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Technical Paper

Online monitoring and evaluation of the weld quality of resistance spot welded titanium alloy

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ABSTRACT

Resistance spot welding is an important branch of the welding subject, and has been widely used in aviation, aerospace, automotive and other industrial areas due to its high efficiency, low cost and small deformation. As the improvement of the product quality, online monitoring of welding quality has become an urgent issue. This paper puts forward an information acquisition and evaluation method based on the online monitoring of the weld quality of spot welded titanium alloys. Through the real-time acquisition and analysis of the welding parameters, the characteristic information of the acquired signal was extracted to achieve the reliable quality assessment of the welding process.

1. Introduction

Resistance spot welding is an important welding technique that has been extensively used in industries due to its high production efficiency and easy realization of automation [1]. The main quality assessment methods of the welding spots are the destructive chisel test and peel test, however, they are time consuming [2,3]. Thus, a development of an online monitoring and evaluation system is urgent. Quality monitoring and evaluation of resistance spot welding has become more and more important and the non-destructive test methods based on the dynamic signals during the welding process have been developed recently [4–6]. The most widely used materials for online quality monitoring of the welding spot are mild steel and aluminum alloy. In 1980, Dickinson established the collection system of dynamic resistance in spot welded mild steel, and pointed out that the dynamic resistance and formation of the nugget are closely related to each other. The dynamic resistance curves are closely related to material type, welding current and electrode pressure [7]. Burmeister used an existing expert system to online assess the weld quality of mild steel based on a fuzzy classification theory and he found a nonlinear relationship between the electrical parameters, the mechanical parameters of the workpiece and quality of the welding spot. Ji et al. [8] studied the electrode displacement in spot welded aluminum alloy, and quality control of spot welding was based on the electrode displacement method. Firstly, ensure that the rise rate of the electrode displacement is equal to the target rate by changing the welding current; then the welding current is unchanged until the electrode displacement reaches the defined value. Hao et al. [9] has done an in-depth research on the quality monitoring of spot welded aluminum alloy. In the monitoring system, they collected the five parameters consisting of welding current, voltage, dynamic resistance, electrode pressure and electrode displacement, and data were then analyzed using statistical methods.

Materials for spot welding monitoring are mild steels and aluminum alloys, however, monitoring of spot welded titanium alloy accounts for a small amount. Titanium and its alloys have been identified as one of the best engineering metals for application in industrial fields [14], such as aviation, medical industry and chemical engineering due to their small density and high strength [15]. This paper aims to investigate the online monitoring and the quality assessment of the spot welding process. A new quality evaluation method of spot welding was proposed. Through the extraction of characteristic parameters of each welding spot, the quality assessment was carried out timely, effectively and accurately. The information management database of the welding spot

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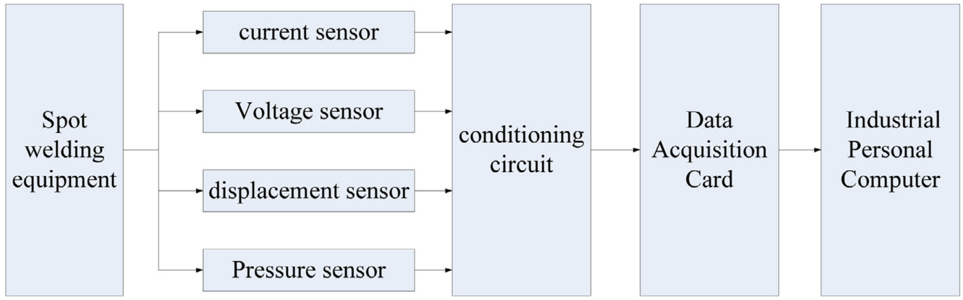

Fig. 1. Flowchart for the online monitoring system.

was established based on LabVIEW, which incorporates the welding characteristic parameters and quality evaluation results into the database.

2. Experimental procedures

2.1. The design of the online monitoring system

Conventional resistance welding process control was based on monitoring the voltage and current, or power and resistance [10,11]. A variety of dynamic signals were measured and different kinds of signal processing technologies were proposed to monitor or control the quality of welding and joining [12,13]. The monitoring system monitors the welding current, welding voltage, electrode pressure and electrode displacement. The outside of the online monitoring system is connected with four sensors for real-time monitoring and collecting signals from the current, voltage, pressure and electrode displacement, then the multiple signals enter into the data acquisition card, finally the collected data was saved to the hard disk and the collected waveforms will be then displayed on the computer screen. Fig. 1 shows the flowchart for the online monitoring system.

It is very important to select the sensors for monitoring the welding process. There is a high requirement of precision and response speed for the pressure sensor and displacement sensor. The pressure sensor of this system is a piezoelectric sensor which is attached to the welding machine. Piezoelectric sensors have the advantages of high sensitivity, high signal-to-noise ratio, simple structure and reliable operation. The sensor was put inside the cylinder to measure the size of the cylinder force. Type of the pressure sensor is German Matuschek SPATZMultimate04. Displacement sensor of this system is a laser displacement sensor which uses the non-contact measurement of displacement, and it has very high measurement accuracy, the displacement sensor measures the downward displacement of the electrode arm. The laser sensor detects the dynamic displacement of the electrodes. The laser sensor is fixed in front of the cylinder and the reflection plate is fixed to the movable block which is connected to the electrode. During welding, the decrease of the movable block was driven by the cylinder, which controls the downward movement of the reflection plate and the upper electrode. Fig. 2 is a schematic diagram of the displacement sensor, Fig. 3 is a photograph of spot welding machine, and Fig. 4 is a photograph of the monitoring system.

Monitoring system collected signals from the four sensors. The evaluation results are saved to the database and the waveform files. Its main interface is shown in Fig. 5 where collection interface will open when the "collection" button was clicked, click "Open" to view historical data, click on the "pads" in the main interface to view the stored information in the database. Because the main defects of resistance spot welding process is divided into incomplete fusion and splash defects, thus the monitoring system investigates the two

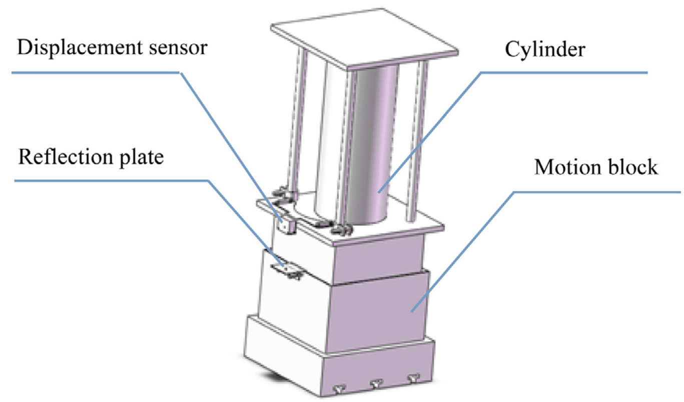

Fig. 2. Schematic diagram of the displacement sensor.

Fig. 3. Spot welding machine.