Design and Manufacture of a Control Unit for Monitoring Welding Parameters in Resistance Spot Welding

Fouad, Y.*, El Batanouny, M.M**

Abstract—Resistance spot welding machines do not always offer the advantage of monitoring the welding parameters during welding. In other words, the complete number or cycles or welding time as well as the welding currents can not be monitored and recorded in every single spot weld. This work presents a simple, inexpensive designed and manufactured separate control unit that can be attached to any resistance spot welding machine; with the required alterations in the software, to monitor, measure, record and display on a PC screen the welding time and welding current. The recoded time is expressed in both seconds and cycles. This control unit is of great importance as there had always been no data recorded from the resistance spot welding machine existed here in the GUC welding workshop. This resistance spot welding machine is quiet small in size and used in educational purposes only, So, with the aid of this control unit, data could be obtained stored for better use of the machine. This could also benefit in case of producing specific procedure for every welding situations.

Experiments on different types of base material sheets have been conducted once by using a stop watch and another by using the control unit. Results have been compared in the two situations for further analysis.

Index Term—(resistance spot welding control unit, control units application in resistance spot welding).

1. INTRODUCTION

Resistance welding is one of the oldest welding processes in use by industry today. The weld nugget is made by a combination of heat, pressure, and time. As the name implies, it is the resistance of the welded material to current flow that results in a localized heating in the part. Many variables are involved in controlling the quality of resistance welding sheets. These variables namely are; the times of welding, the number of welding cycles, the passing current, the time of cooling and the cooling temperature. Unfortunately, in Egypt, most workshops using resistance welding machines are working blindly in the dark or at least when some parameters are involved. This means that there are no internal means of recording the electrical parameters or welding time in the machine. Thus, an external clamp meter should be used along with a stopwatch to record the time or a good alternative is to attach a control unit to the resistance welding machine which is the work carried out in this study. In this study, a control unit was designed and manufactured specifically to function on the resistance welding machine found in the GUC workshop.

Two series of experiments has been implemented with and without the use of the control unit and further testing took place on the spot welded joints. Results of the study emphasized on how important it is to have a simple yet effective control unit to measure and record instantaneously the welding current, time, and number of cycles during spot welding.

2. CONTROLLED VARIABLES IN SPOT WELDING:

Intuitively, welding voltage and current should be monitored, as they are directly related to joule heating, or the formation of a weld nugget. In addition, the thermal process during welding is reflected in the expansion or shrinkage of the sheet metal stack-up, or it can be monitored through the changes in electrode force and electrode displacement.

Electric Voltage: The tip voltage can be measured with two wire leads attached to the electrode tips. As the voltage is kept at a fairly low level at the electrode tips, its value can be directly measured using standard equipment. However, the voltage signal may be corrupted by the noise induced by an alternating current. Induced voltage becomes a strong noise on electrode tip voltage signals because its measurement has a (unavoidable) wire loop in the magnetic field. It is well known that to minimize the inductive noise, one can use twist pairs to reduce the area of the wire loop. However, the wire loop can never be fully eliminated. For production applications, the two wire leads have to follow the arms and encompass the entire throat of a welding machine. To suppress the induced noise on the tip voltage measurement, a compensating loop can be added. However, adjusting the compensating coefficient is machine dependent and can be time-consuming.

Electric Current: The electric current signal is more difficult to deal with than voltage, as the current value is very high in a secondary loop and the measurement is done indirectly. It is usually measured using either a sensor based on the Hall effect or a toroid sensor. Toroid sensors are fairly popular for electric current measurement. As they are based on the induced voltage by a welding current, it is difficult to separate

* Lecturer at Material Science Department, Faculty of Engineering and Material Science, German University in Cairo “GUC”.
** Certified Welding Inspector from the AWS “American Welding Society” and a lecturer at Engineering Design and Production Technology Department, Faculty of Engineering and Material Sciences, German University in Cairo “GUC”.

104301-7878 IJET-IJENS © February 2010 IJENS
the measurement from the process noise, which is also the result of induction.

There are two other methods to measure a current using either a Hall Effect sensor or a resistive shunt. Hall Effect sensors measure the voltage across a semiconductor due to the surrounding magnetic fields. They are small, and thus are more sensitive to temperature change. They are also sensitive to variations in orientation and position. The resistive shunt method directly measures the voltage across a known resistor in the current path. It is a standard means of measuring low amperage or DC currents. However, for RSW applications, electrodes have to be modified to use resistive shunt for measuring electric current.

**Dynamic Resistance**: Resistance of a resistor is usually calculated from the ratio of voltage to current. However, the voltage measured during a resistance welding contains two parts. Therefore, the dynamic resistance curve can be obtained with piecewise polynomial curve fitting through the points obtained at the current peaks.

**Electrode Displacement**: The electrode displacement generally refers to the relative motion of electrode tips, which directly reflects the thermal process involved in a weld. To avoid the influence of other deformable components of a welder, the displacement sensor should be mounted as close as possible to the electrodes. Commonly used displacement sensors for RSW process monitoring are LVDT sensors and fiber-optic sensors.

**Electrode Force**: The signal of electrode force is directly related to the interaction between the electrodes and the work pieces, and it reflects the change in the force imposed by the weld onto the electrodes. Therefore, electrode force yields useful information on the welding process. There are two types of sensors commonly used for electrode force measurement the strain gauge-based sensors and piezoelectric sensors.

3. Experimental Setup

3.1 Spot Welding Machine

The resistance spot welding machine, shown in fig. (1) is found at the GUC workshop. This machine can only achieve the spot welding process with a tiny adjustment to the current value on the machine. This adjustment is a function of the sheet type, mechanical properties and thickness. No other parameters can be measured on this machine.

The specifications of the resistance spot welding machine are as follows:

- **Frequency**: 50 HZ.
- **Power**: 20 kilowatts
- **Current**: Up to 300 Amps.
- **Transmitted voltage through electrodes**: 1-5 volts
- **Model number**: 116
- **Manufacturer**: Jaba electric company

3.2 Control Unit

The control unit shown in fig (2) depicts the whole internal circuit components used in conjunction with the resistance spot welding machine to measure the welding cycled and welding current. This control unit is designed to study the spot welding by monitoring the time and the current output during the spot welding process. The circuit board consists of different electrical segments. Each part’s function is well explained in this section. Fig (3) shows a schematic drawing of these electrical parts. The numbered parts on the figures are:

Support to the lead functions

![Fig. 1. Resistance Spot welding Machine](image-url)
1. Leads
2. Communication circuit
3. Shunt resistor
4. Micro processor
5. Crystal
6. Reset circuit
7. AC to DC rectifier
8. Capacitors
9. Regulator

Detailed Description To The Circuit Parts:

- **LED**: the lead is used to determine the phase sequence.
- **Shunt resistor**: A resistor restricts the flow of current, for example to limit the current passing through an LED. A resistor is used with a capacitor in a timing circuit.
- **Micro processor**: it is the unit which transforms the binary data in the cables to data which we can read by using a program on a computer or on a display screen
- **Capacitors**: A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals. The small capacitors above the regulator are used to remove the noise from the DC waves.
- **Regulator**: the regulator is used to keep constant voltage output on the controller which is less than 5 volts for the controller may be destroyed if higher voltage is used
- **Rectifier**: it is the power and the protection of the circuit board
- **Crystal**: it is a timing crystal
- **Communication circuit**: this is where the output is taken through the cables to the display screen or computer.
- **Zener diodes** are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non-destructive way so that they can be used in reverse to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current. Zener diodes can be...
distinguished from ordinary diodes by their code and breakdown voltage which are printed on them. The sequence of how the control unit functions is as follows:

1. The input cables are put into the shunt resistor which turns the current into voltage.
2. The voltage is moved through the regulator to be sure its not more than 5 volts.
3. The micro processor receives the signal and interprets it to the communication circuit through a COM3 port from the case of the circuit and to the computer through a data cable and the data is read by Microsoft Windows Hyper Terminal program.

### 3.3 Base Materials

Different types of sheets have been tested. The base materials included low carbon steels referred to LCS, galvanized Steel referred to GS, and Stainless steels referred to as SS. The sheet thicknesses varied from 0.8 up to 1.6mm thick. The spot welded samples base martial numbers, types, and sheets dimension are all shown in table (I)

Table (I) shows also the recorded parameters from the control unit namely; the time in seconds and cycles and the welding current which is almost constant.

### 4. Conclusion

In this study, parameters controlling or describing the resistance spot welding were accurately studied. Due to the fact that some of the spot welding machines do not display the welding time or current, an electronic control unit was designed to overcome this difficulty and the results are as follows:

- The use of electronic control units managed successfully to; measure the welding time in seconds and number of cycles during the welding process.
- The control unit is also capable of measuring the current and displaying it during welding on a digital screen.
- Readings are displayed on the computer without using complicated software. Instead through the hyper terminal screen found in the Microsoft Windows Accessories.
- Records can be saved on the computer for later analyses, comparison or calibration purposes.
- The use of the control unit needs no efforts at all. Once the control unit is fixed on the machine; the technician had only to press the electrodes to spot weld the sheets and all records are there on the computer.

Finally, a recommendation in this study is to use the control unit in more experiments and validate its results with other recording techniques.

### Reference

[5] http://www.osti.gov/bridge/purl.cover.jsp;jsessionid=52D38FCC0F5200FC00DF7FD289BD2753;purle=6223;OwvevKE/webviewable/

<table>
<thead>
<tr>
<th>Number of sample</th>
<th>Time of welding/sec</th>
<th>Number of cycles</th>
<th>Current</th>
<th>Sheet (1)</th>
<th>Sheet (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.61</td>
<td>80</td>
<td>190</td>
<td>LCS</td>
<td>LCS</td>
</tr>
<tr>
<td>2</td>
<td>1.96</td>
<td>98</td>
<td>192</td>
<td>LCS</td>
<td>LCS</td>
</tr>
<tr>
<td>3</td>
<td>1.48</td>
<td>74</td>
<td>195</td>
<td>LCS</td>
<td>GS</td>
</tr>
<tr>
<td>4</td>
<td>2.04</td>
<td>102</td>
<td>190</td>
<td>LCS</td>
<td>GS</td>
</tr>
<tr>
<td>5</td>
<td>1.69</td>
<td>84</td>
<td>191</td>
<td>LCS</td>
<td>GS</td>
</tr>
<tr>
<td>6</td>
<td>2.11</td>
<td>105</td>
<td>190</td>
<td>LCS</td>
<td>SS</td>
</tr>
<tr>
<td>7</td>
<td>1.07</td>
<td>53</td>
<td>195</td>
<td>LCS</td>
<td>SS</td>
</tr>
<tr>
<td>8</td>
<td>1.53</td>
<td>76</td>
<td>198</td>
<td>GS</td>
<td>GS</td>
</tr>
<tr>
<td>9</td>
<td>1.54</td>
<td>77</td>
<td>190</td>
<td>GS</td>
<td>GS</td>
</tr>
<tr>
<td>10</td>
<td>2.01</td>
<td>100</td>
<td>190</td>
<td>GS</td>
<td>SS</td>
</tr>
<tr>
<td>11</td>
<td>1.63</td>
<td>81</td>
<td>192</td>
<td>GS</td>
<td>SS</td>
</tr>
<tr>
<td>12</td>
<td>1.94</td>
<td>97</td>
<td>198</td>
<td>SS</td>
<td>SS</td>
</tr>
</tbody>
</table>