to achieve desired market demand. Results obtained are quite satisfactory in terms of improvement in market share, productivity and reducing the waiting time of vehicles in market.

Keywords: Travelling salesman problem (TSP), Robotic arms/Manipulator, Productivity, MOST (Maynard operational sequence technique)

I. INTRODUCTION

Automobile industry engaged in manufacturing of four wheelers vehicle in India is facing many challenges like high level of competition and ever increasing competitive pressure [9]. Increase in demand resulted in the need of business improvement in all aspects of manufacturing, continuous improvement tool are used in all industries engaged in automobile manufacturing. Kaizen is used as a tool for elimination of non-value added activities which lead to the improvement in activities with great focus on cost reduction and improvement in quality and productivity [6]. In present day manufacturing there is a strong need of continuous improvement tools to enhance the productivity. This study has an objective of investigating bottleneck areas by suggesting continuous improvement and further optimizing welding paths for the robot engaged in welding shop for spot welding operations in the four wheeler industries. Travelling salesman problem (TSP) is used for finding the optimal welding paths for the robotic arm/manipulators and suggested most suitable feasible paths without interferences.

Robotic arm/manipulators path optimization is a technique which finds its applications in several areas. One of the areas is the welding shop, where the robotic arm or a manipulator carryout the spot welding process. In spot welding processes, the manipulator/robotic arm [1] as shown in figure 1, is required to weld a predefined number of spots. The manipulator/robotic arm, is programmed in such a way that it welds at a spot and then moves to the next spot until all the spots are welded. However, *while programming the manipulator, no logic was implemented to ensure that the manipulator covered all the spots using the shortest path possible and therefore in minimum time*. This led to time wastage, as the manipulator/robotic arm did not follow the shortest feasible path but followed a different path to cover the required number of spots.

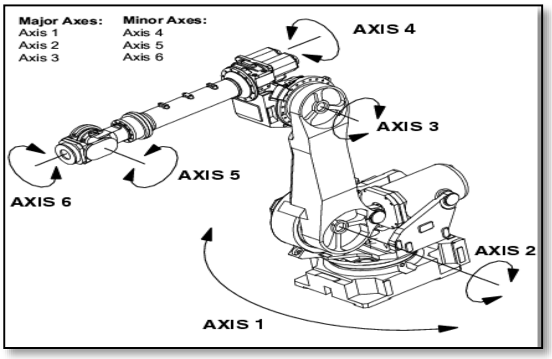

Fig.1: Robotic Arm or Manipulator (Make Fanuc)

As shown in figure 4(a) (on page no.6) the path followed by the manipulator/robotic arm to weld all the spots is repeated using past approach. The shortcomings of this approach were soon realized and a time efficient method needed to be developed for minimum wastage of time during the spot welding process. This necessitated the fact that the path traversed by the manipulator/robotic arm should be the one with minimum distance and therefore minimum time. Travelling Salesman Problem (TSP) principle is used to find a path connecting all the spots (or the dots) such that the path is the one with minimum distance [5].

Now a day's companies are facing problems due to increased demand, excessive back tracking of material, imbalanced assembly line, huge in-process inventories, and under-utilization of human resource and long waiting times resulting delays in deliveries [2]. The main cause of which is imbalanced assembly line. Line balancing is essential to survive in industries hence it is essential to balance line and enhance productivity by using MOST as a tool for the success of company survival in this competitive business era.

The Maynard Operation Sequence Technique (MOST) is a high-level predetermined motion time system (PMTS). It is a work measurement technique that concentrates on the movement of objects. It is used to analyze work and to determine the normal time that it would take to perform a particular process /operation[10].

The basic version of MOST is referred to as Basic MOST.

- The focus of Basic MOST is on work activity involve the movement of objects. The majority of industrial manual work does involve moving objects (e.g., parts, tools) from one location to another in the workplace.

- Basic MOST uses motion aggregates (collections of basic motion elements) that are concerned with moving things. The motion aggregates are called activity sequence models in Basic MOST.

- There are three activity sequence models in Basic MOST, each of which consists of a standard sequence of actions:

    - General move: This sequence model is used when an object is moved freely through space from one location to the next (e.g., picking something up from the floor and placing it on a table).
    - Controlled move: This sequence model is used when an object is moved while it remains in contact with a surface (e.g., sliding the object along the surface) or the object is attached to some other object during its movement (e.g., moving a lever on a machine).
    - Tool use: This sequence model applies to the use of a hand tool (e.g., a hammer or screwdriver).

II. LITERATURE REVIEW

D. Rajenthirakumar and P. R. Thyla in "Quality and Productivity Improvement in Automotive Component Manufacturing Company Using Kaizen" showed that the implementation of lean manufacturing strategy allows strengthening the phase sequence that leads to operational excellence, a continuous improvement and the elimination of non-value added activities. Thus, the impact of lean practices pays substantially with the operating performance of plants and use of lean tools allows the improvement of results. The tool kaizen is applied as a way to progress toward lean manufacturing and as a formula to lead the activities of improvement. It has been gradually adopted as a potential solution for many organizations, particularly within the automotive and aerospace industrial areas. This work addresses the implementation of the lean tool kaizen in an automotive component manufacturing company with a focus on tube sub-assembly line.

The main objective of the study is to develop numerous approaches to remove waste on the shop floor. This paper describes how the value stream mapping (VSM) and other suite of lean tools such as kaizen can be used to map the current state of a production line and design a desired future state. A noteworthy increase in quality and efficiency is confirmed and the manufacture flow was smoothened by removal of several non-value-added activities.

Preyanan Mahakantee A and Kontorn Chamniprasart in "Control of Robot Motion for the Shortest Path from Point to Point Through from Machine Vision" showed that the semi-automatic machines that employees use must work continuously. Body and eye fatigue impacts employee's performance and causes damage to the final product. The automatic machine works until the task is completed. The amount of time used is re-program depend on how different between task change. If the path or motion of automatic machine is change, the re-program time is likely to be long. If there are changes to tasks, the only time lost is in re-programming the automatic machine. Therefore, this paper is using computer vision to solve the problem of the automatic machine motion when it must be move from point to point. The process will be recorded and the image analyzed to find the points of robot motion. After finding these points, the solution uses the 'Traveling Salesman Problem' to control the robot motion to find the shortest path from point to point.

Saravanan Tanjong Tuan, A. N. M. Karim, H. M. Emrul Kays, A. K. M. N. Amin and M. H. Hasan in their case study "Improvement of Workflow and Productivity through Application of Maynard Operation Sequence Technique (MOST)", the problems and challenges of an auto company engaged in assembling car rear window assembly are attributable to non-optimal actions with unproductive capacity planning. The whole assembly line agonizes due to the absence of recognized standard time for actions carried out by operatives, the non-value-added activities involved and the inefficient methods such as unplanned aisle and manual screwing, and walking distance, material wastages and imbalance in the material flow. In this study Maynard

Operation Sequence Technique (MOST) is used. Thus, through the process flow and process redesign analysis, workflow and material handling are improved. Therefore, it has been possible to reduce the production cycle time to supply the higher level of demand with shorter takt time maintaining the current level of manpower.

R. Suganthini Rekha, P. Periyasamyb and S. Nallusamy in "Manufacturing Enhancement through Reduction of Cycle Time using Different Lean Techniques" showed that In recent manufacturing system the most important parameters in production line are work in process, TAKT time and line balancing. In this article lean tools and techniques were implemented to reduce the cycle time. The aim was to enhance the productivity of the water pump pipe by identifying the bottleneck stations and nonvalue added activities. From the initial time study the bottleneck processes were identified and then necessary expanding processes were also identified for the bottleneck process. Afterward the advance actions have been established and applied using different lean tools like value stream mapping, line balancing and 5S. The current state value stream mapping was developed to describe the existing status and to identify various problem areas. 5S was used to implement the steps to reduce the process cycle time and unnecessary movements of man and material. The improvement activities were implemented with required suggested and the future state value stream mapping was developed. From the results it was concluded that the total cycle time was reduced about290.41 seconds and the customer demand has been increased about 760 units.

"Productivity Enhancement by Implementing Lean Tools and Techniques in an Automotive Industry" by B. Suresh Kumar and S. Syath Abuthakeer describes the productivity enhancement by set-up time reduction in a fagor press involved in the machining of evaporator plates. The well-known Single Minute Exchange of Die technique (SMED) was applied in this study. SMED is one of the many lean manufacture methods for minimizing waste in a manufacturing process. It provides a quick and effective way of altering a manufacturing process from running the current product to running the next product. Using SMED technique, the result shows that tool change over time was reduced from 40 minutes to 12.

III. METHODOLOGY

This study at the specific objective of investigating how useful is the continuous improving tool and optimizing the robots engaged in spot welding operations by using TSP method, in the bottleneck areas of manufacturing assembly lines. The study was carried out with the cooperation and support of an Indian four wheeler car manufacturing company.

In Welding shop robots engaged in spot welding operation for notch back car inner doors are studied and matrix for the path stations are made by observations. Detailed matrixes are used as data and further optimization is done by TSP method. TSP method is applied and optimal paths for spot welding operation for the robots are modified by giving new effective paths (most suitable feasible path).

TSP Principle: The Travelling Salesman Problem (TSP) has wide spread application backgrounds and this important theory optimizes value in combination with efficiency [3]. The idea of TSP is to find the shortest tour path between a given number of cities, and each city can be visited only one time to achieve maximum efficiency in terms of distance, time and cost of trip. The feasibility of this solution TSP is (n-1)! /2, when 'n' is the number of cities. If the number of cities increases, the feasibility of the solution increases as well formulating this problem requires the introduction of a decision variable x_{ij} which is given a value of 1.

If the salesman goes from i to j otherwise $x_{ij} = 0$, this is expressed mathematically by

$$\sum_{i=1}^{n} x_{ij} = 1 \quad i = 1,2, \dots n$$

(Because it is assumed that the salesman visits every city once)

$$\sum_{j=1}^{n} x_{ij} = 1 \quad i = 1,2, \dots n$$

(Because every city must be visited)

Where the objective function is:

$$min \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij}\, x_{ij} \quad = z$$

$$d_{ij} = distance\ from\ city\ i\ to\ j$$
$$x_{ij} = constaints$$

And constraint is:

$$\sum_{i=1}^{n} x_{ij} = 1\ \forall j$$

And

$$\sum_{j=1}^{n} x_{ij} = 1\ \forall i$$

$$x_{ij} + x_{ji} = 1 \quad i, j$$

Step 1: In this problem, total 20 spots are to be welded on inner door of a notch back.

Step 2: The distances between each of the spots are entered in the distance matrix as shown in table1.The distance matrix is a square matrix with 20 rows and 20 columns. The diagonal of the square matrix is a zero line, which results from the fact that the distance of each spot from itself is zero.1st row shows the distances of spot 1 from every other spot. For instance, the 2nd cell in the 1st row shows the distance of spot 1 from spot 2 (3.5cm in the present situation).Similarly, the 2nd row shows the distances of spot 2 from every other spot. If seen in a different way, the 1st column also shows the distances of spot 1 form every other spot. Similarly, the 2nd column shows the distances between

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spot 2 and every other spot. The data on the two sides of the zero-diagonal line is a mirror reflection of each other.

Step 3:-The software generates a list of all the possible paths and displays it in the solution summary area. It also shows the distance traversed by the manipulator/robotic arm corresponding to each path [8].

Step 4:-The most feasible /the 'best' near optimal path (row 8th as shown in figure 3) for the manipulator /robotic arm is implemented for spot welding operation as shown in figure 4(b).

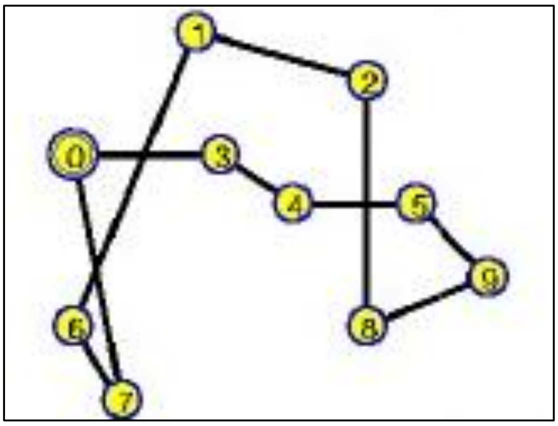

Fig. 2: The example path of TSP showed motion of Robotic arm/manipulator path for 10 point to point spot welds

Table 1: Distance diagonal matrix for spots located inner door

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1	**0**	3.5	27	55	62	67	69	74	78	16	15	14	60	63	65	32	56	71	128	103
2	3.5	**0**	25.5	53	59	66	67	71	74	19	17	16	57.5	59.5	60.5	29	56.5	71	128	103
3	27	25.5	**0**	29	35	40	43	50	56	42.5	40	38	39	42	44	38	73	89	139	89
4	55	53	29	**0**	7	12	14	25	33	70	68	66	23	27	30	58	96	108	152	79
5	62	59	35	7	**0**	6	9	20	31	76	74	72	24	28	31	63	102	111	159	79
6	67	66	40	12	6	**0**	4	19	29	81	79	77	27	30.5	33	69	110	119	162	79
7	69	67	43	14	9	4	**0**	16	26	85	83	81	25	28	30	70	110	120	162	77
8	74	71	50	25	20	19	16	**0**	10	90	88	86	18	20	21	67	105	114	155	62
9	78	74	56	33	31	29	26	10	**0**	92	90	88	19	17	17	66	105	110	150	53
10	16	19	42.5	70	76	81	85	90	92	**0**	5	9	73	76	77	37	49	64	122	109
11	15	17	40	68	74	79	83	88	90	5	**0**	4	72	75	77	39	54	69	125	110
12	14	16	38	66	72	77	81	86	88	9	4	**0**	74	76	79	42	56	72	130	111
13	60	57.5	39	23	24	27	25	18	19	73	72	74	**0**	5	8	48	88	97	137	57
14	63	59.5	42	27	28	30.5	28	20	17	76	75	76	5	**0**	3	50	89	96	133	52
15	65	60.5	44	30	31	33	30	21	17	77	77	79	8	3	**0**	51	8	97	131	49
16	32	29	38	58	63	69	70	67	66	37	39	42	48	50	51	**0**	41	51	102	74
17	56	56.5	73	96	102	110	110	105	105	49	54	56	88	89	8	41	**0**	16	79	97
18	71	71	89	108	111	119	120	114	110	64	69	72	97	96	97	51	16	**0**	55	97
19	128	128	139	152	159	162	162	155	150	122	125	130	137	133	131	102	79	55	**0**	111
20	103	103	89	79	79	79	77	62	53	109	110	111	57	52	49	74	97	97	111	**0**

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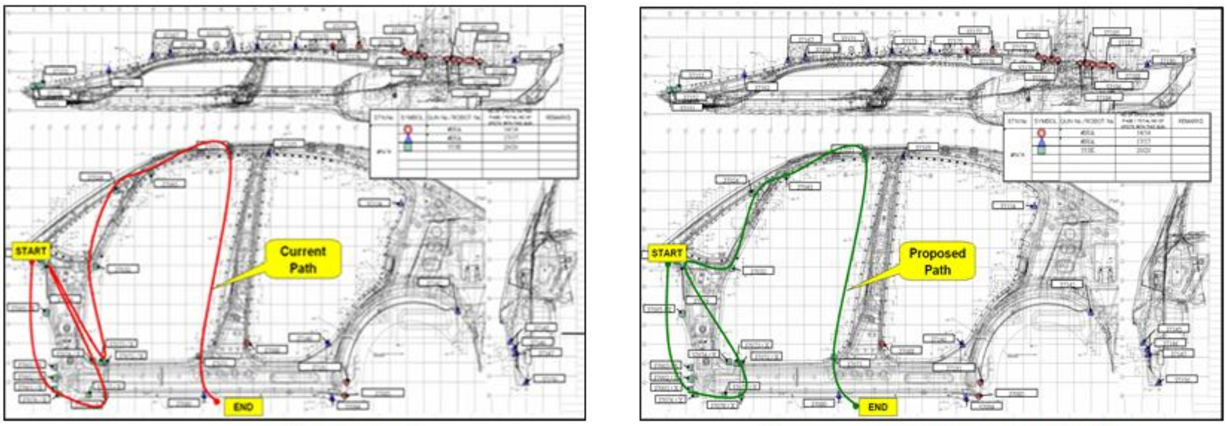
Input steps: (See commnet in cell A4)		*Output steps:* (See comment in cell E3)		
Step 1:	Number of cities = 20	*Step 3:*	Click then select choice	all
Step 2:	Click to enter input data	*Step 4:*	Click to execute heuristic	

Solution sumamry:

S.no	Sequence	Length
1	1-2-12-11-10-16-3-4-5-6-7-8-9-15-14-13-20-18-17-19-1	577.5
2	2-1-12-11-10-16-3-4-5-6-7-8-9-15-14-13-20-18-17-19-2	575.5
3	3-2-1-12-11-10-16-17-15-14-13-8-9-7-6-5-4-20-18-19-3	587
4	4-5-6-7-8-9-15-14-13-3-2-1-12-11-10-16-17-18-19-20-4	498
5	5-6-7-4-13-14-15-17-18-16-2-1-12-11-10-3-8-9-20-19-5	611
6	6-7-5-4-13-14-15-17-18-16-2-1-12-11-10-3-8-9-20-19-6	610
7	7-6-5-4-13-14-15-17-18-16-2-1-12-11-10-3-8-9-20-19-7	607
8	8-9-15-14-13-4-5-6-7-3-2-1-12-11-10-16-17-18-19-20-8 **Most Feasible Path**	492
9	9-8-7-6-5-4-13-14-15-17-18-16-2-1-12-11-10-3-20-19-9	597
10	10-11-12-1-2-3-4-5-6-7-8-9-15-14-13-16-17-18-19-20-10	529
11	11-12-10-1-2-3-4-5-6-7-8-9-15-14-13-16-17-18-19-20-11	536
12	12-11-10-1-2-3-4-5-6-7-8-9-15-14-13-16-17-18-19-20-12	533
13	13-14-15-17-18-16-2-1-12-11-10-3-4-5-6-7-8-9-20-19-13	554
14	14-15-17-18-16-2-1-12-11-10-3-4-5-6-7-8-9-13-20-19-14	568
15	15-14-13-8-9-7-6-5-4-3-2-1-12-11-10-16-17-18-19-20-15	469
16	16-2-1-12-11-10-3-4-5-6-7-8-9-15-14-13-20-18-17-19-16	546
17	17-15-14-13-8-9-7-6-5-4-3-2-1-12-11-10-16-18-19-20-17	519
18	18-17-15-14-13-8-9-7-6-5-4-3-2-1-12-11-10-16-20-19-18 **Min. Travel**	461
19	19-18-17-15-14-13-8-9-7-6-5-4-3-2-1-12-11-10-16-20-19 **Min. Travel**	461
20	20-15-14-13-8-9-7-6-5-4-3-2-1-12-11-10-16-17-18-19-20	469

Fig. 3: Screen Shot showing most feasible/best path starting from spot 8 (or dot 8) and completing at spot 20 in green color (S.No.8 and length 492), no collision between robots operation.



without optimization (a)

With optimization (most feasible path) (b)

Fig 4(a): Robotic arm/manipulator path profile for inner door spot welding (without optimization)
Fig 4(b): The most feasible optimal path (the path in which robots don't have chance of collision during operations)

In order to optimize man movement and to reduce operator fatigue, MOST is applied as following [7]

1. Recording of bottleneck area has been made.
2. The operation/process is broken down into smaller steps/units.
3. The motions are analyzed in each step/unit by using a standard MOST method sequence.
4. Indices to the parameters constituting to the method sequence for each task are assigned.
5. The indices to arrive at a time value for each step/unit are summed up.

Table 2: Bottle neck identification using MOST

LINE NAME:- U/B	PROCESS	member component ,dash fitment on JIG(2341)and JIG(2311)	MODEL:- A	DATE	LINE TACT TIME
CODE L-4	14			2017 Y 8 M 15 D	Seconds 57.00

No.	OPERATION DETAILS / PART NO / PART NAME	SEQUENCE MODEL				FREQ	TMU	0.8 FAC	SEC
1	walk 5 steps, bend 50%, grasp, place with adjustment on Jig	A 10 B 3 G 1	A 10 B 0 P 3		A 0	1	270.00	216.00	7.78
2	with in reach , readjust (take 10% , does not occure every time)	A 0 B 0 G 0	A 1 B 0 P 3		A 0	1	40.00	32.00	1.15
3	with in reach, **tilting the object**, walk one step , place with adjustment	A 1 B 0 G 3	A 3 B 0 P 3		A 0	1	100.00	80.00	2.88
4	**walk four step** , pick a panel dash lower side with R.H.,put in L.H.	A 6 B 0 G 1	A 1 B 0 P 1		A 0	1	90.00	72.00	2.59
5	walk four step, Pick assembly, walk four step , placement with adjustment on JIG(2341)	A 6 B 0 G 1	A 6 B 0 P 3		A 0	1	160.00	128.00	4.61
6	already getting panel dash lower side place it on JIG.	A 0 B 0 G 0	A 1 B 0 P 3		A 0	1	40.00	32.00	1.15
7	walk 2 step, inspect the fittment of component on JIG on GOT.	A 0 B 0 G 0	A 3 B 0 P 0	T 1	A 0 B 0 P 0 A 0	1	40.00	32.00	1.15
8	Walk back two step ,readjust (take 10% ,does not occure every time)	A 3 B 0 G 1	M 3 X 0 I 0		A 0	1	7.00	5.60	0.20
9	walk 2 step, grasp,switch on.	A 3 B 0 G 1	M 1 X 0 I 0		A 0	1	50.00	40.00	1.44
10	walk 5 steps, bend 50%, get bracket suspension upper and panel comp. front apron L.S. from right hand and place it on L.H.	A 6 B 3 G 1	A 1 B 0 P 1		A 0	2	180.00	144.00	5.18
11	get extension appron from L.H.	A 1 B 3 G 1	A 0 B 0 P 0		A 0	1	50.00	40.00	1.44
12	**walk 4 step** , place all these three component with adjust.on JIG(2311)	A 0 B 0 G 0	A 6 B 0 P 3		A 0	3	150.00	120.00	4.32
13	with in reach, inspect the fittment of component on JIG on GOT.	A 0 B 0 G 0	A 1 B 0 P 0	T 1	A 0 B 0 P 0 A 0	1	20.00	16.00	0.58
14	walk 1 step, grasp,switch on.	A 3 B 0 G 1	M 1 X 0 I 0		A 0	1	50.00	40.00	1.44
	Individual Component Times OF SHEET				TMU	SUM	1247.00		
						SUM	997.60		
					Sec	SUM	35.91		

Table 3: MOST Analysis after improvement

LINE NAME:- U/B	PROCESS	member component ,dash fitment on JIG(2341)and JIG(2311)	MODEL:-A	DATE	LINE TACT TIME
CODE L-4	14			2017 Y 8 M 15 D	Seconds 57.00

No.	OPERATION DETAILS / PART NO / PART NAME	SEQUENCE MODEL	FREQ	TMU	0.8 FAC	SEC
1	walk 5 steps, bend 50%, grasp, pull the member front side(L.H.)	A 10 B 3 G 1 M 1 X 0 I 0 A 0	1	150.00	120.00	4.32
2	walk 5 steps,	A 0 B 0 G 0 A 10 B 0 P 3 A 0	1	130.00	104.00	3.74
3	with in reach, **tilting the object**, walk one step , place with adjustment	A 1 B 0 G 1 A 3 B 0 P 3 A 0	1	80.00	64.00	2.30
4	**walk four step** , pick a panel dash lower side with R.H.,put in L.H.	A 6 B 0 G 1 A 1 B 0 P 1 A 0	1	90.00	72.00	2.59
5	walk four step, Pick assembly, walk four step , placement with adjustment on JIG(2341)	A 6 B 0 G 1 A 6 B 0 P 3 A 0	1	160.00	128.00	4.61
6	already getting panel dash lower side place it on JIG.	A 0 B 0 G 0 A 1 B 0 P 3 A 0	1	40.00	32.00	1.15
7	walk 2 step, inspect the fittment of component on JIG on GOT.	A 0 B 0 G 0 A 3 B 0 P 0 T 1 A 0 B 0 P 0 A 0	1	40.00	32.00	1.15
8	Walk back two step , readjust (take 10% , does not occure every time)	A 3 B 0 G 1 M 3 X 0 I 0 A 0	1	7.00	5.60	0.20
9	walk 2 step, grasp,switch on.	A 3 B 0 G 1 M 1 X 0 I 0 A 0	1	50.00	40.00	1.44
10	walk 5 steps, bend 50%, get bracket suspension upper and panel comp. front apron L.S. from right hand and place it on L.H.	A 6 B 3 G 1 A 1 B 0 P 1 A 0	2	180.00	144.00	5.18
11	get extension appron from L.H.	A 1 B 3 G 1 A 0 B 0 P 0 A 0	1	50.00	40.00	1.44
12	walk 4 step , place all these three component with adjust.on JIG(2311)	A 0 B 0 G 0 A 6 B 0 P 3 A 0	3	150.00	120.00	4.32
13	with in reach, inspect the fittment of component on JIG on GOT.	A 0 B 0 G 0 A 1 B 0 P 0 T 1 A 0 B 0 P 0 A 0	1	20.00	16.00	0.58
14	walk 1 step, grasp,switch on.	A 3 B 0 G 1 M 1 X 0 I 0 A 0	1	50.00	40.00	1.44
	Individual Component Times OF SHEET	TMU	SUM	1197.00		
			SUM		957.60	
		Sec	SUM			34.47

IV. RESULTS AND DISCUSSIONS

The welding paths of robots were studied in detailed and a matrix for the paths are developed. The paths for optimal and suitable (most feasible path) are selected for implementation in manufacturing of inner door spot welding operation. The developed path details are shown in Figure 3.

Table 4: Operation time saved after robotic arm/manipulators path optimization and application of MOST

After optimization of path			
Robot ID	Timing before optimization	Timing after optimization	Time saved
M/B#3	110 Sec	89 Sec	21 Sec
After applying MOST Technique			
Member Component and dash fitment on Jig	35.91 Sec	34.47 Sec	1.44 Sec

The Fig. 4 (b) shows the most feasible optimized improved path [9] of the manipulator/robotic arm (inner door spot welding of notch back car) and it has been observed that significant reduction in tack time as shown in table 4 without any collision between the robots during operations.

By applying of MOST technique man movement in shop floor and operator fatigue has been reduce drastically.

A significant decrease in cycle time and tack time resulted in enhanced productivity. TSP software technique for optimization is applied and made manufacturing operations more effective by adopting new feasible paths to reduce operation time and enhancing shop productivity by 8%, i.e. 14 vehicles per day in production target.

V. CONCLUSION

The study has highlighted the need of optimizing the welding path of robots. This will further make manufacturing economical and have competitive edge over the various players of manufacturing in the automobile industries.

- To achieve enhanced productivity, companies need to be able to highlight the bottleneck areas, the key business issues and then apply appropriate tools and optimization techniques.
- Wasting of resources which are valuable and scarce, missing business opportunity in implementing a range of continuous improvement initiatives which are failing to deliver the desired results.
- Optimization of robotic arm/manipulators path in focused areas helped in eliminating non value added activities and resulted increase in productivity.
- The fluctuating demand of industries can be meet very preciously by enhancing productivity.

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