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ScienceDirect

Procedia Computer Science 50 (2015) 316 – 322

Procedia Computer Science

2nd International Symposium on Big Data and Cloud Computing (ISBCC'15)

Use of Machine Learning Algorithms for Weld Quality Monitoring using Acoustic Signature

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Abstract

Welding is one of the major joining processes employed in fabrication industry, especially one that manufactures boiler, pressure vessels, marine structure etc. Control of weld quality is very important for such industries. In this work an attempt is made to correlate arc sound with the weld quality. The welding is done with various combinations of current, voltage, and travel speed to produce good welds as well as weld with defects. The defects considered in this study are lack of fusion and burn through. Raw data points captured from the arc sound were converted into amplitude signals. The welded specimens were inspected and classified into 3 classes such as good weld and weld with lack of fusion and burn through. Statistical features of raw data were extracted using data mining software. Using classification algorithms the defects are classified. Two algorithms namely, J48 and random forest were used and classification efficiencies of the algorithms were reported.

Peer-review under responsibility of scientific committee of 2nd International Symposium on Big Data and Cloud Computing (ISBCC'15)

Keywords: SMAW; Weld Quality, Acoustic Signature; Weld Defects; Burn-Through; Lack of Fusion;

1. Introduction

Physics of arc welding is of highly complex nature, which makes it difficult to develop a mathematical model to correlate the quality factors to the process variables or emissivity characters such as spectroscopic, arc sound etc. It is necessary to study the root cause of weld defects and how the weld parameter's, like current, voltage, speed, arc sound etc. influence the weld defects. Weld defects can be predicted by employing machine learning tools, such as Decision Trees, Artificial Neural Network (ANN), Fuzzy Logic, Support Vector Machines etc.

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Peer-review under responsibility of scientific committee of 2nd International Symposium on Big Data and Cloud Computing (ISBCC'15)
doi:10.1016/j.procs.2015.04.042

Literature review indicates that there exist many computational intelligent techniques for automated weld quality control. A decision support system[1] was used to assess the quality of resistance seam welds of steel strips by statistical analysis. They assessed weld quality by correlating both mechanical and electrical variables involved in the welding process monitored with previously recorded historical data of similar welds. The radiation emitted by the plasma[2, 3, 4, 5] present in the electric arc have been captured using spectroscopy sensors and analyzed to predict the weld quality. Acoustic sensing methods[6, 7] was used to monitor the welding process. Investigations using the arc sound as signature[8] for quality monitoring of GMAW welding process was also reported in the literature. They conducted qualitative and quantitative study of arc sound signals[9] and also uses of arc temperature[10] as signature for weld quality monitoring. The scope of electrical impedance[11, 12] as parameter for weld quality monitoring was also reported in the literature.

In this work an attempt is made to correlate arc sound with the weld quality. An experimental setup was established and experiments were conducted using Shielded Metal Arc Welding (SMAW) of Carbon Steel plates. The welding is done with various combinations of current, voltage, and travel speed to produce good welds as well as weld with defects.

2. Experiment Setup and Methodology

Welding trials were carried out to characterize the nature of various defects such as burn through and lack of fusion. An experimental set up has been established to carry out SMA Welding of CS plates and to capture arc sound during welding. Schematic of the experimental set up is shown in the figure.1 Details and specification of the SMAW test specimen is given in table.1

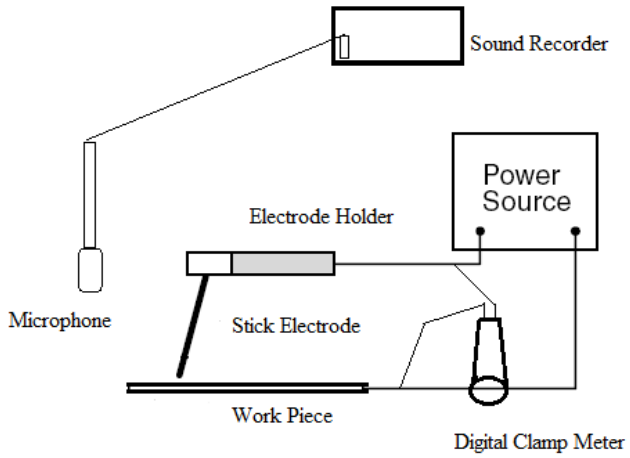

Figure 1: Experimental Setup

Table 1: Test Specifications.

Base Material	C S plates of size 150×100× 6mm thick
Electrode	AWS A 5.1, E6013, Dia 3.15
Position	1 G
Joint type	Single V Butt weld
Root face thickness	1.5 mm
Root Gap	1.5 mm
Groove Angle	60 °
No of Samples	20

Initial trials were carried out to establish the range of welding parameters for obtaining defect free welds and welds with burn through and lack of fusion. Experiments were designed and conducted using the three level Central Composite Design (CCD). CCD for conducting the experiments are based on the data obtained from the initial trials. CCD adopted for conducting the experiments is shown in the Table 2. The input weld parameters chosen in this study are current, voltage and travel speed. Based on CCD, twenty experiments were planned. Carbon Steel specimens were prepared as per the American Welding Society (AWS) structural welding code. Input weld parameters considered in this study are Current, Voltage and Travel Speed. After the welding, weld samples are cleaned and quality of the weld was examined using Non Destructive Testing. Carbon Steel weld samples of good weld, weld with burn through and lack of fusion were identified. A good quality microphone is used to record the arc sound during the welding process.

Table 2: CCD Experiments.