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Design and Manufacture of Fixture for Manually Operated Spot Welding Machine

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Abstract - *Resistance spot welding is a process which is generally used for sheet metal joining purposes in industry. The physical joining processes cannot be performed without the use of fixtures. A fixture is a production tool that locates, holds and supports the work securely so that the required machining operations can be performed. In case of resistance spot welding, the fixture must hold the workpieces in correct relationship during joining , and must offer adequate support during the process. This research emphasizes on the design and manufacturing of a fixture for a hollow cylinder which has its application in separation of solid-liquid mixture in Food Processing, Waste Recycling units. The new fixture increases functionality, also longer and workpieces of varying diameters can be welded.*

Key Words: **Fixture, Design, Spot-Welding, Analysis, Workpiece, Forces**

1.INTRODUCTION

We are working on design of fixture for SCIAKY Manual Spot-Welding Machine; this machine is used to weld ribs (Steel strips,3mm) on the inner surface of the hollow cylinder. The specifications of the machine are as follows:

Throat Depth = 1400 mm

Maximum Electrode Forge = 1000 Kg

Air Pressure = 5.6 kg/cm^2

The electrode actuation takes place by manually operated pneumatic pedal. These copper electrodes, apply pressure and heat to the weld area by passing a high amount of electric current through the thickness of cylinder and ribs. Due to the pressure and heat, the metal at weld area melts and fuses the workpiece together. The molten nugget solidifies to form a joint.

1.1 Fixture

One of the most time-consuming and labour extensive processes in the manufacturing of a mechanical part is the process of work holding or fixturing. In many studies it has been stated that roughly only 10-15% of the overall time needed to produce a part is spent actually on cutting or drilling a workpiece; while the other time is spent primarily in planning, of execution of part setup or work holding.

A fixture is a device for locating, holding and supporting a work piece during a manufacturing operation. Fixtures are essential elements of production processes as they are required in most of the manual/automated manufacturing, inspection and assembly operations. The perfect fixture can be used repeatedly to produce the same parts in the production process. A fixture reduces the operators labour and consequent fatigue as the handling operations are minimized. Also, it reduces the overall cost of machining by completely or incompletely automatizing the process.

1.2 Need for Fixture

The manual spot-welding machine, has an existing hydraulically operated guideway system. This guideway system facilitates the translatory movement of the cylindrical workpiece along the weld path. However, the welding process cannot be carried out unless the movement of the cylinder is restricted. The welding will be successful only when there is contact between the electrodes and the workpieces. As the cylinders are of varying lengths and diameters, a tool that compensates the height difference between the electrodes and cylindrical surfaces is required. Hence, there arises a need for fixture.

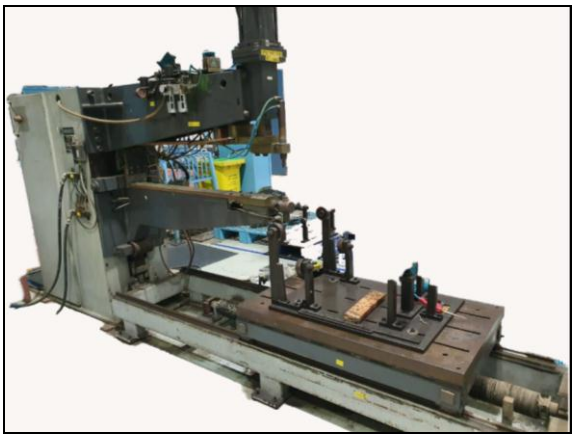

Fig - 1 : Spot Welding Machine with Guideways

2. DESIGN OF FIXTURE

The design of fixture process is sub-categorized into a 5- step problem solving process, which is as follows:

Step 1: Define Requirements
Step 2: Gather/Analyze Information
Step 3: Develop Several Options
Step 4: Choose the Best Option
Step 5: Implementing the Design

Workpiece	Operations
✓ Size ✓ Shape ✓ Required accuracy ✓ Material type ✓ Material condition ✓ Locating points ✓ Locating stability ✓ Clamping surfaces ✓ Production quantity ✓ Pending part-design revisions	✓ Types of operations ✓ Number of separate operations ✓ Sequence ✓ Inspection requirements
Equipment	**Personnel**
✓ Machine tools ✓ Special machinery ✓ Assembly equipment and tools ✓ Inspection equipment and tools ✓ Equipment availability and scheduling ✓ Plant space required	✓ Safety equipment ✓ Safety regulations and work rules ✓ Economy of motion ✓ Operator fatigue ✓ Possible automation

Fig -2: Checklist for Design Consideration

2.1 Aim

As discussed above, the application of the fixture is to support the hollow cylinder while spot welding process.

Following are the requirements regarding the degrees of freedom of the cylinder:

1. The cylinder needs to be fixed along all translation directions – X, Y,Z.
2. The cylinder must be fixed about X and Y axis for rotation.
3. About the Z axis, the rotation must be free.

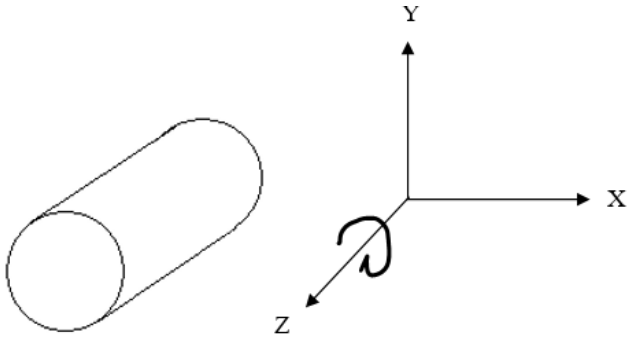

Fig- 3 : Degrees of Freedom of Cylinder Workpiece

2.2 Design

The basic idea behind the fixture design is the restriction and allowance of the movement for the cylinder. The cylinder has to be rotated about the Z axis.

In order to achieve the spot welding over the complete surface of the cylinder, the cylinder needs to be rotated as and when required. Hence, bearings are used to support the cylinder. These bearings are mounted on the support stands which are fixed to the base plate with the help of nut bolts. Two pins on either side of the cylinder are provided to locate and steadily hold the workpiece during welding.

The fixture assembly is positioned and aligned, with reference to the slots provided in the guideway bed. This assembly is fixed with the help of nut and bolt to the guideway.

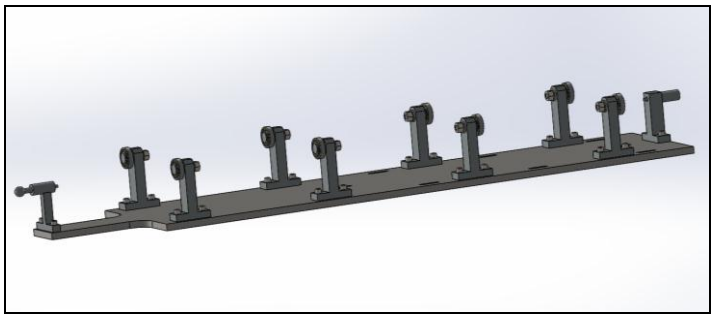

Fig -4: Fixture Design

To hold the ribs along the inner surface of the cylinder in correct position, a ring fixture is designed. A ring fixture with screwing mechanism is designed; the screws help to tighten and fix the ring fixture on the cylinder. This fixture is a hollow disc with its inner diameter equal to the inner diameter of the cylinder. The outer diameter of the fixture is slightly larger than the outer diameter of the cylinder keeping in mind the clearances and tolerances of the cylinder.

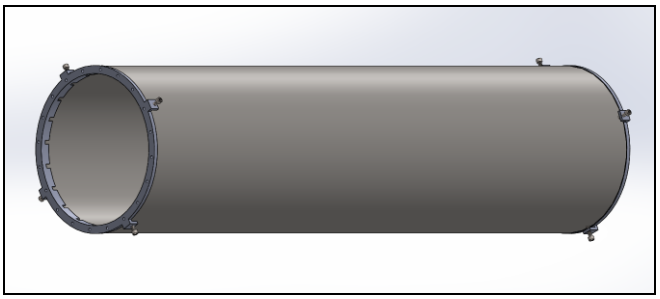

Fig- 5 : Ring Fixture Mounted on the Cylinder

The ring fixture has holes drilled on it, so that the index pin and the spring bob pin(located at the either side of the fixture, Refer Fig-4) of the fixture can be pushed into the hole and the cylinder can be fixed. The holes are positioned according to the position of the ribs.

3. CALCULATIONS [1]

The function of bearings in the fixture set up is to allow free rotation of the cylinder according to welding set up and requirements.

3.1 Static Load

Static load is the load acting on the bearing when the cylinder is stationery and resting on the bearing. The static load on the fixture is the self-weight of the cylinder resting on it,

Static Load = Weight of the cylinder

$= m \cdot g$

= (330.4) (9.81)

= 3237.92 N

where, m = mass of cylinder , kg

3.2 Equivalent Loading

Forces acting on the bearing has two components - radial and thrust. It is hence necessary to convert the two components acting on the bearing into a single hypothetical load. This hypothetical load can be compared with dynamic load carrying capacity.

The expression for the equivalent dynamic load is written as,

$$P=X.V.F_r + Y.F_a$$

where,

P = equivalent dynamic load

F_r *= radial load , N*

F_a *= axial or thrust load, N*

V = race-rotation factor

X and Y = radial and thrust factor given in manufacturer's catalogue.

In our case, the bearing is subjected to maximum radial load and negligible axial load. Hence value of Fa=0. Hence,

$P=F_r$

Radial Force= Electrode Force+ Weight of Cylinder

Electrode Force= 1000*9.8 = 9800 N

Weight of Cylinder= 330.4*9.8 = 3234 N

Radial Force= (9800+ 3234)

F_r = 13034 N.

3.3 Load – Life Relationship

The relationship between the dynamic load carrying capacity, the equivalent dynamic load, and the bearing life is given by,

$L_{10}= (C/P)^{1/n}$

For ball bearings, P = 3 , n= 3 and considering L_{10}=3,

$C = P \cdot (L_{10})^{0.3}$

$= (13034) *3^{0.3}$

= 18122.33 N

C = 18.13 kN

Comparing the parameters with the values of various bearings.

C: 18.13 kN<19.5 kN

C_o: 3.238 kN<10 KN

where,

L_{10}*= rated bearing life*

C= dynamic load capacity

C_o *= Static Load Carrying Capacity*

Hence, comparing these parameters, SKF bearing 6206 is selected for the setup.

4.ANALYSIS

Analysis has been carried out by using finite analysis method with help of Ansys software. The solid model of the component is selected and geometric conditions are selected, direction of the force is selected and electrode force of 10 kN and weight of the workpiece is given and results are evaluated using the software. Analysis of critical components is done.

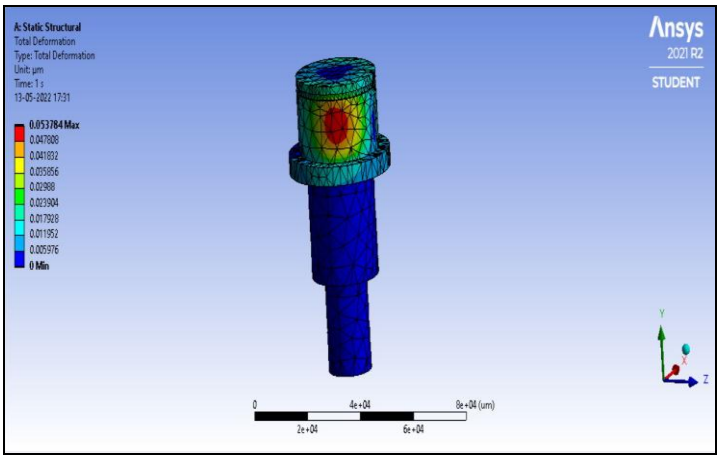

Fig- 6 : Total Deformation of Bearing Spindle

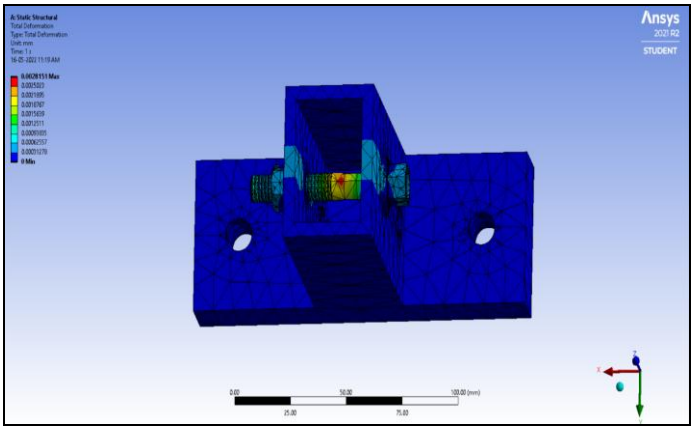

Fig- 7 : Total Deformation of Bolt of Support Stand

The results obtained after analysis indicate that the total deformation after application of force if almost negligible. Hence, we conclude that the design is safe.

5. RESULTS

Table 1 : Performance Characteristics

Sr. No	Parameter	Before	After
1.	Operator Safety	No Safety for Operator	Safety for Operator
2.	Welding Thickness	2 mm – 3mm	2mm-4mm
3.	Job Diameter	300mm-360mm	300mm-450mm
4.	Job Length	800mm-1500mm	800mm-2000mm

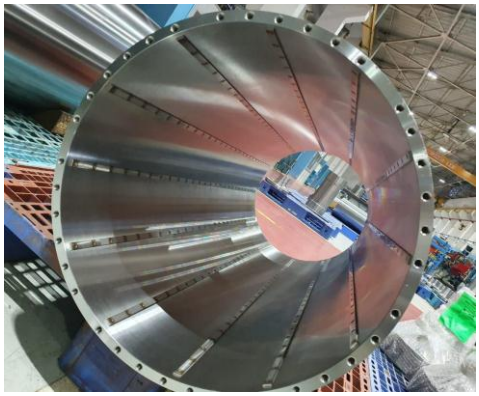

Fig- 8 : Cylinder with Ribs Welded

6. CONCLUSION

The fixture designed is simple and cost effective. This will help to increase the productivity rate. It is easy to manufacture and possesses easy maneuverability. The fixture is operator friendly and easy to maintain.

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