http://dx.doi.org/10.21611/qirt.2008.08_03_03

Wavelet based feature extraction algorithm for porosity and Lack of Penetration detection for On-line Monitoring in Gas Tungsten Arc Welding by Infrared Thermography in AISI 316 Stainless Steel

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ABSTRACT

Welding is one of the widely used manufacturing methods for joining metals. In spite of the numerous advances in the science and technology of welding, failures do occur and weld is still considered to be the weakest portion. This is because the formation of the weld is affected by a number of process parameters, which make it difficult to ensure the quality of weld. Conventionally, Non Destructive Testing (NDT) techniques are applied after the welding is completed. So a lot of time, material and manpower are wasted before one comes to know about the soundness of the weld. These inherent limitations of the conventional welding processes can be overcome if the weld is continuously monitored in real time for the assessment of defects and their automatic elimination by on-line control of the welding parameters.

Infrared Thermography is the best suited sensor for on-line weld monitoring. It monitors the surface temperature distributions of the plates being welded and produces thermal maps called thermographs. Thermograph is defined as a 2D radiance function g(x, y), where x and y denote spatial coordinates and the value of g at any point is proportional to the heat energy emitted from the specimen. Traditionally, low intensities are represented by dark shades and high intensities by bright shades. The paper aims at developing an image-processing algorithm for automatic identification, quantification and elimination of porosity in Gas Tungsten Arc Welding (GTAW) from the acquired thermograph.

The 3mm thick American Iron and Steel Institute (AISI) type 316 steel plates measuring 125 x 50 mm in size are used. The edges and the surfaces of the plates were prepared using standard preparation techniques to facilitate butt-welding. The experiments were performed without filler material. The Infrared camera mounted at an angle of 45 degrees to the weld plate captures the temperature distribution at the weld pool. The Infrared camera obtains thermographs and a custom built interface transfers these images from the camera to the computer for further analysis. Lack of penetration and Porosity are introduced by varying current and torch speed and applying grease on weld surface. Porosity is a group of small voids that occur mainly due to the entrapped gases. Porosity appears as abrupt low temperature regions within uniform high temperature region (hot spot) in a thermograph. Lack of Penetration can be best described by the size and shape of the hot spot.

On-line weld monitoring requires a parameter independent, image independent standardized image processing algorithm for defect feature extraction. The proposed algorithm develops a wavelet based image processing algorithm that automatically identifies and quantifies porosity and hotspot. The moving picture of the acquired thermographs is converted into frames. On each frame the following operations are performed. Color to gray level conversion is performed to avoid computational complexity. Wavelet decomposition with Haar wavelets is applied on thermographs and the approximation images are considered because of the defect nature. From the approximated images the defects are isolated. The isolated defects are then characterized by mathematical descriptors (major axis length, minor axis length, area) and also by statistical moments.

Keywords:
AISI 316, GTAW, Porosity, Lack of Penetration, Haar wavelets

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