iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** IX **Month of publication:** September 2023

DOI: https://doi.org/10.22214/ijraset.2023.55640

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue IX Sep 2023- Available at www.ijraset.com

Assembly of Portable Spot-Welding Machine

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Abstract: Resistance spot welding is required to connect the thin metal sheets by heat in automobile and aircraft industries. Shaped copper and zinc alloy (brass) electrodes apply pressure to hold the workpieces together and focus the welding current into a dense area. Spot welding machine occupies a wide area with lots of electricity and is very heavy to transport. In this work, we have tried to overcome the structured problems by replacing portable structures. The newly established tool is easier to use, lightweight, more portable, economical, compact, and versatile. It can weld at any angle and be easily operated by even unskilled laborers with the necessary proficiency and precision. The first step in making a portable spot-welding machine is to construct its basic circuit, which consists of a tiny transformer with an output voltage range of 0 to 12 volts, 35mmsq wire, and a power switch. The second step is to construct the structure of the machine and arm mechanism.
Keywords: spot-welding machine, Assembly, Modelling, Implementation, Portable structure

I. INTRODUCTION

The transportation industry is currently a very promising industry. The overwhelming majority of vehicle machinery must be lightweight, fuel-efficient, least deformable, and most importantly, cost-effective. To meet this challenge, numerous experiments have been conducted, and numerous materials have been studied while taking into account all of these characteristics as well as tensile and shear stress. Alloys of steel, aluminium, magnesium, and other metals are frequently used materials in the automotive industry. Resistance spot welding (RSW) is a method of welding in which a connection is formed by the heat generated by the contact resistance of the working component to the flow of an electric current through it [1]. This method is appropriate for connecting components made of low-carbon steel, stainless steel, nickel, aluminium, or titanium alloys. This welding technology is suitable for the bodies and axles of automobiles, trucks, trailers, buses, and railroad passenger cars, as well as cabinets, workstations, and a variety of other products [2, 3]. Resistance spot welding is a commonly used joining process in which two or more metal sheets are joined together by applying pressure and passing an electric current through the interface between the sheets. The working principle is shown in Figure 1. This technique is widely utilized in the automotive industry and manufacturing of household appliances due to its high efficiency in producing thin metal sheets. Resistance spot welding is a highly efficient and widely employed technique in the automotive industry and the manufacturing of household appliances. It is capable of handling a wide variety of metal sheets up to 3 mm thick, making it a versatile method. This technique is commonly used in the automotive industry and for manufacturing house appliances, owing to its high efficiency in producing thin metal sheets. The heat input and the establishment of weld pieces during spot welding have been associated with a number of welding processing parameters, including welding current, an additional current pulse for the purposes of preheating and slow cooling, welding time, welding force, electrode face dimension, and workpiece surface condition. Spot welding is typically used for welding vehicle body parts. Resistance spot welding (RSW) is a reliable joining technique that is frequently used to create sheet metal assemblies. RSW is a great technologically-economical option for auto-body assemblies, and home appliances because of its low cost, fast speed, and compatibility for automation. Resistance welding is a type of fusion welding in which metals merge at the fusing surfaces due to the heat created at the junction by the resistance of the work to electrical current. The work components develop a molten weld nugget because of contact resistance and Joule heating. Work parts are linked while the weld pool solidifies.

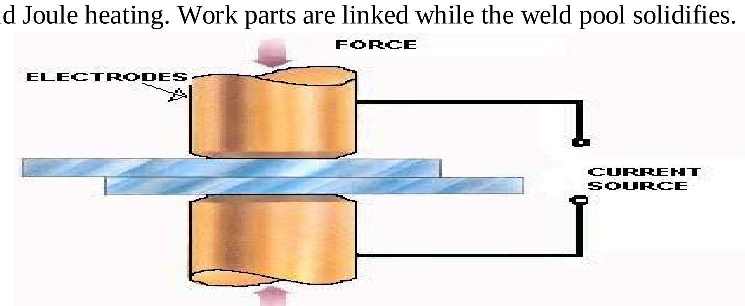

Figure 1 working principle

Spot welding is used for a variety of applications, including attaching sheets to one another, sheets to rolled sections or extrusions, wire to wire, and so on. When attaching relatively thin gauge parts (up to around 3 mm thick) overlaid on one another (as a lap joint), spot welding is the method of choice.

II. CIRCUIT DIAGRAM

Circuit diagram presented in Figure 2 of the spot-welding machine consists of one main switch and one led and one cooling fan connected in parallel then an industrial NO switch in series and then a step-down transformer and in the secondary of transformer electrodes are connected. Spot welding is a type of resistance welding in which overlapping sheets are joined by local fusion at one or more spots. This fusion is caused by the heat generated by resistance to the flow of electric current through workpieces that are held together under force by two electrodes, one of which is located above and the other of which is located below the two overlapping sheets.

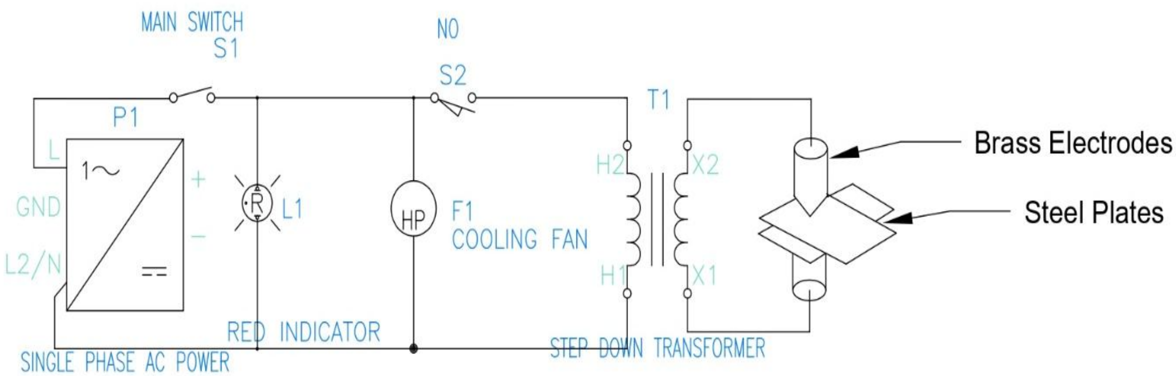

Figure 2 Circuit Diagram

Resistance spot welding is quick, simple to automate, and low maintenance compared to other welding methods like arc welding. Electrical, thermal, mechanical, and metallurgical phenomena interact in this process. The quality of the weld mostly depends on the joint's tensile strength, the shape and size of the nugget, the appearance of the blowhole, and ejection. The following equation determines how much heat is produced in the welding area.

$$Q=I^2 RT \qquad (1)$$

whereas Q is the heat produced in Joules and I is current in Amperes. R is the workpiece's resistance in Ohms. T represents time in Seconds. This equation informs that the square of the variance in current equals the variation in heat. As a result, the weld zone and weld properties are most affected by current.

III.LITERATURE REVIEW

The extensive literature on resistance spot welding provides valuable insights into the process parameters, weld quality evaluation techniques, and advancements in equipment and technology. Furthermore, research papers and articles in this field discuss the challenges associated with achieving consistent weld quality and explore strategies for improving electrode life and reducing maintenance costs.

[4] represent that the resistance spot welding used in the manufacturing process in a number of sectors. It was very effective and efficient in use since it was simpler to use, but occasionally there were connection issues that were still of low quality, including nuggets and regions that receive electrode pressure. A number of variables, including material preparation, welding time, welding current, electrode pressure used during welding, and post-welding treatment, all had an impact on the quality of the resistance welded joint. Designing a prototype for material preparation and examining the resistance spot welding material prototype's test results are the two main goals of this study. Designing a prototype for the resistance spot welding material preparation and evaluating the best materials' strengths served as the study methodology.

In [5] author explains that resistance spot welding is a workforce- and money-intensive process used to attach intricate automotive parts. The production of automotive parts using additive manufacturing technology results in high accuracy while cutting down on production time. This study compared and contrasted the weldability of conventional (C) 316L stainless steel with additively produced (AM) 316L stainless steel.

The monitoring data, nugget diameter, tensile shear strength, and hardness were examined after the lobe diagrams for the two materials were derived. The study's conclusions have created a huge opportunity for resistance spot welding technology to be used in the manufacturing of additive materials in the years to come. However, compared to other joining methods [6], it has a limited range of use at high temperatures. From a technological point of view, adhesive joints require immobilization of the joint until it reaches the minimum strength, which can significantly complicate the process and extend the production time. The integration of advanced resistance welding techniques with bonding offers new opportunities for combining construction materials in different industrial fields. This article presents the findings from experiments conducted on resistance spot welding-adhesive bonding, utilizing a weld-through technique. The study [7] examines the impact of various welding conditions (such as technological parameters) and adhesive bonding factors (like surface preparation methods, overlap size, and thickness during bonding) on the formation process of hybrid connections. Dynamic resistance plays a crucial role in monitoring and controlling the resistance spot welding process [8,9]. However, limited qualitative analysis has been conducted to understand the mechanism behind signal evolution, leading to an unclear interpretation of its formation. To address this issue, [8] study adopts a collaborative simulation approach for bare DP590 steel RSW. This enables us to accurately compute temperature and potential distributions inside the weld area. Building upon these findings, we have developed an analytical mapping model that establishes a link between dynamic resistance signals and weld profile based on fundamental physical principles. Through this quantitative model, we are able to reveal insights into the mechanism governing signal evolution during RSW processes more precisely. Resistance spot welding is a welding technique that is commonly employed in the joining of sheet metal due to its notable cleanliness and efficiency. This procedure encompasses interactions of an electrical, thermal, and mechanical nature. Resistance spot welding is a process that involves the localized melting of the sheets at their interface, followed by rapid solidification. This is achieved by applying controlled pressure from a water-cooled electrode and directing the appropriate electric current for a certain period. The study [9] focused on investigating tensile testing and spot weld diameter through experimental methods. The primary aims of this analysis are to comprehend the underlying physics of the resistance spot welding process and to demonstrate the impact of key variables such as electrical current, weld time, and material type. Previous study [10-12] has examined the potential for analyzing the mechanism of nugget growth and calculating weld quality using a variety of methodologies. The destructive test method was a prevalent approach utilized for assessing spot weld quality, extensively employed for macrostructure or microstructure examination and mechanical feature analysis. The primary focus of numerous researchers has been directed towards the examination of temperature distribution within the welding region [13,14]. The utilization of numerical computational models has been found to have the potential to enhance efficiency and cost-effectiveness in the development of novel welding technologies, as indicated by recent research findings [15,16]. The dimensions of the weld nugget and the residual stresses induced during welding are critical factors that influence the mechanical properties of spot weld connections.

IV. PROBLEM FORMULATION

The manufacturing purpose of conventional spot-welding machines necessitates the use of a step-down transformer. However, it is challenging to get a step-down transformer that meets the specific specifications in the market. Additionally, the cost of acquiring such a machine is considerable. In order to fulfill the requirements of our project, it is necessary to acquire a step-down transformer capable of converting a standard input of 230V and 7 amps into an output of 12V and 7 amps. The acquisition of this particular step-down transformer is not readily available in mainstream markets. In the context of transformers, the determination of the output voltage is mostly contingent upon the quantity of turns present in the secondary winding.

Our objective is to develop a portable, lightweight, and cost-effective spot-welding machine specifically designed for sheet metal operations in workshop environments. The spot-welding equipment now available on the market is characterized by its large physical dimensions and high electrical power consumption. The portability or convenience of these objects is rendered impracticable due to their large dimensions. The analysis of several spot-welding procedures and a range of automatic and semiautomatic spot-welding machines indicates the potential for making modifications to the design of traditional spot-welding systems.

V. MODELLING AND IMPLEMENTATION

Before starting out the process of spot welding, one needs to make sure that the technique is clean, which means that it is free of any grease, dirt, paint, scale, or Oxide, among other things. Since it must transmit the current into the work with as little loss as possible, the surface of the electrode tip is kept clean. The low-energy fabric can be utilized for general housekeeping duties. Water is being circulated between the electrodes in order to prevent the electrodes from becoming overheated and, as a result, damaged, and cool the weld. The correct amount of welding current has been selected using the current selector switch. The wild-timer has been calibrated to the correct amount of time.

1) *Step 1:* After removing any undesired film that may be present on the workpieces, the electrodes are brought together so that they are pressed up against the overlapping workpieces, and pressure is then applied. This causes the surfaces of the two workpieces that are under the electrodes to come into direct physical contact with one another.
2) *Step 2:* After a predetermined amount of time has elapsed, the welding current is turned back on. Depending on the composition of the material and the thickness of it, the current might be anywhere from three thousand to one hundred thousand amperes for a fraction of a second to a few seconds. A localised region of the area where the workpieces are in touch gets heated as the electric current travels from one electrode to the other electrode through the workpieces and the first electrode. The temperature of this weld zone ranges between 815 and 930 degrees Celsius. In order to produce a spot weld that is up to par, the nugget of coalesced metal must form without any melting of the material that lies in the gap between the flying surfaces.
3) *Step 3:* At this point, the current that is being used for welding is turned off. The electrode force is then increased further, or the initial force is maintained for a longer period of time. This force or pressure from the electrode forges the weld and maintains its integrity while the metal cools and hardens.
4) *Step 4:* After the spot-welded workpieces have been removed, the electrode pressure is allowed to relax. The Foundations of Electric Resistance Welding. The two primary contributors to resistance welding, which factors are, the application of heat at the location where two pieces are going to be united.

The application of pressure at the location where a weld connection is going to be produced. to Heat A significant electrical current (on the order of 3000 to 1,00,000 Amps with a voltage between 1 and 25 volts) is passed through two pieces of metal that are touching each other in order to produce heat, denoted by the letter H, for the purpose of electrical resistance welding. The voltage of the electrical current ranges from 1 to 25 volts.

$$H \alpha I^2 RT \qquad (2)$$

where H is the heat generated indicated in joules, I is the current in root mean square amperes, R is the resistance in ohms. T is the time (from the fraction of a second to a few se nods) of current flow through the pieces to be welded.

Advantages of Spot Welding

a) Low cost,
b) High speed of welding (in) Dependability
c) Less skilled worker required More general elimination of warping or distortion of part
d) High uniformity of products,
e) Operation may be made automatic or semi-automatic,
f) No edge preparation is needed.

A. *Applications of Spot Welding*

Spot welding of two 12.5 mm thick steel plates has been done satisfactorily as a replacement for riveting. Many assemblies of two or more sheet metal stampings that do not require gas-tight or liquid-tight joints can be more economically joined by spot welding than by mechanical methods. (iii) Containers such as receptacles and tote boxes frequently are spot-welded. (iv) The attachment of braces, brackets, pads, or clips to formed sheet metal parts such as cases, covers, bases or trays if another application of spot welding. (v) Spot welding finds applications in automobile and aircraft industries.

B. *Operation of Machine*

Spot welding machine's operation is simple and easy and does not require any skilled labor.

1) Connect the machine to a single phase 230v, 50hz AC power supply and turn on the power switch as shown in Figure 6.
2) Clean the welding surface and electrodes before operation
3) Hold both sheets together with the help of thermally insulated gloves or two pliers.
4) Now ask the second operator to press the Normally open switch provided and press the arm to the welding area for about 4-5 seconds.
5) Remove the arm and ON switch
6) Now let the welded area cool for about 6 -7 seconds.

Note: If a proper sheet holding mechanism is employed then only a single operator is required to use this machine.

VI. ASSEMBLY OF PORTABLE WELDING MACHINE

The main circuit comprises a transformer, 35sqmm copper wire, brass electrodes, and connecting thimbles. To begin, we have to transform the step-up transformer into a step-down transformer with an output voltage of around 12 volts and a power of 1.84 kV. To do this, 35MMsq wires are required for constructing a single-turn winding, which yields 12 volts according to the electromagnetic law of induction. A secondary voltage circuit is connected by a pair of brass electrodes. The generated voltage is around 12 volts, resulting in a high current of 153 amps. Both ends of the 35MMsq copper wire have been removed and joined with two thimbles that grasp the brass electrodes. The electrodes have the capability to be modified over time, and their diameters can be adjusted to accommodate specific requirements. The fundamental circuitry of the machine has now been constructed represented in Figure 3, enabling it to do spot welding on two thin sheets. The machine's body is constructed from wood, resulting in a lightweight, insulated and economical easy to make structure without any big machinery reducing its manufacturing cost. The material employed for constructing the machine's body consists of plywood and softwood.

Figure 3 Assembly of Machine

The arm mechanism comprises a lever and a spring that deliver the appropriate magnitude of force necessary for the purpose of spot welding the metal sheets. During the actuation of the switch, an electrical current will be directed through an electrical wire, subsequently supplying power to the various electrical components housed within the welding machine. Electrical power is transmitted directly through an electrical cable to the device known as the "transformer". The process involves utilizing a transformer to convert the high voltage and low current obtained from the wall outlet into low voltage and high current that is subsequently applied to the work item. The generation of heat is attributed to the phenomenon of electrical resistance. In order to generate thermal energy, copper electrodes facilitate the conduction of an electrical current through the work parts. The electrodes are subsequently utilized to momentarily apply an electric current to the metal, resulting in the formation of a weld nugget that facilitates the joining of the metal components.

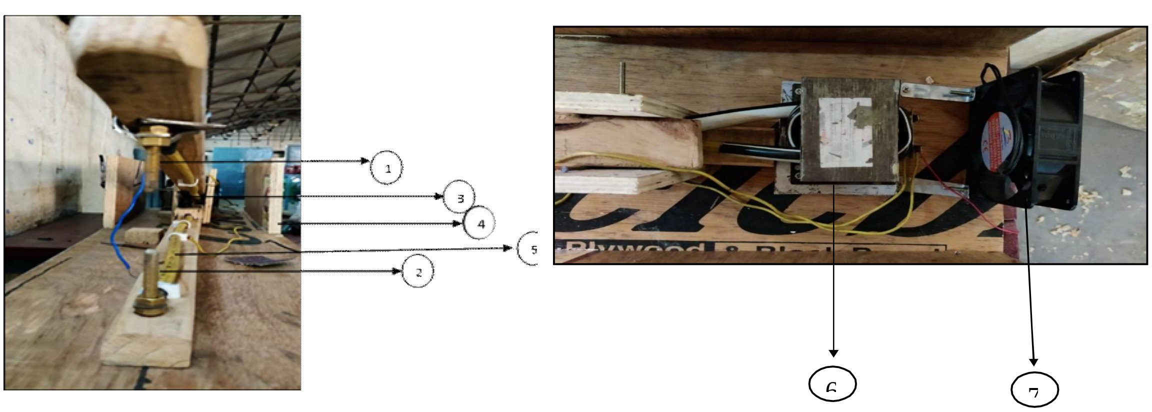

Figure 4 (a) shows the front view and (b) shows the top view of model.

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Volume 11 Issue IX Sep 2023- Available at www.ijraset.com

Upon the closure of the switch, the flow of electric current will cease. The portable spot-welding equipment exhibits high speed, cost-effectiveness, efficiency, flexibility, consistency, and superior aesthetic outcomes compared to other alternatives. Arc welding is a welding process that utilizes an electric arc to join metal pieces together. The implementation of this approach in the manufacturing line yields greater cost-effectiveness. The approach described is significantly more energy efficient as it effectively utilizes electricity in comparison to alternative welding methods. The utilization of environmentally friendly processes results in the reduction of resource consumption. The safety of this procedure is significantly higher when compared to other conventional processes. The method utilizes minimal resources and adheres to environmentally friendly practices, as it does not emit any poisonous gases or necessitate the use of hazardous materials for its completion. The operation does not necessitate a highly skilled operator.

A. Pressure or Electrode Force

Electrode force is the force applied to the workpieces by the electrodes during the welding cycle. Pressure exerted on the workpieces by the welding electrodes brings the various interfaces into intimate contact and thus affects the contact resistance between the two workpieces. It ensures the completion of the electrical circuit between the electrodes through the work. It permits the weld to be made at lower temperatures. It provides a forging action and thus reduces weld porosity. If too little electrode force is used, the contact resistance between the two workpieces is high and surface burning and pitting of the electrodes may result If too high electrode force is used, it decreases the contact resistance of the work metal and, therefore, reduces the total heat generated between the flying surfaces of the workpieces by the welding current. Figure 5(a) shows the brass electrode and (b) shows the electrode during operation. Too high electrode force may, also squecze softened hot metal between the flying surfaces or the work may be indented by the electrodes. Pressure on the workpieces is exerted by the electrodes extending from the arms of the welding machine. Resides this, the other functions performed by electrodes are that they carry the current which passes through and generates heat at the place where the two workpieces are in pressed contact. Depending upon the area of the electrodes face or tip, they determine the current density in the weld zone. They dissipate the heat front e weld the weld zone and thus prevent surface fusion of the work.

Figure 5 (a) Brass Electrode

(b) Electrode during operation

These electrodes can be replaced throughout time, and numerous sizes of electrodes can be utilized depending on circumstances. Additionally, researchers have also focused on developing new techniques for resistance spot welding, such as laser welding and friction stir spot welding. This kind of research and development is crucial for industries that heavily rely on resistance spot welding, as it can significantly impact their manufacturing processes. Spot welding requires high resistivity materials so low carbon steel is most suitable for spot welding some materials like silver, copper, lead and zinc cannot be spot welded due to their high electrical and thermal conductivity, the material readily welds to the electrodes themselves. In conclusion, the literature on resistance spot welding offers a wealth of knowledge and information that is vital for understanding and improving the process.

VII. FORMATION OF STRUCTURE OF MACHINE

The structure of the machine is simply constructed from wood, which makes it lightweight, strong, thermally insulated, electrically insulated, economical, easy to make and compact. The material utilized in the structure of the machine is plywood and softwood. Holes are provided in body of machine to ensure proper air flow through the machine. It is worth here to mention that as we used wood here so chances of operator getting electric shock under earth fault is negligible. The arm mechanism consists of a liver and a spring that provide the exact amount of force required to spot-weld the metal sheets. Figure 6 depicts the complete structure of the machine on which the electrode is fixed including the operating framework and Figure 7 represent the final welded specimen.

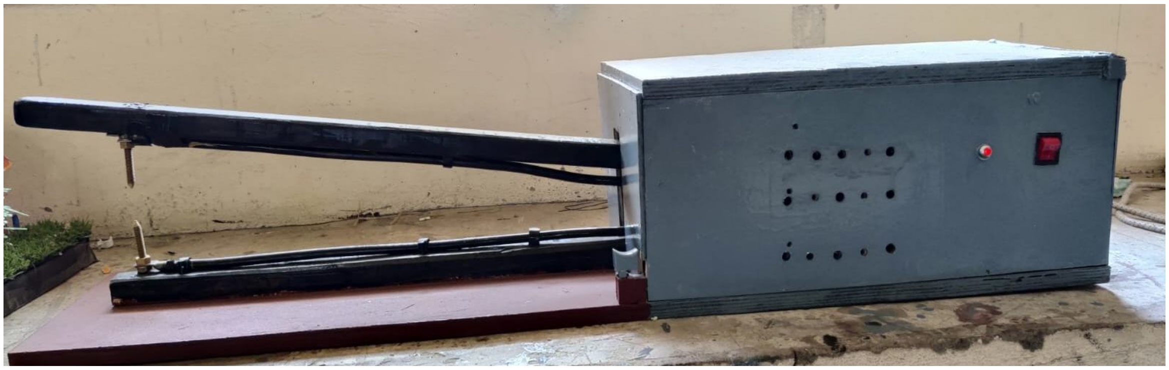

Figure 6 Final Structure of machine

Figure 7 Welded Specimen

A. *Material Used and Cost of Machine*

Table 1 shows the material used in construction of arc welding machine

Table 1 material used

Material	QTY.	Rate
Transformer	1	800
35MM SQ Copper wire	2 meters	750
Brass Electrode	2	80
Timbals	2	80
Spring	1	30
AC Cooling fan	1	350
Indicating lamp	1	10
Switch	1	40
Clamps	10	50
Nut bolts	3	20
Total		2210 Rs

B. Care and Maintenance

Spot welding machine although requires very low maintenance as compared to other welding processes but there are some points that the operator should keep in mind so that the machine can be used effectively for long periods of time.

1) The machine should be kept at room temperature as the transformer heats up a lot during its operation which can lead to insulation failure of its windings.
2) Operator should ensure that the cooling fan is working properly before its operation.
3) The operator should ensure that holes provided in the body for air flow should not be blocked.
4) The machine arm mechanism should not be subjected to much horizontal mechanical forces as it can disturb its pivot and will cause difficulty in making proper contact.
5) The machine's electrodes should be rubbed after 4-5 operations.
6) Machine's electrodes should not be short-circuited without any welding material in between as it can lead to arc production and welding of electrodes which disturbs its shape and leads to the formation of carbon over it which disturbs its contact operation.
7) Before operation of the machine the welding material and electrodes should be kept dust-free to ensure their proper operation.
8) The welding material should not be touched with bare hands as it could lead to injury.

VIII. CONCLUSION

1) The adaptability and portability of a welding machine provide a significant benefit to the user due to the fact that it may be employed in a variety of locales and working conditions, such as overhead work.
2) The market price of portable spot-welding machines runs from Rs 5000 to Rs 9,000 and weighs between 14 kg and 16 kg, however, the machine we developed costs only Rs 2210 and weighs 12.5 kg. This clearly shows that the machine's starting cost and weight are greatly decreased.

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