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Study of Special Purpose Machine for Motor Body Welding Integrated with Lean Strategy & Human Ergonomics

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Abstract

The Gas Tungsten Arc Welding (GTAW) process has always offered high quality weld deposits suitable for higher alloys with the low deposition rate. It is essential to have an automated welding machine in pump industries to increase productivity and quality which can also make the work easier for a welder. GTAW with hot wire for circumferential seam welding of motor body is a major development for pump industries which is required for good quality welding and mass production of the pump motor body. So it has been planned and designed a Special Purpose Welding Machine for Circumferential Seam Welding of Motor Body with respect to Lean Strategy & Human Ergonomics which will be a major challenge for all pump industries with latest technologies at low cost with respect to the current market scenario and also the customer requirements by analyzing and implementing their needs.

Key-words: Study on Pump Motor body welding machine, SPM integrated with Lean Strategy & Human Ergonomics, Circumferential GTAW (tig) Welding Machine with respect to Human Ergonomics & Lean Strategy, SPM for Motor Body Welding.

1. INTRODUCTION

PSG Industrial Institute is the pioneer in the manufacture of Pumps and Motors in India, with a proud track record tracing back to 1926. A typical submersible pump motor body shown in Figure 1 which is of different variants (i-e) 6" (V6), 8" (V8), 10" (V10) is being developed at PSG Rotary Motor Division. It has been categorized with respect to the OD of the submersible pumps motor body for different motor capacity varying from 3 hp to 32 hp. The OD of the motor body varies from Ø 140 mm min to Ø 254 mm max and the weight of the motor body varies from 30 kg min to 50 kg max for the above three variants. The Motor body consists of 3 different components (i.e.) Carbon steel body and 2 mild steel covers on either side of the body assembled and welded at the two similar joints of the body and cover.

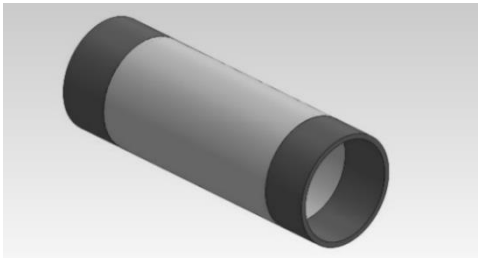

Fig.1 Typical Pump motor body

Special Purpose Machine (SPM) offers tremendous scope for high volume production at low investment and at low cost of production when compared to other machines. SPM is a high productivity machine, with specially designed tooling and fixture, dedicated for mass producing the same component day in and day out. A judicious combination of the processes such as loading, unloading, positioning and welding which is done with limit switches, PLC controls and also the automatic job clamping is the essence of a SPM. A well-conceived SPM finds ways to utilize the man and machine to the optimum. The proposed SPM is suitable for mass production of circumferential seam welding of motor body which is offered at low cost. Three different models of SPM design were designed with respect to the current market scenario. Out of three one model is chosen for the development at Centre of Excellence in Welding Engineering and Technology, PSG College of Technology with respect to

customer requirements and needs in a very low cost. The manually GTA welded pump bodies are shown in figure 2.

Fig. 2 Manually Welded pump motor body

The comparison of time duration for manually and mechanized welding is presented below in Table 1.

Table 1 Comparison of Manual with Automated Welding

S. No	Process	Manual	Mechanized (Estimated)
1.	Welding Time for Two seam of a motor body on after the other (Excluding Loading, Unloading, Fitting, etc.)	13 mins	7 mins
2.	Welding Time for Two seam simultaneously (Excluding Loading, Unloading, Fitting, etc.)	---	3.5 mins
4.	Total Setting Time.	12 mins	6 mins
5.	Total Welding Time of two circumferential seams for one motor body.	25 mins	13 mins

From the above table it is clear that mechanized welding is essential to enhance productivity.

2. SPM

For GTA Welding of motor body a SPM is designed taking in to consideration the welding sequence, relative motion required for welding, welding tact time which is in the above table 1 and also the total weight of the motor body. The designed SPM consists of following sub-assemblies.

Head Stock
Tail Stock
Torch Manipulator
Conveyor
Lifter

Working of SPM

In submersible pump motor body welding, the motor body is positioned along the centre axis of the head stock and tail stock arrangements and clamped with a tapered collet fixture. The head stock of the machine is fixed and tail stock of the machine is moveable. The spindle mounted in the head stock has only rotary motion whereas the spindle in the tail stock has both rotary and linear motion. The motor body is made to rotate with the head stock and tail stock at 360^0 rotation whereas the torch is mounted on the perpendicular axis of the motor body which is positioned accurately at the motor body seam with the help of a joy stick arrangement. The welding quality can be enhanced by Pulsed GTAW Process with Hot wire attachment and increase in productivity is achieved by reducing the overall process time which is by automating the loading and unloading process by a conveyor. This can also eliminate human error. The block diagram of the proposed Special Purpose Machine is shown in Figure 3.

2.1 Product Layout design

It is a design that positions workstations together with respect to the motor body welding.Machines are laid out sequentially so the motor body manufacturing can transfer from one station to the next in order until they are finished without any ideal time. Hence it is mainly done to increase in productivity and also to have a systematic work setup. In the proposed SPM the conveyor plays the major role where the motor body is loaded at one end and unloaded at the other end.

The main purpose here is to eliminate two out of seven forms of waste that is implementation of Lean Strategy, transportation wastes and motion wastes. In this proposed SPM the transportation refers to the movoment of the motor body from its initial storage position to the end that is the welding area, here the transportation is therefore cut by introducing an wooden bin next to the conveyor setup which helps in storage of 20 motor body at a time so the transportation of the motor form time to time is being cut down totally. The motion in this proposed SPM refered to the operators motion for transportation of the motor body and setting p every time which is totally cut down by using a semi-automated conveyor setup.

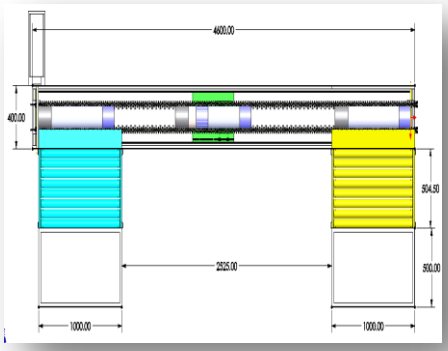

Fig. 3 Product Layout Design of SPM

2. Human Ergonomics Design

Human factors and ergonomics (commonly referred to as HF&E), also known as comfort design, functional design, and systems, is the practice of designing products, systems, or processes to take proper account of the interaction between them and the people who use them. Here, three different centre height levels where taken into consideration such as 0.8 mts, 1.1 mts, 2.0 mts, It is analyzed by making the operator is made to stand next to the machine, The operator helps in order to make sure the quality of welding is good and to operate the whole sequence of the machine appropriately. The machine centre height from the ground level is maintained as 1.1 mts exactly with respect to human factor ergonomics. There are some contributions from numerous disciplines, such as psychology, engineering, biomechanics, industrial design, physiology, and anthropometry. In essence, it is the study of designing equipment, devices and processes that fit the human body and its cognitive abilities. The two terms "human factors" up is 4.5m x 2.5m. The Layout of the machine without conveyor is shown in figure 4 below. The Centre axis of the machine is 1.1m from ground level.

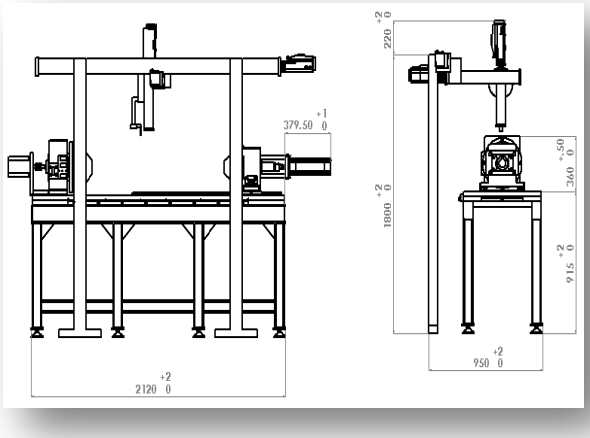

Fig. 4 Machine Layout

The head stock and tail stock sub-assemblies are designed and assembled in such a way that both the spindle are assembled to same centre axis whereas the tail stock spindle is concentric with reference to head stock spindle, this is assembled in such a way that the run out in the assembly is minimized to a level as per standard. This kind of design will lead to a major defect in the process. The Conveyor acts as the heart of the machine where it helps in auto loading, unloading of the motor body which comes from below the machine bed. The work piece is supplied to the machine by a lifter which is a pneumatic driven lifter lifts the motor body to the centre axis of the machine in the provided gap at machine bed as shown in figure11. There is a Vibro mount provided to machine for mounting the machine on irregular surface.The proposed SPM has four different automation steps.

Loading & Un-loading

The loading of the work piece was done from the left hand side of the machine with the help of a conveyor. Here the requirement of operator is 1 for loading and Un-loading of the work piece, unloading will be done automatically in the bin at the RHS which will be later un-loaded(i-e) after welding, the welded motor body is held lowered and taken away from the right hand side conveyor. The un-loading will be done in the BIN provided on the RHS, a capacity of 10 will be un-loaded at a time one after the other and then moved to the stock area for further process of the motor body.

- **Positioning**

Once the loading is completed the conveyor helps the body to move and stop exactly at the place where it is required for positioning with the help of a PLC Controller. The Pneumatic lifter helps the V-block to lift up to the center axis of the machine for exact positioning as shown in figure below. The tapered collet pushes the tail stock spindle with the help of the pneumatic force towards the inner diameter of the motor body for clamping of the work piece.

- **Welding**

Once the positioning is done accurately the welding torch is moved along the X, Y & Z axis using the sequence the process with the controller and a precise moment of torch can be achieved using a joystick setup for accurate seam welding along the circumferential seam of the motor body

5. Failure Mode Effective Analysis

The Failure mode effective analysis is done to understand the mode of failure which can likely occur in the machine at the time of usage. Hence the assumed failure which can likely occur in the machine is shown in pareto chart and the cause and effect diagram.

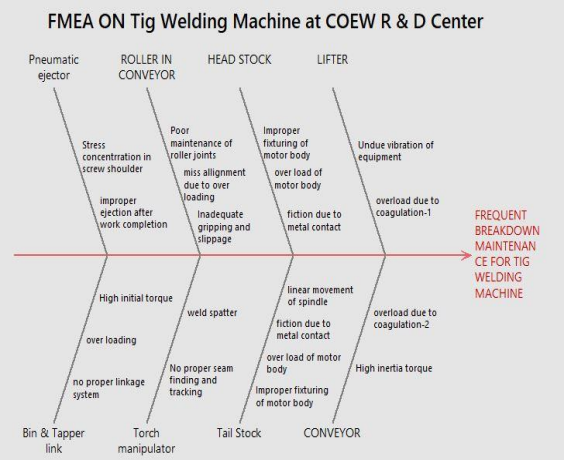

Fig. 5 Cause and Effect Diagram

	FREQUENT BREAKDOWN MAINTENANCE	RPN
1	Undue vibration of equipment	150
2	overload due to coagulation-1	120
3	High inertia torque	20
4	overload due to coagulation-2	4
5	Improper fixturing of motor body	175
6	over load of motor body	6
7	fiction due to metal contact	36
8	Improper fixturing of motor body	42
9	over load of motor body	6
10	fiction due to metal contact	20
11	linear movement of spindle	42
12	Poor maintenance of roller joints	175
13	miss allignment due to over loading	175
14	Inadequate gripping and slippage	42
15	No proper seam finding and tracking	20
16	weld spatter	6
17	Stress concentrration in screw shoulder	6
18	improper ejection after work completion	20
19	no proper linkage system	20
20	over loading	6
21	High initial torque	6

Fig. 6 (a) Pareto Chart

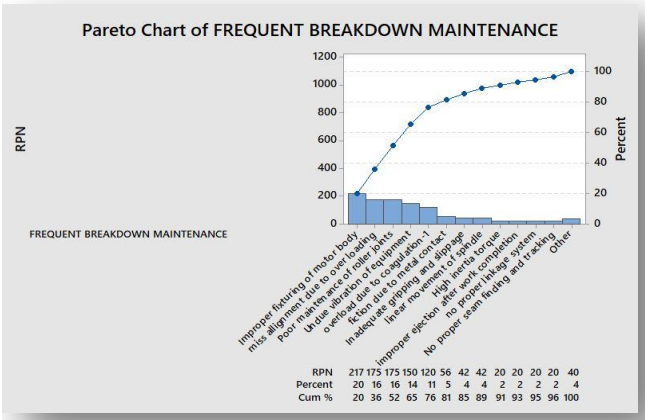

Fig. 6 (B) Pareto Chart

The whole of the process of failure mode effective analysis is done using the Software Minitab 16.0. Which is analytic software used to intended as a tool for teaching statistics, is a general-**purpose** statistical software package designed for easy interactive use. **Minitab** is well suited for instructional applications, but is also powerful enough to be used as a **primary** tool for analyzing research data.

6. SUMMARY

- It is designed in such a way that the resource used has been optimized to maximum (i.e.) Man power used is optimized from three to one and the welding time has been reduced.
- Human Factors Engineering design is achieved and the operator comfortness working on machine is 90 %.
- The operator fatigue can be reduced by 60% by eliminating the handling of the motor body through mechanization of loading, unloading, setting etc.
- The productivity can be increased to 65% and also there is no necessity for skilled labor for this process.
- The time has been optimized such that the total welding time can be reduced by 50% compared to the existing practice.
- The quality of the weld has be an enhanced by PTIG process that results in excellent bead profile and appearance without defects due to low heat input.

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