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Design and Manufacturing of 35 KVA Table Top Spot Welding Machine

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Abstract — *Recent advance in mechanical engineering includes the exploration of mechatronics. Robotics has emerged as an outcome of intra-disciplinary study of mechanical and electronics engineering. Presently each sector is identifying the potential of robotics as a part of Automation engineering program. Robots or robotics guns provides a feasible solution to welding sector, whenever mass production is to be done. The efficiency and weld quality are well justified with robotics, but the decision is made considering the mass production as initial investment is very high. There are large numbers of industries, small scale as well as medium scale centering to welding application. These industries are facing the challenge of providing cost effective welding solution with the increased efficiency and improved weld quality, for material like stainless steel and section thickness varying from 0.2 to 0.8 mm. Presently there is no option other than robotic guns to achieve the desired results.*
This paper highlights, Design and Manufacturing of 35 KVA Table Top Spot Welding Machine is done overcome to the mentioned problems and to produce a cost-effective welding solution for small and medium scale industries.

Keywords- *Mechatronics, Resistance welding, Nugget formation*

I. INTRODUCTION

Resistance welding is one of the oldest of the electric welding processes in use by industry today. The weld is made by a combination of heat, pressure, and time. As the name resistance welding implies, it is the resistance of the material to be welded to current flow that causes a localized heating in the part. [3] The pressure exerted by the tongs and electrode tips, through which the current flows, holds the parts to be welded in intimate contact before, during, and after the welding current time cycle. The required amount of time current flows in the joint is determined by material thickness and type, the amount of current flowing, and the cross-sectional area of the welding tip contact surfaces [9]. In the illustration below a complete secondary resistance spot welding circuit is illustrated Fig1.for clarity; the various parts of the resistance spot welding machine are identified.
For decades current and time have been the vital control parameters in the industry due to the availability of electronic controllers which allow the development of closed loop control system. Electrode force was not a control parameter because of the use of the pneumatic system to supply force during welding. Pneumatic system, being a mechanical system, does not allow the development of a closed loop control system; therefore, force could not be monitored or controlled during spot welding.

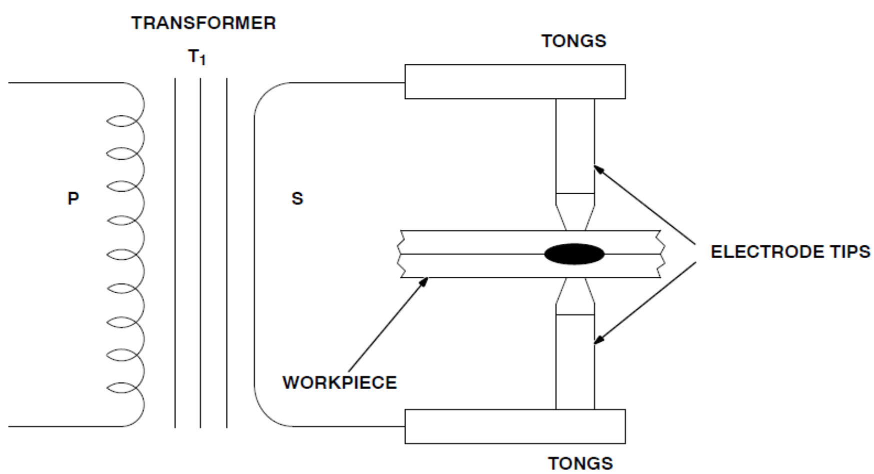


Fig no.1 Schematic diagram of Resistance Spot Welding.

The nugget formed in the work piece plays a crucial role in joining structure. Nugget forming process is not visible and also hard to test [1]. Researchers have studied the effect of electrode load on the growth of the weld nugget in resistance spot welding has been investigated for 0.9 mm (0.036 in.) and 1.6 mm (0.064 in.) mild steel sheet using a specially constructed low inertia, rigid experimental machine. It has been shown that spot welding can be made tolerant to variations in welding current and time by automatically controlling the electrode load as a function of the weld expansion [2]. Study shows that welding processes and weld quality are affected by machine stiffness and friction. The moving mass does not significantly affect the process and quality of resistance spot welding [3]. Decrease in electrode force during welding was found to increase resistance which in turn increased Joule heating and facilitated weld nugget growth and vice-versa [5].
The static and fatigue strengths of spot welded joints are influenced by the nugget diameter and residual stress. Therefore, generating a large nugget and decreasing the residual stress are crucial for increasing the static and fatigue strengths [6]. Cooling system should be given to the spot welding machine to improve the life of the electrodes.

II. COMPONENTS OF MACHINE

Components required for the assembly of Table Top Spot Welding Machine is as followed:

1. Frame
2. Housing
3. Plates
4. Anti-rotation plate
5. Upper electrode holder
6. Upper electrode
7. Transformer
8. Water inlet valve
9. Water cooling system
10. FRL
11. Transformer
12. Fix block
13. Cylinder-Piston
14. Bakelite
15. Lower electrode holder
16. Lower electrode
17. Transformer stand
18. Water outlet valve
19. Copper band
20. Door

III. MATERIAL SELECTION

Table no I

Sr. No.	Name of Component	Materials	Properties
1.	Machine Frame	Mild Steel	C% <0.3, S_{ut}= 400-560 MPa, S_{yt}=300-440 MPa , E= 205 GPa
2.	Cylinder Housing	Mild Steel	C% <0.3, S_{ut}= 400-560 MPa, S_{yt}=300-440 MPa, E= 205 GPa
3.	Plates	Brass	Cu-Zn alloy, (Cu=63%, Zn=37%), S_{ut}=338-460 MPa S_{yt}=124-310 MPa, E= 97 GPa
4.	Fix Block	Brass	Cu-Zn alloy, (Cu=63%, Zn=37%), S_{ut}=338-460 MPa, S_{yt}=124-310 MPa, E= 97 GPa
5.	Anti-Rotation Plate	Mild Steel	C% <0.3, S_{ut}= 400-560 MPa, S_{yt}=300-440 MPa , E= 205 GPa
6.	Upper Electrode Holder	Brass	Cu-Zn alloy, (Cu=63%, Zn=37%), S_{ut}=338-460 MPa, S_{yt}=124-310 MPa, E= 97 GPa
7.	Lower Electrode Holder	Brass	Cu-Zn alloy, (Cu=63%, Zn=37%), S_{ut}=338-460 MPa S_{yt}=124-310 MPa, E= 97 GPa
8.	Upper Electrode	Copper	Thermal conductivity(k)=394 W/mK Melting point=1083°C, E=121 GPa
9.	Lower Electrode	Copper	Thermal conductivity(k)=394 W/mK Melting point=1083°C, E=121 GPa
10.	Shunt	Copper	Thermal conductivity(k)=394 W/mK

			Melting point=1083°C, E=121 GPa
11.	Bakelite Plate	Bakelite	Chemical formula: $(C_6H_6O{\cdot}CH_2O)_n$ Thermal Conductivity(k)=0.2 W/mk
12.	Transformer Stand	Mild Steel	C% <0.3, S_{ut}= 400-560 MPa, S_{yt}=300-440 MPa , E= 205 GPa
13.	Door	Mild Steel	C% <0.3, S_{ut}= 400-560 MPa, S_{yt}=300-440 MPa , E= 205 GPa
14.	Water Valve	Aluminium	S_{ut}= 310 MPa, Syt= 276 MPa, E= 70 GPa

Above materials and properties are referred from "Machine Design Data Book" by V. B. Bhandari.

IV. DESIGN CONSIDERATION

Electrode Dimension:

From Standard chart of welding parameters, we have considered electrode contact diameter as 6 mm for welding of 0.2 to 0.8 mm sheet thickness.

Thinnest Material Thickness (mm)	Recommended Electrode Contact Diameter (mm)	Fused Zone Diameter Expected (mm)	Recommended Flange Overlap (mm)	Recommended Single-Spot Weld Spacing (mm)	Expected Shear Strength in kg. /shot Stainless Steel
0.25	3.0	2.5	10.0	19	170
0.53	5.0	3.0	11.0	19	470
0.79	5.0	4.0	11.0	25	800
1.02	6.5	5.0	13.0	25	1270
1.27	6.5	5.5	14.0	25	1700
1.57	6.5	6.5	16.0	31	2400

Transformer Rating:
Nominal Power: 35KVA
Rated Duty Cycle: 50%
Primary Voltage: 440V

Cylinder Dimensions:
Bore =63 mm
Stroke Length =80 mm
Maximum Pressure =6 bar

Dimension of Frame:
L×W×H = 200×600×600(mm)

V. CAD DRAWING OF MACHINE COMPONENTS

After the designing of the components, CAD drawing was done on the design software. The software used for these was CATIA V5.

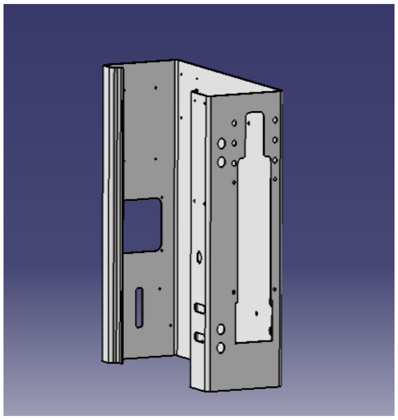


Fig no.2 Machine Frame

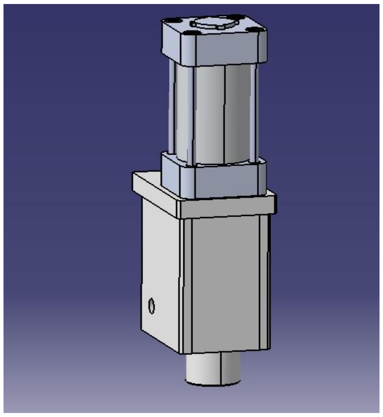


Fig no.3 Cylinder and cylinder housing

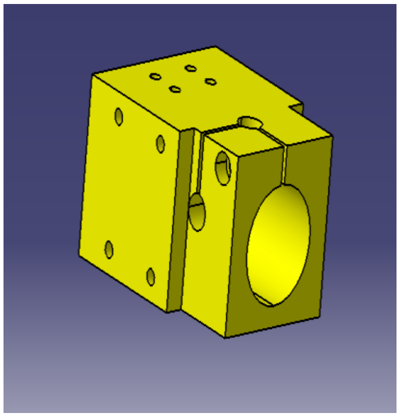


Fig no.4 Fix block

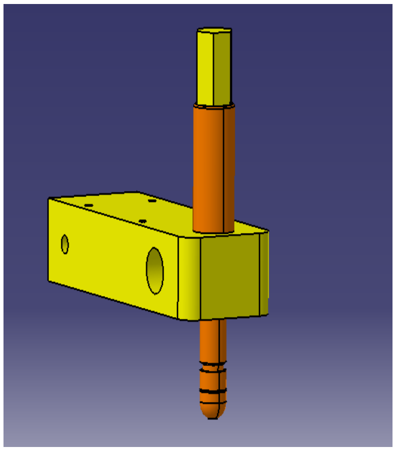


Fig no.5 Upper electrode and Electrode holder

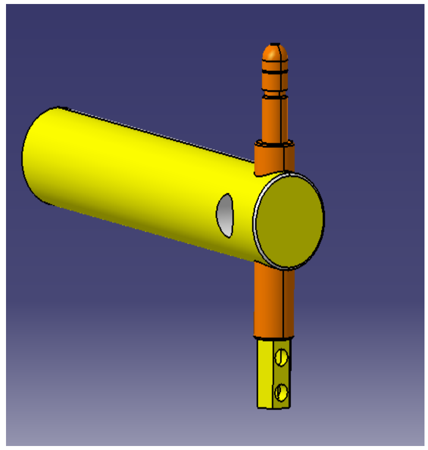


Fig no.6 Lower electrode and Electrode Holder

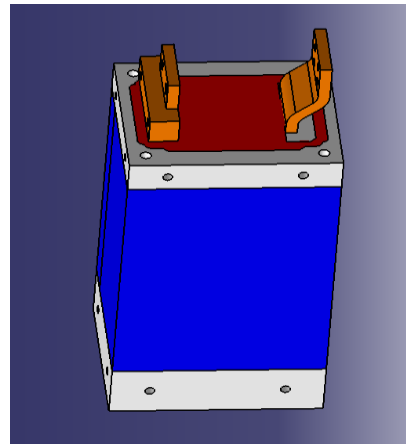


Fig no.7 Transformer

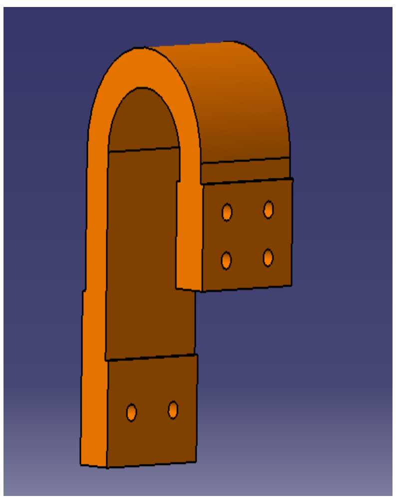


Fig no.8 Shunt

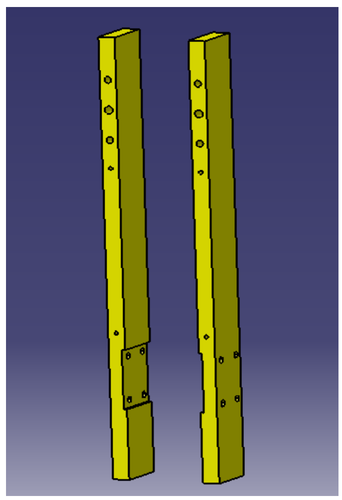


Fig no.9 Plates

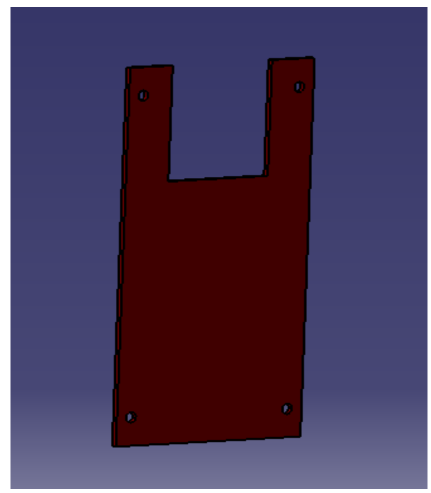


Fig no.10 Bakelite

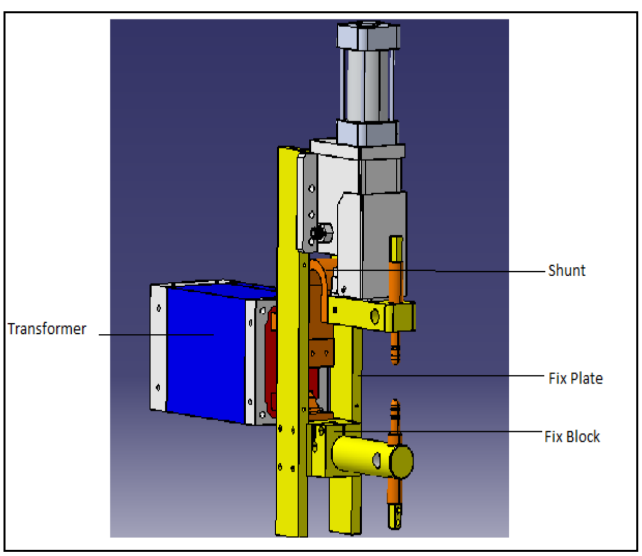


Fig no.11 Figure indicating different parts of machine

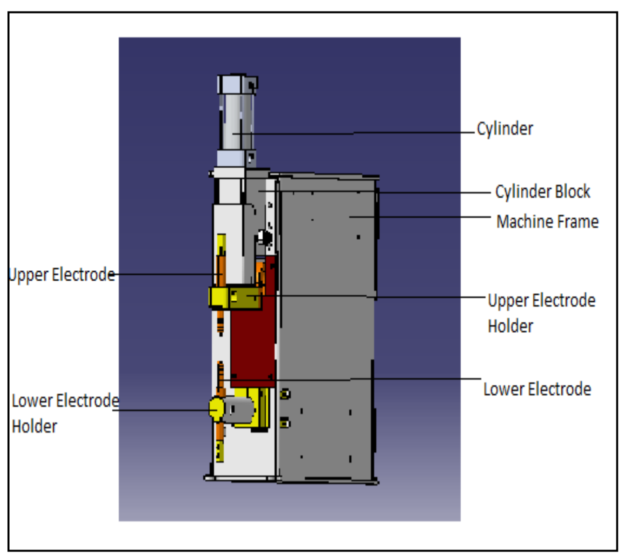


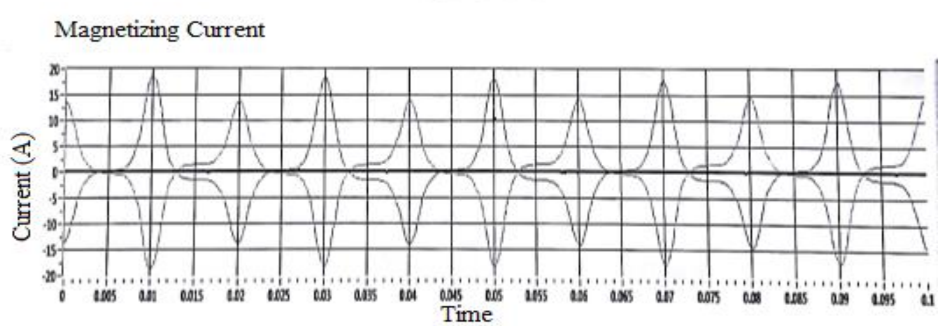
Fig no.12 35KVA Table Top Spot Welding Machine

Fig no. 13 Actual Machine

VI. TESTING OF MACHINE

A. Current Test:

No Load Test: - No load test on a transformer is performed to determine 'no load loss (core loss)' and 'no load current I_0'.



Supply voltage (V): 427.3

Positive peak (A): 18.7

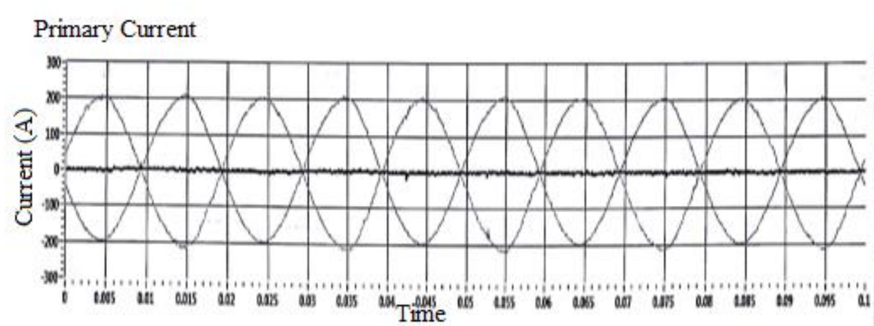
No load secondary voltage (V): 4.61

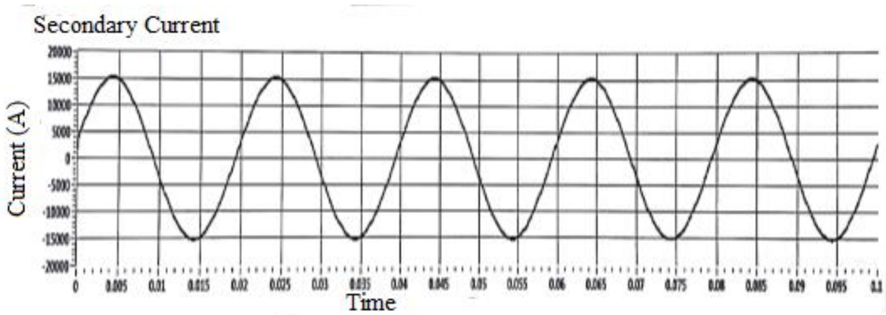
No load primary RMS current (A):7.14

Negative peak (A): 18.7

Short Circuit Test

The test is conducted on the high-voltage (HV) side of the transformer where the low-voltage (LV) side or the secondary is short circuited.





B. Water Leakage Test:

In water leakage test, cooling system is tested by flowing water through pipes in machine. It is done to check the leakage in the machine. Water leakage testing is visual. Parameters while testing are as followed-

Cooling Water Pressure: 2.5 Bar; Water Flow: 7-8 LPM; Inlet Water Temperature: 30°C

VII. CONCLUSION

The cost of machine is less compare to the robotic guns and other stationary spot welding machines. Different class of weld can be produced by 35KVA Table Top Spot Welding Machine i.e. class A, class B, class C. Due to the frequent flow of current through the electrode, the temperature of the electrode increases which reduces the life of the electrode. So, to improve the life of the electrode, cooling system is provided to the machine. The small and medium scale industries can get a cost effective and improved weld quality by using 35KVA Table Top Spot Welding Machine.

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