Microcontroller For Spot Welding

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Abstract: Welding is a common term that defines the joining of two metals. Presently, industries take advantage of Arc welding, Spot welding, and Laser based Welding for a variety of applications. All these methods have their own advantages and disadvantages. This paper presents the design of a microcontroller used to perform resistance spot welding. This paper consists of introduction to welding, arc welding, spot welding, critical factors in welding, Principle of spot welding, Microcontroller fabrication.

Keywords: Welding, Arc welding, Spot welding, Laser welding, Micro-controller

1. INTRODUCTION

Welding is a kind of fabrication process that is used to amalgamate two or more metal pieces together by means of heat, pressure or electricity. The metals that are to be joined are heated at high temperature and then cooled off to form a joint. This is the basic working of the welding process. There are various types of welding process: Arc welding, Resistance welding, Gas welding, Solid State welding, etc. The key factors like material, area, amount of temperature material can support,etc plays an important role in determining which type of welding technique is to be used.

The Arc welding uses the heat generated by the electric arc. The Resistance welding uses the heat produced by the current flowing through resistance. To achieve automated resistance welding, a microcontroller is used.

Microcontroller in an automated welding process is used to receive various inputs from users, schedule the timing of welding and set other critical factors to get the desired result. Front Panel of the microcontroller shows indications of schedule time, weld time, cool time, and hold time. The panel also indicates and monitors the current flowing through the resistance to generate the heat for welding. The microcontroller panel helps to control the operation sequence of welding by controlling squeeze time through weld, hold and off time. This system is designed with an approach to reduce size, cost and increase the reliability and performance.

This kind of system is required to prevent industrial accidents that occur due to lack of controlling parts in machinery. Also the normal welding machines creates accuracy issues in products and results in improper welding on work pieces and decreases the quality of weld. The quality of weld also decreases with varying pressure. [1] - [5]

The Welding industry has an immense impact in the world around us. The welding process provides an advantage over other joining processes as it is easy, quick and helps to join complex materials. As it is used to join metals, it is used in the Automobile industry, aviation industry, construction work, etc. Without welding, buildings, gates, utensils, etc. won't exist.

2. ARC WELDING

Arc welding makes use of an electric arc for forming a weld. It is a kind of fusion welding technique, which uses heat to join two materials by melting and then cooling to fuse them. Basic components of arc welding include: electrodes, electric arc, power supply and work-pieces. Power supply can be AC or DC. Electric arc is formed between the electrode and the work piece. It is created by current passing through a gas, usually air, between two conductors. In this technique, the positive voltage is applied to the electrode and negative voltage is applied to the work-piece. This forms an arc from work piece to electrode. The heat of the arc is used as a heat source for welding. The output current of arc lies in the range of 5-1000 A and the output voltage is about 8-40 V. DC power supply is more beneficial as it produces current in a single direction and produces a more stable arc. Generally, 50-60V of DC power supply is sufficient enough to form an arc. **Fig. 1** shows the working of an Arc welding.

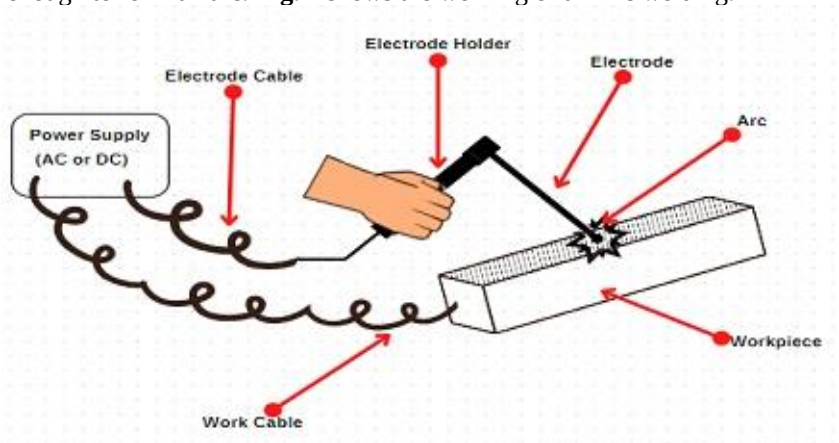

Fig 1. Arc Welding

The DC power supply offers a smooth and easily controllable arc. Therefore, DC is more widely used in Arc welding.

The electric arc generates a heavy amount of heat that melts the work-pieces and forms a weld. The function of the electrode is to carry the current or conduct the current and is moved along the joint to join the two materials. Electrodes can be consumable or non-consumable electrodes. Consumable electrodes are the one that melts with the heat and diffuses in the weld whereas non-consumable electrodes are the one that do not melt with the heat and preserve their structure. [6] - [17]

Arc welding is beneficial over other welding processes as it produces high quality welds, requires low operator skills, and ease of automation. The major drawback of arc welding is that it emits more wastes than other techniques and hence increases project costs. It is not very useful for thin metal sheets.

3. SPOT WELDING

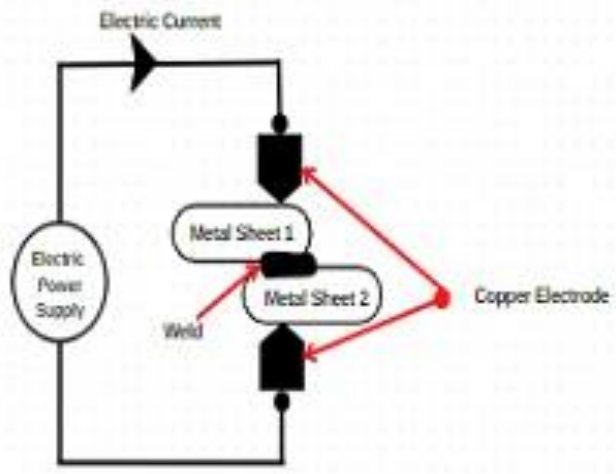

Fig 2. Spot Welding

Spot Welding is a form of resistance welding. It utilizes the heat energy produced because of current flowing through resistance. It is a process used to produce a weld at a specific spot on a work-piece between electrodes.

It was first introduced in 1855 when Elihu Thomson accidentally fused two wires together.

There are various types of resistance welding machines classified on the basis of different shapes of work pieces and forms of electrodes. Various forms includes: spot welding, Projection welding, Seam welding, Butt welding. Spot welding is primarily used in the automotive industry for assembling automobile bodies. It is also used in manufacturing furniture. Projection welding is generally used for thick metals and is used for exceptionally strong weld. Seam welding process uses roller electrodes.

Spot Welding uses two copper alloys through which pressure, heat and current is applied to weld at a particular spot. The heat is used to melt the metal and applied pressure is used to fuse the two metal sheets to form a weld. **Fig.2** shows the working of Spot welding. Copper, because of its high thermal conductivity and low electrical resistance is preferred for electrodes. The sheets to be joined are placed between the two electrodes. The name “spot” indicates the tiny dot size weld, which is of approximately electrodes tip size. The weld formed is also called a “nugget”. Electric power supply produces electric current which is applied to the metals by copper electrodes. Heat energy is produced due to the metal's internal resistance to the electric current. The heat melts the metals and applied pressure forces the two metals to squeeze and fuse. After cooling the fused metal, the metal hardens and a spot weld is formed.

Spot welding is effective for welding multiple metal sheets at same time. It is a cost effective technique as it doesn't need any filler material or gas.

Spot welding is best for the metals with low thermal conductivity and high electrical resistivity, such as steel, as it has low carbon content. The metals with high carbon content are more prone to poor welds or cracks in weld due to the hard microstructure it forms.

Spot welding is generally used for welding thin metal sheets. It is mainly used in manufacturing automobile body parts. It is also used in industries like aerospace, rail, electronics, battery, etc.

Though spot welding proves its importance in every sector of daily life, it continues to have some drawbacks as well.

1. HIGH INITIAL COST

Though spot welding is cost friendly, it is expensive to get started. All the equipment required to set up the spot weld is high in cost.

2. NOT SUITABLE FOR THICK METAL SHEETS

It is mainly suitable for thin metal sheets.

4. CRITICAL PARAMETERS

There are certain parameters which are critical to create a satisfactory quality weld.

A. Pressure

Applying an appropriate amount of pressure to the electrode is an important aspect of spot welding. Less pressure would lead to weak weld/joint whereas more pressure may develop cracks in weld. Pressure is important as it produces mechanical force needed to hold the metal sheets together. Penetration depth of electrode must not exceed 25% of metal’s thickness.

B. Welding time cycle

Spot welds can be improved by adjusting the time metals are exposed to the pressure and current.

- Squeeze time: It refers to the amount of time electrodes exerts pressure on metal sheets to join them.
- Weld time: It refers to the amount of time electric current circulates between the two electrodes. In this duration, heat is

produced due to flow of current and metals are fused.

- Hold time: It is also referred to as cooling time. It is the amount of time when molten metal cools down and solidifies.
- Off time: It is the duration when electrodes are at rest i.e. they are off work.
- UpSlope: It refers to the time when currents reach its peak value.
- DownSlope: It refers to the time when current decreases from its peak value.

C. *Current*

Welding current determines the amount of heat produced at electrodes. Weld current and weld time are inversely proportional to each other. If weld current is less, weld time must be increased and vice-versa to maintain appropriate amounts of heat.

D. *Electrode Tip Diameter*

Tip diameter is important. It determines the size of the weld

5. WORKING PRINCIPLE

Resistance spot welding works on the principle of *Joule's Law of Heating*. According to Joule's law of heating,

$$\text{Heat} = V*I*\text{time} \quad (1)$$

And according to Ohm's Law,

$$V = I*R \quad (2)$$

Therefore,

$$\text{Heat} = I^2 * R * \text{time} \quad (3)$$

It states that the heat energy required for welding is proportional to the current flowing between two electrodes and resistance between two electrodes. The resistance here includes both resistances of electrodes as well as resistance of the metal pieces. [15] – [17].

6. SYSTEM OVERVIEW

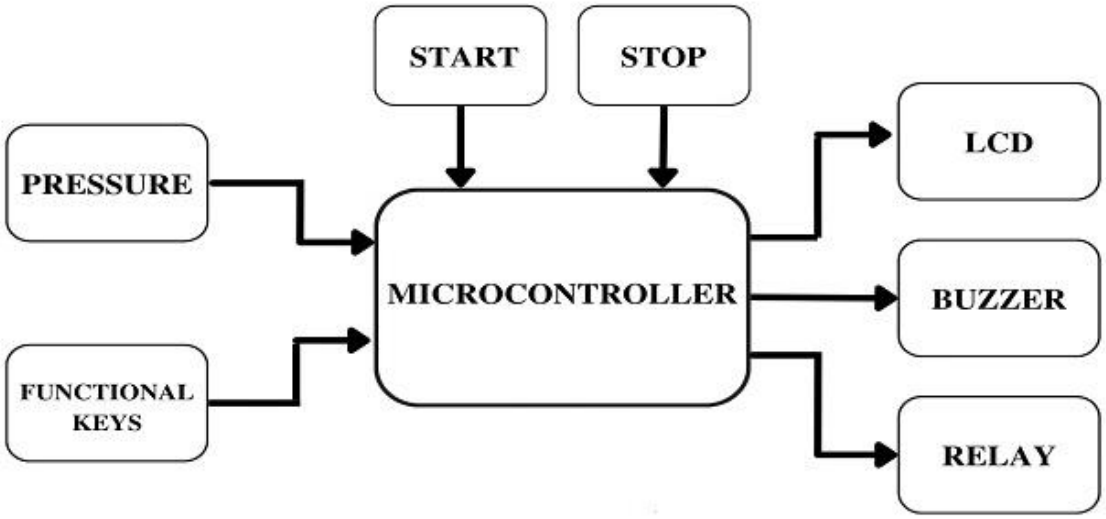

Fig 3. System Overview

Fig.3 shows the System overview. The system mainly consists of a microcontroller, Pressure inputs, Functional keys, LCD, Buzzer, Relay switch. Microcontroller is used to control physical parameters such as pressure, for controlling the welding.

The microcontroller is provided with analog inputs pressure and time. These parameters are controlled by microcontroller and decide when the electrodes are supposed to start and stop the welding. Depending on the function of the microcontroller, Buzzer gives the alert. Applied analog pressure and various other parameters are displayed on the LCD. Maximum count value input is given to the microcontroller depicting the number of strokes electrodes must perform. Relay switch is used to protect the system from the overflow of current or voltage.

When the system turns ON, the initial weld count is set to zero, and with each occurring weld stroke, weld count is incremented. If weld count equals the maximum value, given as input to the microcontroller, the machine is turned OFF. This reduces the human efforts required to produce the efficient welds.

7. MICROCONTROLLER FRONT PANEL

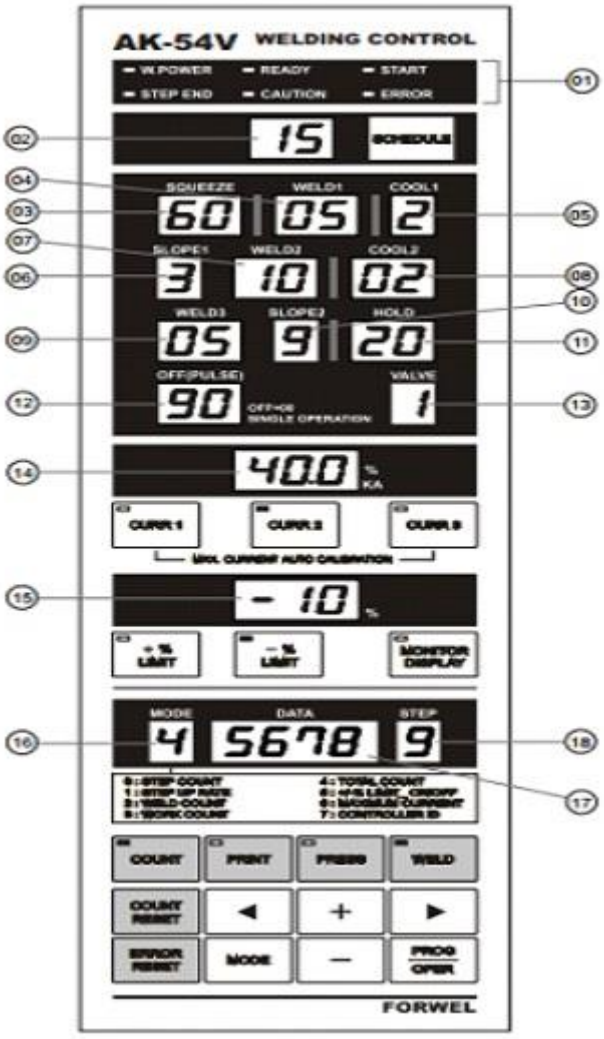

Fig 4. Front Panel [18]

The Fig. 4 shows the design of the front panel of the microcontroller to be used in a spot welding machine.The various sections of microcontroller are explained as below:-

01 - Section shows indication of different status. It has LED's showing start, end, and step status.
02 - SCHEDULE indication
03 - SQUEEZE indication
04, 07, 09 - WELD indication
05, 08 - COOL indication
06 - UP SLOPE indication
(It indicates the time needed to each peak current value)
10 - DOWN SLOPE indication
(It indicates the amount of time needed to decrease the amount of current from peak value)
11 - HOLD indication
12 - OFF indication
13 - VALVE indication
14 - Indication and monitor of current
15-±% indication and monitor of current
16 - MODE no. indication
17 - MODE and STEP Data indication
18 - STEP No indication

8. CONCLUSION

The microcontroller can be used to make spot welding easier in industries. The design of the microcontroller is simple. It reduces the human effort and makes welding more convenient.
The project can be extended in future by involving sensors in place of push up buttons.

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