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Research Article

Productivity Improvement in Welding Robot

Bhagyashri G Chandankar†* and Viresh M Chapte‡

†Marathwada Mitra Mandal's Institute of Technology, SPPU, Pune 47, India
‡Dr. D Y PATIL Knowledge City, SPPU, Pune 412105, India

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Abstract

One of the most common automated processes in an assembly line is welding. Robotic welding is used by many companies around the world because the process is easily automated and more efficient than a professional welder. The main benefits of an automated welding process are, improved weld quality, increased productivity, decreased waste production, decreased costs associated with labor .We adopted a chance to work on that robot to improve its productivity for the company. Our job is to provide company with such productivity increment by making improvement of welding robot. So that their requirements are fulfilled and it would be economical also.

Keywords: *Downtime analysis. Efficiency, Position, Productivity, Welding robot*

1. Introduction

For a manufacturing company to remain competitive in today's market they must produce a quality product at the highest possible efficiency. Over the past century there have been large strides in manufacturing processes. Ever since Henry Ford's introduction of the assembly line, businesses have been focused on using available technologies to manufacture their products at minimal cost. During the manufacturing process there are many different parameters that need to be controlled, such as, limiting waste, assembly downtime, and labor compensation to be able to produce at a minimal cost. In recent years the concentration of the manufacturing community has been on automated processes because they produce higher quality products and higher production rates. In 2003 North America alone spent 877 million dollars on robotics used for manufacturing, a 19 percent increase over the amount spent in 2002. This increase in spending reflects manufacturers need for greater efficiency from their manufacturing process (James S. Albas , 1982).

One of the most common automated processes in an assembly line is welding. Robotic welding is used by many companies around the world because the process is easily automated and more efficient than a professional welder. The main benefits of an automated welding process are, improved weld quality, increased productivity, decreased waste production, decreased costs associated with labor. However, an automated welding operation may not be best suited for every application. A company must consider many variables when deciding if a robotic operation is appropriate for their application. The initial cost of a manual welding process is significantly lower than an automated welding process so an automated system must be able to quickly recover the initial investment. Flexibility is also an issue that must be considered because in a manual system the worker can easily adjust to any new tasks, where as it is much harder to adapt a robotic welder to a different job, Mikell P. Groover, *et, al*, 1986).

Fig.1 Welding Robot (OTC Daihen DR -4000)

2. Welding Robot

When following through the history of welding, in year 1988, matrix of robots are employed in the automobile industry to perform resistance spot welding on car bodies. Following that, more and more arc welding

*Corresponding author: **Bhagyashri G Chandankar**

robots are being installed both in large and small manufacturing plants. Since then, welding robots are used in two ways in manufacturing as elements in a production line and as stand-alone units (or Flexible Robotic Manufacturing System) for batch production. Though, robots work well for repetitive tasks on similar pieces that involve welds in more than one axis or where access to the pieces is difficult, manufacturers who have automated their welding operations request to include more flexibility to process a variety of parts with the same robot system. This results in the creation of Flexible Robotic Manufacturing System. The Robot system here possesses flexibility to facilitate quick changeover by changing the robot end-effector and modifying the robot program, (Ganesh S. Hegde, 2008).

In addition, material handling robots are used within welding systems to position the part while welding or also to load/unload the part into a secondary operation such as an inspection station. The gas metal arc (GMA) welding process is a welding process that yields coalescence of metals by heating with a welding arc between continuous filler metal (consumable) electrode and the -work piece. The continuous wire electrode, which is drawn from a reel by an automatic wire feeder, and then fed through the contact tip inside the welding torch, is melted by the internal resistive power and heat transferred from the welding arc. Heat is concentrated by the welding arc from the end of the melting electrode to molten weld pools and by the molten metal that is being transferred to weld pools. Molten weld pools and electrode wire are protected from contaminants in the atmosphere by a shielding gas obtained from various combinations.

3. Robot Specifications

3.1OTC Daihen DR -4000

The OTC Daihen DR-4000 will allow you to reach further, while still conserving floor space. Servo controls and a light build provide swift, effective movements for any welding needs. This sophisticated "Sychromotion" was developed by Daihen to allow for multi-mechanism movement. An optional free system layout allows for wall, shelf, angle or floor mounting.

Table 1 Robot Motion speed and range

Axes	Robot Motion Speed	Robot Motion Range
Axis1	120 °/s (2.09 rad/s)	±340°
Axis2	120 °/s (2.09 rad/s)	±240°
Axis3	145 °/s (2.53 rad/s)	±270°
Axis4	330 °/s (5.76 rad/s)	∞
Axis5	330 °/s (5.76 rad/s)	±280°
Axis6	480 °/s (8.38 rad/s)	±640°

3.2 CO2/MAG Welding Robot System

Table 2 Model DR-4000 Basic Configuration

1	Manipulator	IRB-601	1	
2	Control unit (DR CONTROL)	IRBC-602	1	
3	Teach pendant	BBTP-1708	1	With 8m cable
4	Operation Box	BBOP-5005	1	With 5m cable
5	Control Cable 1&2	BIRB-9005	1	Length:5m

2. Present Theory

MIG/MAG is a rapid method for fully and semi-automatic welding. Depending on the arc's characteristics, welding can be carried out in all positions. Because the weld metal has low oxide and slag levels, its mechanical properties are very good. This is particularly true of impact strength. Suitable metal thicknesses are 2 – 10 mm. A typical gas flow in manual welding is 14 – 16 l per minute. Friction in the wire conduit has a critical impact on wire feed ability.

Table 3 Welding Parameters

Parameters	Units Range
Weld Current (amps)	100 ~ 250
Arc Voltage (volts)	18 ~ 30
Weld Speed (cm/min)	15 ~ 72
Wire extension (mm)	12

4.1 Welding Parts

a)Bonnet Lock Plate (370N)

Bonnet lock plate is used to engage Bonnet of vehicle which is situated below bonnet of vehicle. The part 370N is used in Mahindra Bolero and Mahindra Maxx Pick-ups.

Welding process: Projection welding (M6, M8) manually had done on it. And the robot does tack welding on bonnet lock plate.

Fig. 2 Bonnet Lock Plate (370N)

b)Wind Shield (1900N)

Wind shield is used to support wind glass of vehicle which is situated below wind glass of vehicle. The part 1900N is used in Mahindra Bolero and Mahindra Maxx Pick-ups.

Welding process: Spot welding is done by manually on it. And the robot does run welding on wind shield (1900N).

Fig. 3 Wind Shield (1900N)

4.2 Wire Diameter

Robotic welding involves very precise tolerances and even minute variations in the wire feed process can result in unacceptable welds; it is important to choose a wire designed to feed smoothly through the drive rolls and liner. Wires engineered specifically with robotic applications in mind often provide better feeding characteristics than those designed for all-purpose use. A wire that produces unreliable and inconsistent arc starts can negate the productivity benefits of a robotic system by creating substantial down time, or downstream rework. Presently we are using wire of 0.8 mm (0.030 inch) diameter for welding.

4.3 Cycle Time

This is the amount of time allotted to an operation to perform its task(s). It is part of the manufacturing lead time (the time needed to finish a complete underbody). Cycle time is composed of processing time. The cycle time studied for this is tabulated as follows

Table 4 Cycle time table

Aspects	Bonnet Lock Plate (370N)	Wind Shield (1900N)
Total Time (Home-Welding-Home)	49.3 sec	93.14 sec
Welding Time	46.8 sec	86.21 sec
Part loading/Unloading	49.5 sec	71.55sec

Total parts produced=4056, Performance rate=60.53%

4.4 Work Space

The task-oriented workspace, which is the workspace enabling specific rotations, has been defined in order to validate the welding ability of the robot, and incorporating the required rotational capabilities. The Robot is working in either front or right side or front and left side. The Robot is welding Wind shield on front side and Bonnet lock plate on left or right side.

Fig.4 Robot working on two fixture positions

5. Working

5.1 Wire Diameter

The robot was using 0.8 mm wire diameter which has reduced the welding speed as well as accuracy. Type of material for welding rod is similar to the material of part to be weld. i.e. Mild steel (MS). The recessed tip greatly extends the tip life, reducing wire burn back potential and robot downtime. The recessed contact tip provides a lightly extended wire extension which lowered the weld current. The reduction in current enabled to increase the wire feed rate increasing the weld travel rate and decreasing the weld time.

The requirements of customers are not satisfied by welding wire diameter 0.8 mm (0.030 inch). So it's necessary modify some parameters in the welding. The welding process variables mainly affect the geometry of the weld bead such as the penetration and bead size.

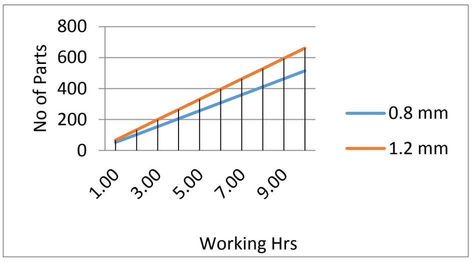

Fig. 5(Graph) No. of parts Vs Working hours

By changing welding wire diameter 0.8mm to 1.2mm, there is increase in the `welding speed of robot by 50%. Welding speed is increased by 1.5 times the actual speed. Welding rod having diameter of 1.2 mm is covered by copper coating.

5. SAP Calculations (Down Time Details)

The fundamental industrial processes interacts with SAP, SAP stands for System Application and Product in Data Processing, in the functional areas of Sales and Distribution, Materials Management, Production Planning, Financial Accounting, Controlling, and Human Capital Management.

Applications of SAP

1. Customer Relationship Management (CRM) – helps companies acquire and retain customers, gain marketing and customer insight.
2. Product Lifecycle Management (PLM) – helps manufacturers with product-related information.
3. Supply Chain Management (SCM) – helps companies with the process of resourcing its manufacturing and service processes.
4. Supplier Relationship Management (SRM) – enables companies to procure from suppliers.

Table 4 Down time table for August & September

Sr. No.	Reason	Monthwise down time analysis in min		Average
		Aug-12	Sep-12	
1	Material not available (MN)	1455	1130	1292.5
2	Machine Breakdown (MB)	120	105	112.5
3	House keeping (HK)	230	230	230
4	Power off (PO)	135	135	135
5	Breakdown losses (BL)	0	15	7.5

The down time analysis in SAP is done by using command *zrrOEE.* The controlling of any machine by hourly monitoring system is one of the applications of SAP. The average of major downtimes for August and September month is given in table.The average of major downtimes for August and September months is shown in graph.

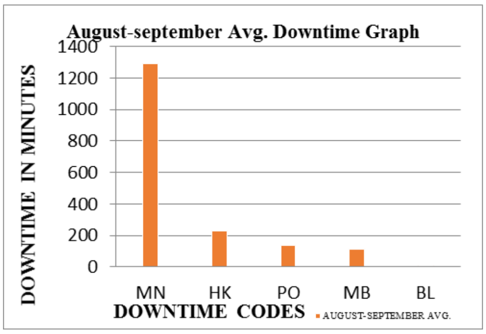

Fig.6 (Graph) Down time graph of August & September

Actions to be taken for major downtimes are given as below:

1. Material not available (MN)
Action: For material is not available, we have to go for 5-why or why-why analysis with the help of shop instructor.

2. House keeping (HK)
Action: For house keeping reason we should implement 5-S with the help of 5-S coordinator.

3. Power off (PO)
Action: For power off, we must have extra generator set for the machine. And the maintenance actions like housekeeping and CILT can be completed within the PO downtime period.

4. Machine Breakdown (MB)
Action: For machine breakdown, prepare PM sheet and reduce frequency from bimonthly to monthly.

The above suggested actions were continued implementing for October month. The downtimes for October, November, December months are given in table.

Table 5 Down Time Table For October, November & December

Sr No	Reasons	Monthwise down time analysis in min		
		Oct-12	Nov-12	Dec-13
1	Material not available (MN)	675	535	125
2	Machine Breakdown (MB)	0	0	0
3	House keeping (HK)	30	80	50
4	Power off (PO)	0	0	0
5	Breakdown losses (BL)	0	0	0

These Downtime values are plotted on a graph

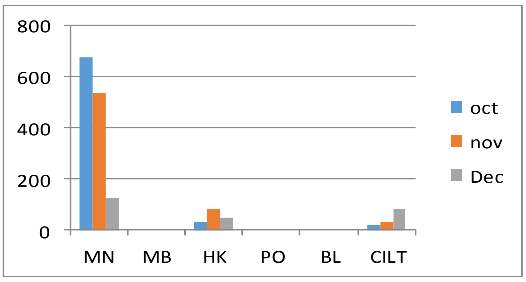

Fig.7 Down time graph of October, November & December

6. Results

Changing welding wire diameter from 0.8 mm to 1.2 mm, there is 28% increase in the performance rate. Welding wire shows drastic change in production. Downtime Analysis through SAP codes gives good results in terms of increase in availability. The increase in availability rate results improvement in production. The welding torch following minimum possible travel shows reduction in cycle time of robot. Figure shows Increase in Performance rate for august, September, October, November, December and January respectively.

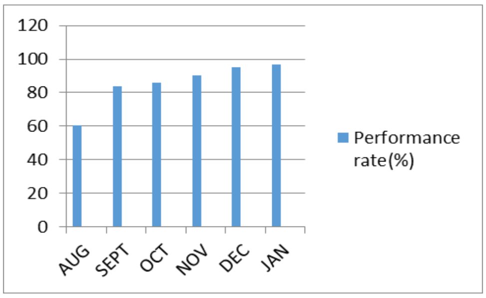

Fig. 7 (Graph) Performance rate

Conclusions

In this paper we have studied, down time analysis through SAP. Consistent efforts by us, to achieve the productivity improvement of welding robot results in increase in Performance rate from 60% to 97% , has been achieved satisfactorily. We are glad to say that we have learned to implement our knowledge in practical field of company premises.

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