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Statistical Approach for Identification of Porosity in GMAW by Arc Signature Analysis

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Abstract

This paper addresses the statistical approach for identification of welding defects in CO_2 welding system by signature analysis technique [1,2]. The term signature refers to the instantaneous arc current and arc voltage in the online welding process. Metal transfer is reflected in terms of arc current and arc voltage of the welding process. By predetermining good weld specimen signature and its statistical parameters for a specific chosen electrode size with proper settings as per the user manual specifications that are considered as reference signature and subsequent online samples are compared with it and statistical parameters of error is used for identifying quality of weld [3,4]. Based on this, a decision may be arrived for rectification or rejection or acceptance of the weld based on application and usage involved.

Key words: Porosity, Signature Analysis of weld, Statistical Parameters of Weld

Introduction

CO_2 welding is the metal active gas system which is commonly used for welding most structural and alloy steels. The operating principle and the equipment required are same as for GMAW [5]. The CO_2 welding system is basically very simple and its special features are different mode of metal transfer are possible, self adjusting arc, higher current density, higher welding speed. A filler wire is continuously fed by motor driven rolls to a welding gun where current is fed into it from a power source [6]. The welding arc is struck between the work piece and the tip of the wire, which melts into the weld pool. The arc and weld pool are both shielded be C02 gas flowing from the gun. The process is very versatile in that, by selection of the proper wire diameter and composition it can be used for welding of thin sheet as well as thick plates. CO_2 welding system normally powered with constant voltage source.

Experimental setup:

The newly developed statistical analyzer setup is shown in Fig.1 comprises of Hall effect voltage, current sensors [7], A/D converter, amplifier with signal conditioner and industrial computer. Online voltage and current samples are digitalized, processed and then viewed in the computer monitor instantaneously, which reflects the welding process in terms of arc current and arc voltage and its samples are collected a rate of 1000 samples per second over a period of one minute duration (or at any desired rate), then stored in the buffer memory in first input to first output basis (FIFO). The stored data are retrieved and its statistical parameters are obtained with the newly developed software package using Micro soft Excel package.

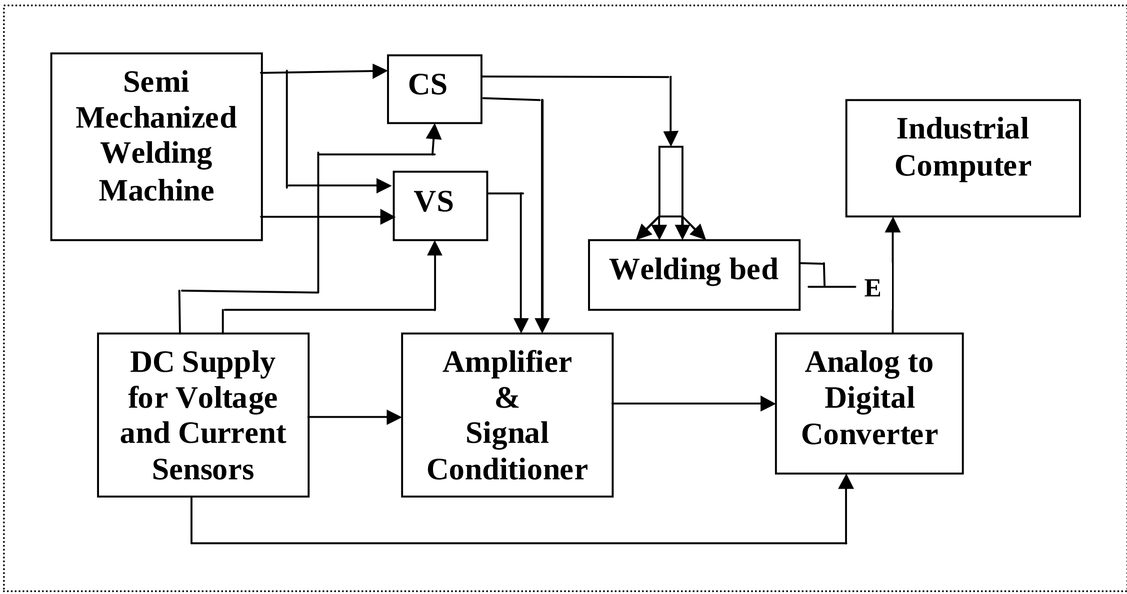

Fig.1-Statistical Analyzer with Semi Mechanized Welding Machine
(**CS**-Current Sensor, **VS**-Voltage Sensor, **E**-Earth)

Analysis of arc current signature, evaluating upper and lower specification limits from z distribution curve

In this work welding has been carried out on a 10mm thick plate using a 1.2mm dual electrode with appropriate setting of shielding gas (CO_2) pressure, gas flow rate and wire feed rate for a specific settings as specified in the MEMCO™ make user welding manual [8]. The constant voltage source welding system current gives more information then the voltage hence arc current alone taken into consideration.

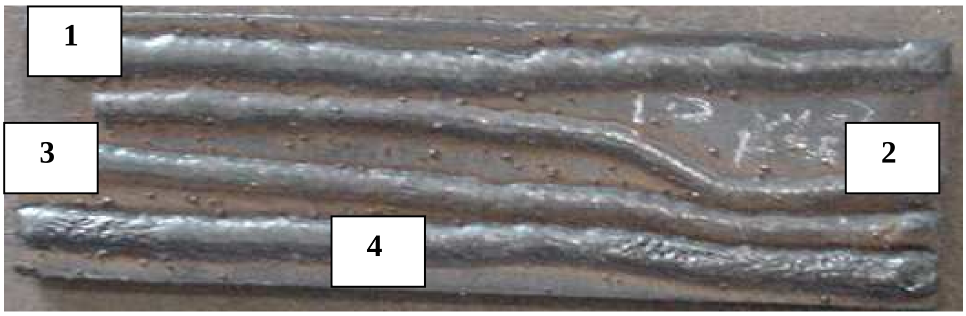

Fig.3

Fig.3 signifies three weld bead specimens 01, 02, 03 and 04 with voltage and current settings of 175 A, open circuit voltage 28V, during welding voltage 22V, Shield Gas CO_2, Gas pressure 10 Kg/sq.cm. In specimen-03 and 04, defect is identified.

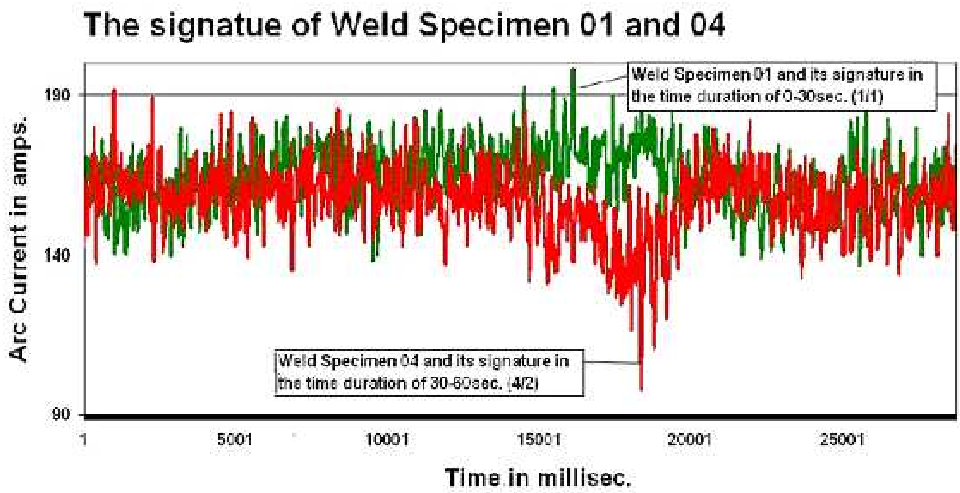

Fig.3

Fig.3 shows the weld bead specimen 01 arc current signature of sample 1/1 in the time duration of 0-30sec. and defect weld bead specimen 04 arc current signature of sample 4/2 in the time duration of 30-60sec.

Welding signature and Z – Distribution Curves

A continuous variable yielding a bell-shaped curve is called as a normal random variable which describes the probability distribution of the normal variable x, here x represents arc current in on-line welding process, with parameters of mean μ and standard deviation σ. Denoted as n (x; μ, σ) a normal distribution is completely defined by the mathematical equation-1 to the normal curve [8, 9, 10].

F (x) =n (x,μ, σ) $= \dfrac{e^{-(xi - xm)^2 / 2\sigma^2}}{\sigma\sqrt{2\pi}}$ ----------**Equ.01**

Z(x) = **(X_i-X_m)/ σ** **----------Equ.02**

The measure of skewness indicates that the greater the divergence between the mean and mode. A distribution whose polygon has a high peak is known as leptokurtic distribution, polygon with flatness at its top is called platykurtic distribution and the polygon that does not have a very high peak and is not even too flat at its top is termed as mesokurtic distribution. The mesokurtic distribution is also frequently referred as a normal distribution. [10].

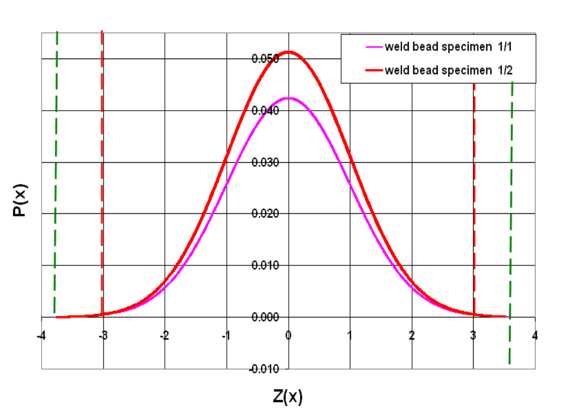

Fig.4

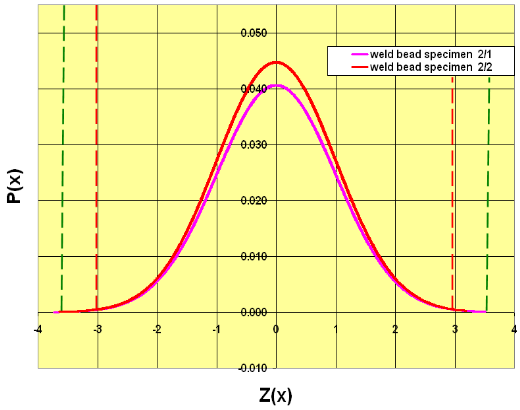

Fig.5

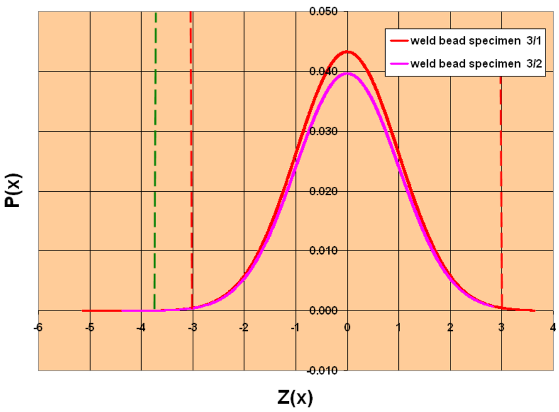

Fig.6

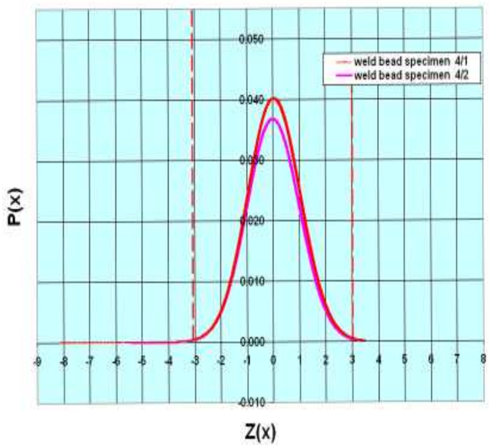

Fig.6

Fig. 4 and Fig.5 shows the z-score curves of weld bead specimen 1and 2 and and Fig.6 and Fig.7 shows the weld bead specimen 3 and 4.

The control limits and user specification limits may be easily obtained form the good specimen and subsequent samples may be compared with the reference for defect identification.
The measure of skewness indicates that the greater the divergence between the mean and mode. the greater the skewness. It is negative when the value of mode is higher than that of a mean and positive when the value of mode is less than that of mean. Kurtosis is indicates the degree of peakdness at the top of a distribution. It is to be understood in relation to a symmetrical distribution. A distribution whose polygon has a high peak is known as leptokurtic distribution, polygon with flatness at its top is called platykurtic distribution and the polygon that does not have a very high peak and is not even too flat at its top is termed as mesokurtic distribution. The mesokurtic distribution is also frequently referred as a normal distribution. [10].

Statistical parameters Weld bead Specimens

Statistical parameters of Good weld bead specimen 01 and Each specimen welded in one minute duration which consists of two samples in 30minute time duration.								
Weld Specimen No & Sample No.	**P(x)**	**X_m**	**σ**	**$σ_2$**	**Range**	**S_k**	**K_r**	**%CV**
1/1	0.042	164.134	9.418	88.692	61.159	-0.005	-0.196	5.738
1/2	0.051	166.454	7.780	60.523	56.733	0.00	2.999	4.674
2/1	0.041	149.685	9.827	96.570	71.230	-0.108	0.131	6.565
2/2	0.045	154.891	8.924	79.643	61.068	-0.243	0.139	5.762
Defect identified in the weld specimen 03 and 04								
3/1	0.043	165.383	9.226	85.122	**81.149**	-0.081	1.082	5.579
3/2	0.040	157.344	10.071	101.428	**72.634**	0.000	-2.977	6.401
4/1	0.040	167.600	9.939	98.783	**114.627**	-0.761	-2.981	5.930
4/2	0.037	156.992	10.857	117.868	**93.967**	-0.736	1.831	6.915

Table.1

Table-1 shows the measures of central tendency and measures of dispersion of 4 weld bead specimens.

ANALYSIS AND INTERPRETATION OF WELD SIGNATURES BASED ON STATISTICAL PARAMETERS

The Range gives more information about the flaw in the specimens by comparing the range of the good specimen, In the 3rd weld bead specimen sample in the time duration of highly skewed in the negative direction which indicates the presence of porosity and in the 4th welld bead specimen samples 1 the skewness and krtosis indicates presences of cluster porosity.

ANALYSIS AND INTERPRETATION OF WELD SIGNATURES BASED ON STATISTICAL PARAMETERS

Table 1 elucidates the relevance of using the statistical moments as a measure since it augurs well for classifying the weld defect samples in addition to providing a mechanism of template for each class of weld defect. Though it is observed that the values of kurtosis for signatures of good samples and signatures of high current values seem to be similar the distinct difference is evident from the values of skewness in the case of high current weld signatures which varied from 0.3 to 1 (good signals indicated almost no skew and formed a part of standard normal distribution).

CONCLUSION

A novel method to find out the defects in welding has been proposed in this paper. The control limits and user specification limits have been found out from the z distribution curve which is obtained from signatures of good weld bead specimens. Then these limits are used as reference. This scheme may serve as templates for identifying various categories of weld defects from these statistical parameters in conjunction with the specification limits devised from the z distribution curves. Thus exhaustive types of defects may be categorized into various set templates based on this simple yet effective approach.

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