Development and Characterization of Real Time Metal Transfer Recording Facility for Submerged Arc Welding

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Abstract
Commercially available metal transfer recording units for Submerged Arc Welding (SAW) are expensive and beyond the reach of Small Scale Industries. This paper describes the development and characterization of a low cost, easy to use real time metal transfer recording facility. The characterization of the system was done with the help of different fluxes and with different welding parameters. The system so developed also doubles up as a study tool for research purposes. This makes use of the concept of arc-through sensing which is of non-contact type and hence non invasive. The sensed arc data (voltage and current transients) is fed into a PC via a digital to analog card. This data can be stored for study purposes and also for qualitative analysis of welding consumables.

Keywords
Metal Transfer, Voltage and Current Transients, Submerged Arc Welding

I. Introduction

In the arc welding processes where consumable electrodes are used, the metal droplets resulting from molten electrodes are transferred on to the weld pool. This phenomenon is called as metal transfer [1]. The metal droplets that are transferred are responsible for particular shape to the weld bead. There can be three main groups into which metal transfer can be classified, viz. Free-flight transfer, bridging transfer, and slag protected transfer. The classification is given in Table 1.

Table: 1: Classification of Metal Transfer

S. No.	DESIGNATION OF TRANSFER TYPE	WELDING PROCESS
1	**FREE FLIGHT TRANSFER** 1. Globular (i). Drop (ii). Repelled 2. Spray (i). Projected (ii). Streaming (iii). Rotating	 Low Current GMA CO_2 Shielded GMA Intermediate Current GMA Medium Current GMA High Current GMA
2	**BRIDGING TRANSFER** 1. Short Circuiting 2. Bridging Without Interruption	 Short - Arc GMA, SMA Welding with Filler Wire addition
3	**SLAG PROTECTED TRANSFER** 1. Flux Wall Guided 2. Other Modes	 SAW SMA, CORED WIRE, ELECTROSLAG

Effectiveness of such arc welding processes can be increased if losses due to spatter, while the metal is transferred from the electrode are minimized. Thus, if the mode of metal transfer can be detected and according corrections are made, the utility of the welding process can be enhanced [2-3]

A. Design and Development

The present system was designed by the principle of "Arc - Through Sensing". Fig.1 shows a block diagram of the system. In this case the arc facilitates the information about the metal transfer mode by detecting changes in arc voltage and current in real time. The frequency of the periodic drop in voltage and the frequency of short circuit (if any) are sensed and thus the same can be correlated to the mode of metal transfer, weld bead geometry and for characterizing fluxes for their arc stability etc. [4 - 6]

1. Features

(i). Through the arc sensing of the weld pool.
(ii). Graphics User Interface (32-bit).
(iii). Real time visual display.
(iv). Graph Data Compatible and exportable to MS-Excel.

(i). The Components of the System

- SAW Semi-Automatic Weld head
- Data acquisition System
- Software implementation
- PC/Weld unit interface

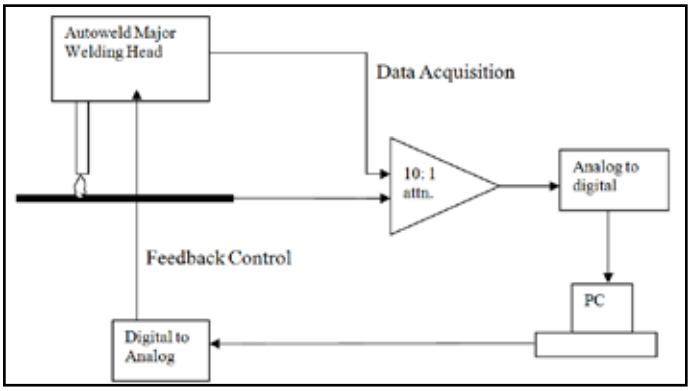


Fig. 1: Block Diagram of Remote Welding Station [4]

2. Data Acquisition System

The data acquisition card (Analog to Digital Card) used is the PCL-818HG, which has the following features

Channels	: 16 Single Ended Or 8 Differential
Resolution	: 12 Bits
FIFO Buffer	: 1k
Input Range	: 0 to 10V
Over-voltage Protection	: 30V Max Continuous
Conversion Type	: Successive Approximation
Conversion Rate	: 100khz Guaranteed 40khz
Data Transfer	: DMA, Interrupt, and Program

An attenuation circuit is employed to reduce the signal to correspond to the range of the card i.e. 0 – 10V. The fluctuations in voltage are reflected in the parallel circuit with low current rating. This system was successfully employed by Maheshwari et.al. [4]

II. Software Implementation

The software is developed for operation in 32-bit windows environment and requires Windows 7/8.The data can be exported to Microsoft Excel. It generates real time graphs showing the voltage transients.

Fig. 2 shows the block diagram of the software. As the program runs in a 32 bit environment no direct system calls are made, instead it is done via a dynamic link library or DLL of the A/D card shown as DAS DLL. This links the software to the operating systems kernel as a result of which the program can run in a multitasking environment.

III. PC/Weld Unit Interface

The computer output is obtained via PCL-818HG that supports the transition of digital output signals. It provides 16 TTL compatible digitally latched output signals, through ULN2803 NPN Darlington pair relay driver chip. The ULN2803 used was as per following configuration:

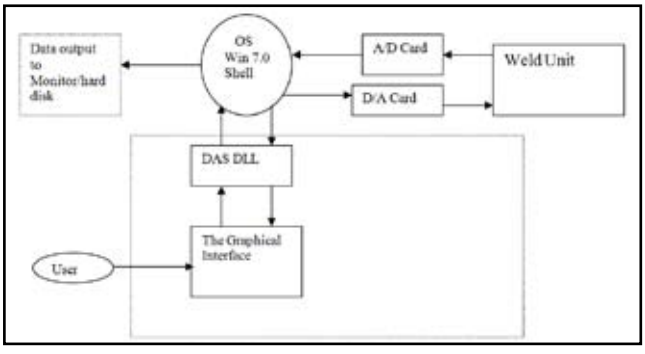


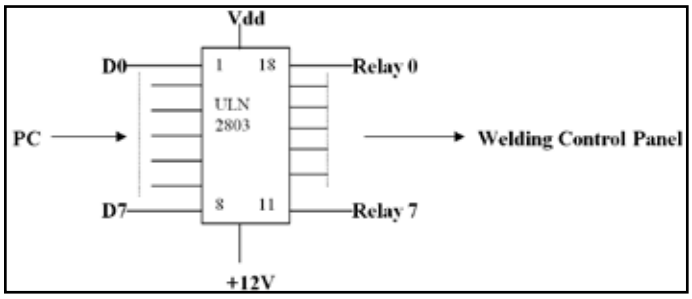
Fig. 2: Software Block Diagram

A. ULN2803

8-bit 50V 500mA TTL-input NPN Darlington driver.

The drivers need no power supply; the VDD pin is the common cathode of the

Eight integrated protection diodes. [10]



IV. Experiments

The standard bead on plate technique was used for submerged arc welding. The experiments were conducted by varying the short circuit current value. Standard deviation in the V-I transients were recorded with the help of this set up for all the designed experiments. The data was collected after the process had stabilized i.e. five seconds after the arc initiation.

V. Results & Discussions

The values obtained for the standard deviation in current and voltage are shown in table 2. It clearly indicates that the increase in current value is attributed to lower standard deviation in the current and voltage. Thus it can be inferred that the arc gap variations at higher currents are smaller and therefore smaller diameter droplets are being formed at higher currents.

Table 2: Standard Deviation Values of Current & Voltage

S. No.	Short Circuit Current (Amp)	Standard Deviation in I	Standard Deviation in V
1	250	37.50	.92
2	300	33.10	.84
3	350	32.56	.82
4	400	29.85	.80
5	450	27.35	.76

VI. Conclusion

The designed system is able to quantify the stability of the arc welding process by ascertaining the standard deviation values of the data. The system is capable of characterizing welding consumables for their respective arc stability and arc initiation behavior. The mode of metal transfer and the size of droplets can also be correlated to the variation in the arc current and arc voltage. Submerged arc welding, where it is not possible to record the metal transfer through the normal high speed cameras, this tool is an effective method to have an insight about the mode of metal transfer.

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