DESIGN AND CONSTRUCTION OF A PORTABLE SPOT-WELDING MACHINE FOR SHEET METAL PROCESSING

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***Abstract*—**The spot welding machine typically requires a significant amount of power, takes up a lot of space, and is heavy, making it difficult to transport. Additionally, it has limitations in height and the angles at which it can weld. In this project, we aimed to address these issues by redesigning the apparatus. The new design is simpler, lighter, portable, compact, and versatile, enabling welding at any angle and allowing even unskilled workers to operate it with ease and precision. The development of the portable spot welding machine involves two main phases. The first phase includes building the basic circuit, which features a small 1.2 kVA transformer that provides an output voltage of 0 to 2.2 volts, along with a power switch and 2.5-gauge wiring. The second phase focuses on constructing the machine's body and arm mechanism. We utilized modeling software, such as Autodesk Fusion 360, to create the design and build a prototype. To meet our welding specifications, we also designed our own transformer, as standard transformers used in electronics were both expensive and bulky.

***Keywords*—Spot Welding, Design, construction, Sheet metal**

I. INTRODUCTION

Resistance welding is one of the oldest electric welding methods still used in industry today. This process creates a weld by combining heat, pressure, and time. As suggested by its name, resistance welding relies on the material's resistance to current flow, which generates localized heat at the joint. The pressure applied by the tongs and electrode tips ensures that the parts being welded remain in close contact before, during, and after the welding current is applied. The necessary duration for the current to flow through the joints depends on factors such as the thickness and type of material, the amount of current used, and the cross-sectional area of the welding tip contact surface. Resistance spot welding occurs when electric current flows through the electrode tips and the metal pieces being joined. The base metal's resistance to the electric current generates localized heat at the joint, creating the weld. The distinctive feature of a resistance spot weld nugget is that it forms internally relative to the surface of the base metal.

II. WORKING PRINCIPLE

The portable spot-welding machine operates on the same principle as a conventional one: when low voltage and high current are applied to two thin metal plates at a specific point, the metals fuse together, creating a weld. The 2014 literature review on "Experimental Investigation of Resistance Spot Welding" focuses on how various input parameters affect weld quality. Experimental studies examined factors like welding current, time, squeeze, and hold time, with tensile strength assessed using Grey Relational Analysis. Optimal welding parameters were determined through this method. In 2015, Dariusz Ulbricht and colleagues conducted a study on the ultrasonic analysis of spot-welded joints in thin steel sheets with closed profiles [1]. This research included non-destructive ultrasonic testing, which was validated by destructive testing of welded joints, leading to the development of a technique for evaluating such joints in industrial applications. In their study, Zhang X. et al. [2] examined the strength of multiple spot weld joints, particularly in the context of automotive applications, such as vehicle chassis that feature numerous spot welds. Their analysis utilized both finite element modeling and experimental approaches. They focused on the finite element model of multiple spot weld joints subjected to tensile shear loads through experimental methods. The investigation assessed how various factors—including spot weld spacing, edge distance, weld size, and thickness—affect the strength of these joints using finite element analysis. The study concluded that weld parameters, especially weld size and thickness, are the primary factors influencing joint strength in materials.

III. MATERIALS AND METHODOLOGY

The portable spot welder consists of several key components: a cabin and base, a transformer, an electrical circuit, and the design of offset lugs, all of which have been analyzed for their requirements.

A. Materials of spot welding

The cabin serves as the primary housing for the transformer and electrical circuit, which we will be working on next. The cabin has an L-shaped cross-section when viewed from the front. To accommodate the electrodes, we plan to make some modifications. We chose wood as the material for the cabin and base due to its reliability and low cost. Although wood is a poor conductor of electricity, it can withstand heat and securely hold the transformer, making it suitable for rough use. The main reason for selecting wood is its affordability, as we aim to keep the project cost-effective. We assembled the wood using nails, which helps reduce both cost and weight. In the event of any damage, we can easily remove the nails and replace the affected wood. In addition to the cabin and base, we also used wood to construct the electrodes. Since the operator will have direct contact with the electrodes, we designed them to be shock-proof, ensuring that the operator can handle them safely during welding.

B. *Transformer*

A transformer is an electrical device that transfers energy between circuits through electromagnetic induction, generating an electromotive force in a conductor subjected to changing magnetic fields. It consists of two main components: the primary and secondary windings. Power is supplied to the primary winding, while the output is determined by the secondary winding, which is crucial for the transformer's function [3] [4]. There are two types of transformers: the Step-Up Transformer, which increases voltage and decreases current from primary to secondary, and the Step-Down Transformer, which decreases voltage and increases current from primary to secondary [5].

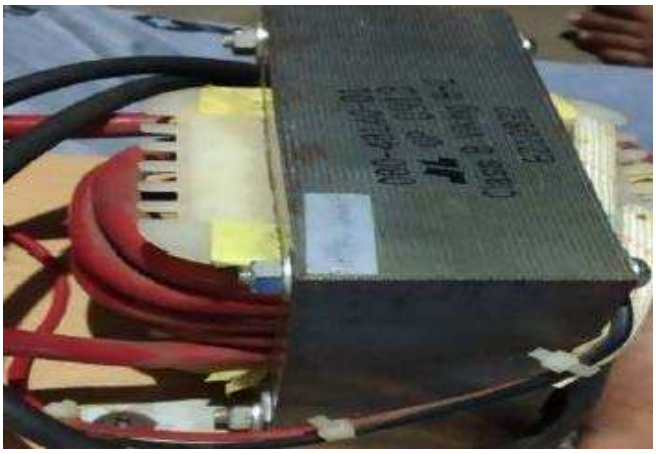

Figure 1: Micro wave oven Transformer

C. *Electrical Circuit*

The transformer, which is central to our welding project, cannot operate solely with the metal meter. Additionally, supplying power directly to the transformer is extremely hazardous and could pose a serious risk to the operator's safety.

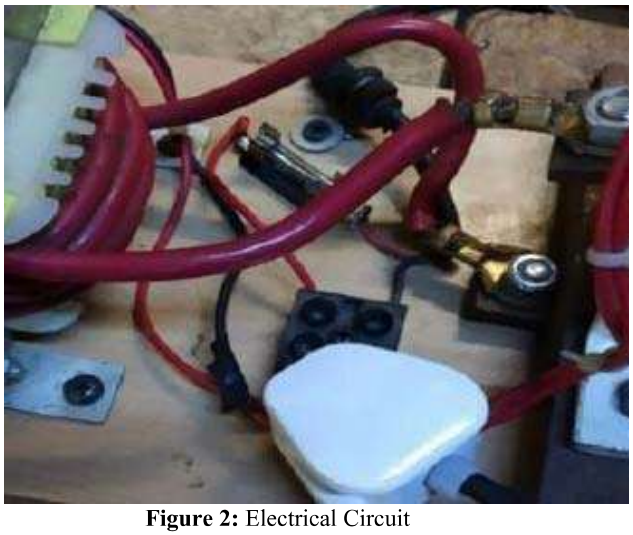

Figure 2: Electrical Circuit

IV. FABRICATION

We designed offset lugs to secure electrodes in our holders, using a 1 cm thick copper bus bar. From a 10 cm long bus bar, we created two Z-shaped lugs, each consisting of two straight sections of 2 cm and a 0.5 cm curvature. Internal tapping on one side of each lug allows us to attach them to the electrode holders. [6] Additionally, we used a 14 cm long bus bar, cutting it into two halves and forming square sections of 2 cm at the ends. Brass welding was employed for joining, with internal tapping to secure the electrodes, leveraging the use of a copper electrode.

A. *Fabrication of portable spot-welding machine*

The main circuit consists of a transformer, 2.5-gauge copper wire, copper electrodes, and connecting thimbles. First, we need to modify a step-up transformer into a step-down transformer, aiming for an output voltage of about 2.2 V and a power rating of 1.2 kW. To achieve this, we will use 2.5-gauge wire to create a five-turn winding, which will generate approximately 1.2 V through electromagnetic induction. A pair of copper wire electrodes is then connected to the secondary voltage circuit, producing a high current of 550 Amps. [7] [8] Both ends of the 2.5-gauge copper wire are stripped and attached to thimbles that hold the copper electrodes, which can be replaced as needed, allowing for various electrode diameters. This sets up the basic circuit for a machine designed to spot weld two thin sheets. The machine's frame is constructed from plywood and soft wood, making it lightweight. The arm mechanism features a lever and spring to provide the necessary force for effective spot welding. For further information on writing about scientific topics, a valuable resource is [9]. When the switch is opened, current flows through a cable to the welding machine's components. The transformer converts high-voltage, low-current electricity from the wall outlet into low-voltage, high-current electricity for the work piece. Heat is generated through electrical resistance as copper electrodes transmit current to the metal, forming a weld nugget that joins the pieces together. Once the switch is closed, the current stops. Portable spot-welding machines are fast, economical, efficient, flexible, and provide a cleaner finish compared to arc welding. They are more cost-effective for production, utilizing energy efficiently and being environmentally friendly, as they consume fewer resources and release no toxic gases or hazardous materials. The process requires less skilled labor. Our project conforms to ASTM Standard ASTM E751 – 17 for portable spot welding, and after testing, it received approval. We addressed economic constraints by modifying high-cost components, ultimately reducing the product's cost.

Figure 3: Fabricated Spot-Welding Machine

V. CONCLUSION

We designed and built a portable spot-welding machine at a very low cost, making it suitable for both domestic and some workshop applications. The affordability of this machine ensures that even small workshops can utilize it. Due to budget constraints, we opted for a half kV transformer; using a higher capacity transformer would improve welding efficiency and reduce welding time. Our machine does not require separate cooling, as air cooling is sufficient. However, if we want to enhance the machine's capacity, adding an exhaust fan for better cooling would be advisable.

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