Resistance spot welding - at maximum speed

Resistance spot welding is a fast and reliable joining method. The article examines one way of achieving the optimum conditions necessary for the best welds.

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Resistance spot welding is normally a fast and reliable method of joining sheet metals. Despite the speed, a well defined sequence of events has to occur during the welding process in order for acceptable results to be achieved. This welding sequence can be adjusted to maximise the throughput. Danger lies in trying to shorten the cycle too much which leads to a host of welding defects. On the other hand, overcautiousness results in longer welding times and reduced productivity. How can the best and fastest welding conditions be established? The clues are to be found by having a closer look at the events which take place during a single welding cycle.

The three steps to make a resistance weld

Every resistance weld has three stages - the Squeeze Time, the Weld Time, and the Hold time as shown in fig. 1. These three steps occur seamlessly in the fraction of a second it takes to make each weld. Each stage takes up a proportion of the total welding time.

1. Squeeze Time The welding electrodes are brought together and a forging force is applied which squeezes the sheets of metal together. The forge force takes a short time to reach the correct value and a particular force has to be established before the second stage can commence.

2. Weld Time Once the correct welding force is applied, the welding current is passed between the electrodes for a defined period of time. This is usually expressed as a number of cycles of the welding current. The electric current heats and melts a spot between the sheet metal layers causing them to weld together.

3. Hold Time After the electric current is turned off, the electrodes remain clamped across the spot weld whilst it resolidifies. Only then can the electrodes be withdrawn.

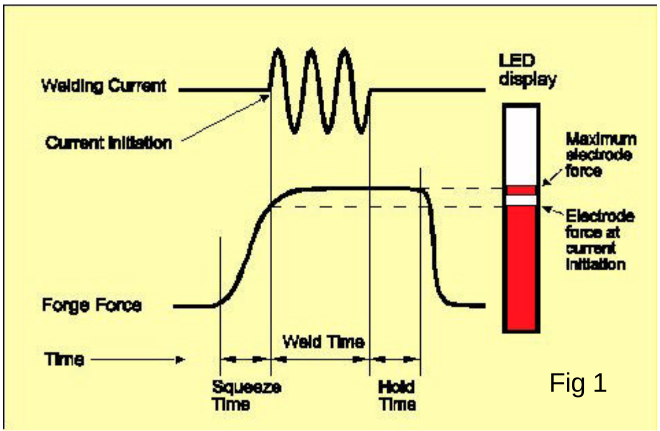


Fig 1

However, setting the welding parameters may not be as simple as it seems.

Welding control systems enable operators to set the key parameters for resistance welds. These should define the sequence of events that take place during each spot weld, but this may not be the case in practice. Control systems for the timing and value of the welding current usually ensure that the prescribed values are achieved. However, there is not such a degree of control over the timing and value of the forge force. Differences in the action of pneumatic cylinders can lead to significant variations from gun to gun on both the forge force achieved and the speed which the forge force is applied in the Squeeze time.

Defects in Resistance welds
due to incorrect timing...... of the Squeeze Time

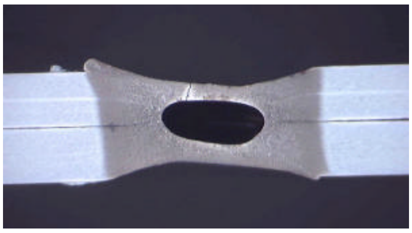
If not enough time has been allowed for the welding electrodes to come together, the correct force may not have been achieved before the electric current starts. The sheet metals will start to heat up and melt whilst the force between the electrodes is still increasing.

In this case, the metal sheets are not properly squeezed together by the welding electrodes before the welding current starts. As a result, the electrical resistance will be greater than it should be. This causes the metals to be heated up to a higher temperature so that their outer surfaces can melt. A second consequence is that since the welding current came on too soon, the force between the electrodes continues to increase causing molten metal to be forced away from the weld resulting in severe surface splashing. The excessive temperature rise of the sheets can result in burnt surface conditions and the electrodes can stick to the hot surfaces which causes electrode pick up, copper deposits in the weld area and excessive electrode wear.

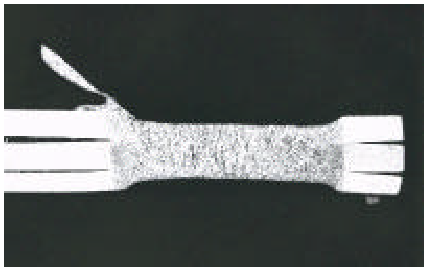
Meanwhile, in the space between the sheets where the spot weld should be formed, the prematurely melted material can be expelled between the faying surfaces, and the subsequent weld nugget can contain voids and porosities.

Surface splash and surface cracking in coated steel

Excessive heat and surface splash leading to gross porosity



Severe surface splashing



... of the Weld Time

The welding current supplies the energy to produce the spot weld between the two sheet metals. If too little energy is supplied, the welded volume will be smaller than required with the possibility of subsequent failure. If too much energy is provided then the material will overheat and molten metal may form leading to many of the potential defects highlighted above.

The energy supplied to a weld is controlled by adjusting the welding current and the time for which it flows. These two parameters must be determined during welding trials and then entered into the control system for the welding equipment.

... of the Forge Time

The electrodes have to remain clamped together long enough for the weld bead to solidify after the current has ceased flowing. If this time is too short, then the weld bead between the sheets may still be molten so that the sheets spring apart. The result is a weak or failed weld.

If the forge time is too long to ensure that weld beads have solidified, this unnecessarily slows down the production rate.

Defects in resistance welding - due to incorrect forge force

The forge force which is produced between the welding electrodes should achieve the required value just as the welding current starts. It is useful to call the force which applies just when the welding current starts, the Squeeze Force. The Squeeze force should be high enough to produce good electrical contact with the welding electrodes. In practice, it has been found that the Squeeze force can be slightly less than the peak force to achieve reliable welds. If the welding controller is adjusted to achieve this condition, then this goes a long way to achieve the optimum speed for the weld.

We then call the maximum force which occurs whilst the welding current is operating, the Peak Force. See fig. 1. If the Peak Force is too low, the electrical resistance between the metal sheets will be high and the heating effect of the current will be greater leading to the possible defects described above. If the Peak Force is too high then the sheet metal surfaces may be indented and the change in section could produce cracks or tears which will result in future defects.

Maximising the weld speed - Minimising the defects

Measure the force between the electrodes on the gun using the Squeeze Analyser. This will display two values of the force - the Squeeze Force and the Peak force.

Adjust the Peak Force to the correct value

If the two values (Squeeze Force & Peak Force) shown on the Squeeze Analyser are the same then the Squeeze Time is too long. In this case decrease the Squeeze Time until the Squeeze Force is just lower than the Peak Force. This is shown on the Squeeze Analyser analogue display as two adjacent illuminated LEDs. The Squeeze Time has now been reduced to the minimum acceptable value. The welding Speed is maximised.

In this way, not only does the Squeeze Analyser allow users to set the correct electrode force, by indicating both the Squeeze Force and the Peak force during the welding cycle, it also enables the correct Squeeze time to be set.

By correctly setting the Squeeze Time, it is possible to maximise the production rate without introducing potential defects. For example, if the Squeeze Time can be reduced by twenty milliseconds per weld (1/50 of a second per weld) and the welding gun makes 60,000 welds per day, then a total time saving of 20 minutes per day is achieved. The productivity of the welding sequence has been improved, and the reliability of the welds has also been assured.

Diverse Technologies, Cambridge UK supply the Squeeze Analyser
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