RESISTANCE WELDING CONTROL SYSTEM

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In order to increase the accuracy of forming the welding pulses for resistance welding, it is suggested to use the dilatometric effect (the phenomenon of expansion of welded parts under heating) by measuring the shifts of welding electrodes caused by this effect using modern MEMS sensors. The topology and the operation principles of resistance welding control system implementing this approach are developed. It is expected, that applying this solutions would improve the quality of the welded joints.

Keywords: control system, pulse forming, resistance welding, welding quality, dilatometric effect.

Resistance welding is a well-developed technology that is widely used today to create permanent joints. It is particularly worth to mention the micro resistance welding applied in precise industries, such as instrument making, electronics, medicine, etc. [1, 2]. To achieve high quality joints in resistance welding, particularly in micro resistance welding, special profiles of welding pulses should be formed. As shown in [3, 4], the highest results can be obtained by forming the welding current power. The analysis of electrophysical processes given in [4] made it possible to state that the optimal power profile is the following one (Fig. 1): on the initial stage the power should rise as a power function (with the exponent n depending on specific welding conditions), after that it should be kept constant during some time, and on the final stage it should be reduced to zero.

It must be emphasized that it is very important to move from one interval of pulse formation to another in the proper moments, since specifying the transition moments incorrectly can cause critical welding defects. Thus, delaying the rise interval while keeping the same total welding time is dangerous by lack of penetration, the too short rise interval can lead to molten metal splashes, the excessive prolongation of the interval of flat top can entail the burnout of the welded parts.

In [4], the transition from welding pulse rise to its flat top (the point **1** in Fig. 1) is suggested to be done after the voltage on welding electrodes reaches the reference value corresponding the phase between melting and boiling of metal of the welded parts, and the transition from the top to the fall (the point **2** in Fig. 1) — when the energy amount in the welding contact reaches the necessary value for welding core formation. The latter is calculated beforehand and is tracked during the welding process as an integral of welding pulse power over time. However, it is not very accurate to do the transition **2** according to the calculated energy value, which is rather approximate because of complexity of considering all the influence factors (including the surface state of the welded parts, the electrode squeezing force etc.). It seems to be more correct to move from the pulse top to its fall according to the actual value of the electrode shift caused by heated parts expansion, so called dilatometric effect, which confirms that the welding core reaches the necessary parameters.

It is known from [5] about the earlier attempts of using this approach, but the represented level of its technical implementation can not be recognized as allowable for providing the accurate formation of welding pulse according to electrophysical processes in welding contact. This is especially true for micro-welding.

The analysis of technical parameters of modern microelectromechanical MEMS-sensors given in [6] confirmed the possibility of using them for measuring the small shifts of the welding electrodes. The aim of this work is to increase the accuracy of forming the welding pulses in resistance welding through the highly precise measurements of electrode shifts caused by dilatometric effect using high-sensitivity MEMS sensors.

A topology of the circuit implementing the approach described above is represented in Fig. 2. The circuit includes the transistor Welding Pulse Generator providing the welding pulses in the load (the contact of welded parts), Welding Power Control block controlling the power curve formation, Electrode Shift Measurement block controlling the values of the electrode shifts caused by dilatometric effect, the sensor of welding current, the sensor of the voltage on the electrodes, the MEMS-sensor rigidly fixed on the moving electrode for measuring its shifts, and the multiplication block (×) multiplying the signals of the welding current i_{weld} and of the voltage on the electrodes u_{weld} to provide the signal of the welding pulse power p_{weld}. The circuit operates in the following way. At first, Welding Power Control block outputs the control signal specifying the rise interval of power pulse profile for Welding Pulse Generator. The control signal is corrected during the welding process according to feedback power signal p_{weld}. Welding Pulse Generator forms the welding pulse rise until Voltage Sensor detects the voltage value corresponding the phase between melting and boiling of metal of the welded parts (point **1** in Fig. 1). After that, the generator forms the flat top $P_{weld\,max}$ of the welding pulse until the MEMS-sensor detects the given value of the electrode shift (point **2** in Fig. 1). Further, depending on specific welding conditions, the welding process terminates or the power pulse fall starts forming.

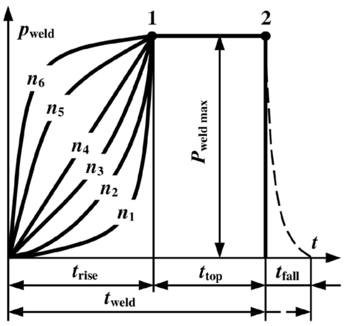

Fig. 1

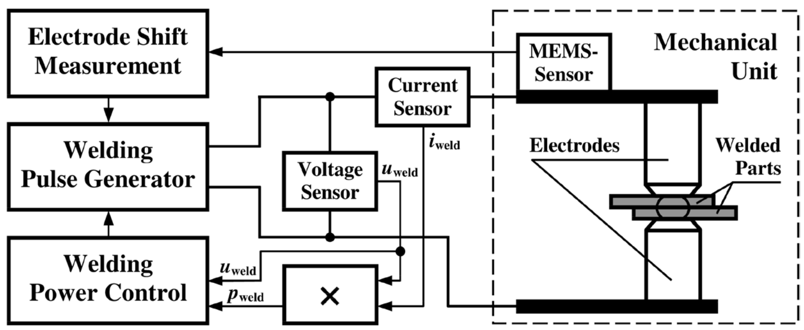

Fig. 2

The suggested approach to the welding control maximally takes into account the particularities of electrophysical processes in the welding contact. The developed circuit, due to use of modern element base, is able to implement this approach with the high accuracy. Therefore, the application of the presented solutions in practice makes it possible to expect the increase in the accuracy of forming the welding pulses and to improve the quality of the welded joints.

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Система керування процесом контактного зварювання

З метою підвищення точності формування зварювальних імпульсів при контактному зварюванні запропоновано використовувати дилатометричний ефект — явище розширення зварювальних деталей при нагріванні — шляхом вимірювання переміщень зварювальних електродів, обумовлених цим ефектом, з використанням сучасних MEMS-давачів. Розроблено топологію та принципи функціонування системи керування процесом контактного зварювання, що реалізують цей підхід. Очікуваним результатом застосування запропонованих рішень є поліпшення якості отримуваних зварних з'єднань.

Ключові слова: система керування, формування імпульсу, контактне зварювання, якість зварювання, дилатометричний ефект.