Inline-Process and Quality Control of Spotwelds of Car Bodies - Ultrasonic Sensors Integrated in Resistance Welding Electrodes

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Abstract. The self-developed inline ultrasonic testing system SPOTline is used for inspection and process control of resistant spot weldings. SPOTline provides a 100% inspection during the welding process. The through transmission and pulse echo signals will be collected, stored and evaluated by means of fuzzy-logic and neuronal network technic. The results will be transmitted online from the spotline-client in the sql-data-base of the server for processing. World-wide SPOTline is the only ultrasonic inspection system, which is working under real production conditions in a network of welding robots. Test with 2 and 3 plates, high strength steels and all coatings demonstrate the accurately identification of discrepant welds.

Spotline –
Inline Process control of Resistance Spot welding of car body frames

The self-developed inline ultrasonic testing system SPOTline is used for inspection and process control of resistant spot weldings. SPOTline provides a 100% inspection during the welding process by ultrasonic sensors which are integrated directly into the welding tong. SPOTline provides with directly into the welding. During the welding process ultrasonic pulses are conducted with 500 Hz from the SPOTLINE - client through the weld nugget. The through-transmission and reflection signals are recorded, stored and evaluated. Immediately after completion of the spot weld a result value is available which correlates to the quality (diameter) of the spot weld. This value is assigned according to quality characteristics by two limit values into three classes: good spot, average spot or discrepant spot. Therefore the inspection result is not a diameter value but one of the classes mentioned correlated to the quality of the spot weld. In production stick welds, discrepant and small nuggets are recognized during welding.

The basic testing system consists of four components (figure 1):
SPOTLINE client, SPOTLINE communication unit, ultrasonic sensors and optional SPOTLINE information terminal.
The ultrasonic sensors produce the required ultrasonic pulses for testing which run through the weld during the welding procedure. Therefore ultrasonic transducers are positioned at both sides of the welding tongs. The accurate classification of spot welds depends on reliable basic measurements which only can be obtained by optimal positioning of the sensors in the tongs. Due to the big variety of tongs and electrode shaft forms, different sensor types, and resulting from this, different sensor positions have been developed. The sensors are producing a longitudinal wave, which usually is located on the tip base and transmits directly and vertically through the electrode tip into the spot weld which is to be tested.

Figure 2: Internal standard sensor
The ultrasonic sensor housing consists of two parts, the upper and lower part. The actual ultrasonic sensor is located in the bottom of the housing, which is coupled up to the tip ground by means of a coupling pad. In order to catch up the displacement of the electrode tip at the clamping cone, the whole sensor housing is spring-suspended. The upper part of the sensor housing serves for the guidance of the cooling water up to the tip ground. Both parts of the housing are linked to each other by a screw connection. The cooling-water pipe is interconnected into the upper part of the housing in which a compression spring is situated. By means of the spring the ultrasonic sensor will be pressed to the tip ground with a certain minimum force. The sensor cable outgoing from the lower part of the sensor can be led on arbitrary. At curved tong arms (guns) this should be laid completely through the cooling pipe in the tong arm. In case electrode holders are used, the cable will be led out at the face side of the holder.

Due to the design of the sensor housing, it is guaranteed that the cooling-water flows to the front of the tip ground around the lower part of the sensor housing. The principle allows a sufficient cooling of the tips and of the ultrasonic sensors. Only rotation symmetric electrode tips with face flatness inner tip ground are to be used. Excenter tips prevent a sufficient through-transmission, which is influencing the test result negatively. Roofing tips with tapering bottom hole drillings are also affecting the through-transmission as well as the coupling because of the not face flatness of the tip ground (figure 4).

In principle X- as well as C-tongs can be equipped. The expenditure for installation resp. the modifications which have to be made are based on the design of the tong arms and the electrode holder and out of this reason have to be considered individually. For closed tongs the entering angle X of both electrode shafts to one another should be within 180° ±12° (figure 5).
The ultrasonic signals of both UT sensors are recorded in order to generate the raw data. The test range (spot weld) is right between the two sensors implemented in the shafts. Data acquisition starts with the end of the squeeze time and continues during the entire welding-time lasting into the hold time. During this period the sensors are operating alternating in through transmission and in pulse/echo mode with a pulse rate of 500 Hz each. (each 2 ms one measurement). The amplitude and time-of-flight data resulting from this are continuously recorded and analysed thereafter.