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Optimal Parameters for Prevention of Power Source Breakdown in SMAW

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Abstract —*Aim of study is to reduce the breakdown of power source used for welding process and also increasing its duty cycle. The main requirement of a power source is to deliver controllable current at a voltage according to the demands of the welding process being used. Each welding process has distinct differences from one another, both in the form of process controls required to accomplish a given operating condition and the consequent demands on the power source. Therefore, arc welding power sources are playing very important role in welding. The versatility of waveform control is a major achievement of power source developers and manufacturers. To enable the exploitation of such advanced capability however, the personnel in charge of utilizing the sophisticated equipment must have sufficient training. We identify the problems like unstable arc generation with optimum arc length and also Power source break down during overnight and continuous production. As observed in SMAW process as current increases, heat generated, heat accumulated and rest time increases while duty cycle decreases. Parameters responsible for unstable arc length are studied and solution for stable arc is obtained. Formula for desired duty cycle is obtained which can be controlled by setting various parameters.*

Keywords*- SMAW; Welding current; Transformer Voltage; Power source; Duty cycle.*

I. INTRODUCTION

SMAW process is used widely in order to join different parts of boiler. With the help of different electrodes and proper combinations of current and voltage the desired joint is obtained. A problem frequently faced is generation of discontinuities in weldment which often results into failure of those joints. Therefore, it is necessary to set certain parameters by which weldment with less or negligible defects could be obtained. Removal of discontinuities requires great amount of work which is time consuming and costly process. The second and another major problem challenged is of power source breakdown. During overnight and continuous production, the SMAW power source gets accumulated with higher amount of heat inside.

Nomenclature:

OCV	Open Circuit Voltage
SCC	Short Circuit current
V_t	Voltage of Transformer
I_t	Current of Transformer
Q_{gs}	Heat Generation inside
I	Welding Current
R	Resistance
t	Time Duration
Q_d	Heat Dissipation from Transformer
Q_{accu}	Heat accumulation
R.T	Rest Time
h	Convective heat transfer coefficient
A	Heat Dissipating surface area
ΔT	Temperature difference
I_r	Rated Current
I_d	Desired Current
D_r	Rated Duty Cycle of Transformer
D_d	Desired Duty Cycle of Transformer

Power-Source or supplies generates and maintains the electric arc.Arc Welding Machines either produces a constant current (CC) or a constant voltage (CV). Other manual welding processes, such as SMAW requires a constant current (CC) welding machine. If a constant current welding machine is not used, major changes in current are observed, whenever slight changes are given in arc length. Hence it is almost not possible to maintain a constant arc length, hence a constant current welding machine is used. A constant current welding machine is also called drooper or droop curve machine. The name is obtained from the voltage versus amperage curve produced by the machines. Figure1 shows the curve for a constant current welding machine.

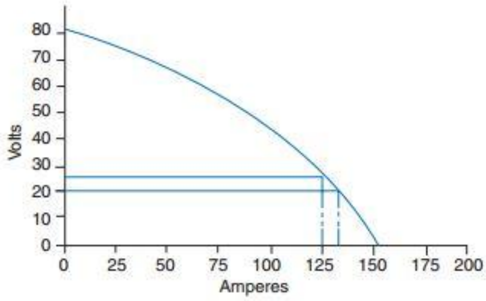

Figure 1-The voltage versus amperage curve

An increase from 20 volts to 25 volts is observed as a 25% increase in the voltage. This change in voltage results in a growth of current from 125 amperes to 130 amperes, i.e. 4% increase only. If the welder changes the arc length, a change in voltage is observed. However, a minor change is observed in amperage with a constant current welding machine. The welding machines are considered constant current, although the current varies just slightly. AC as well as DC current welding machines are available as constant current machines. While selecting an Arc Welding Machine Ac welding machines , most welding requirements are met. They are easy to use and generally cost efficient than other DC welding machines. Therefore, they are mostly used in farms as well as in the home shops. Here the changes in polarity can be done; DC welding machines are mostly preferred over AC machines. The changes in the polarity allows the welder to make out of position welds and to weld thin metal better.

Figure 2-Welding power source

It also allows to vary the heat which is supplied to the metal. As observed DCEP provides deep penetration for welds on thick sized metals; DCEN transfers the filler metal very fast. DCEN is mostly used on thin sized metals. Some of the arc welding machines are combination of both Ac and DC machines.Mostly for the welding purposes, the voltage ranges from 20 voltsto 80 volts (V) and current from 30 Amperes to 1500 Amperes (A).

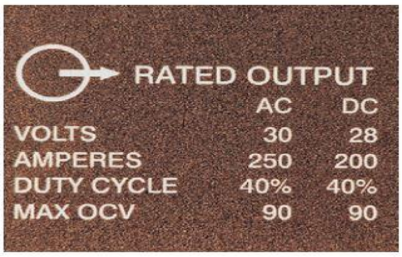

Figure 3-Rated output

Welding processes uses Alternating Current (AC), Direct Current (DC) or Pulsed Current. The Power-Sources are basically classified asconstant voltage, constant current, and pulse welding. That constant must be understood as a very useful simplification. The relationship is depicted graphically in a static volt-ampere characteristic diagram.To reach higher levels of control,More advanced Power-Sources with dedicated electronic devices are used .The output is truly constant, basically supplied in pulses over a range of frequencies, as required.

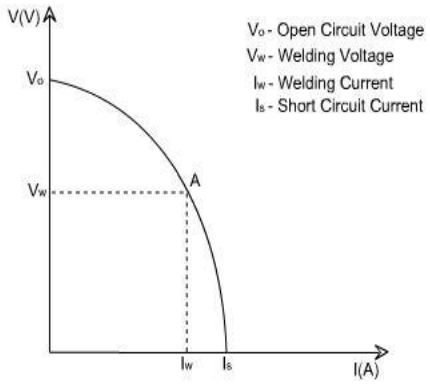

Figure 4-Drooping or Constant current or Falling Characteristic.

Figure 4 illustrates diagram for a typical constant current welder. As shown in the figure, welding set point is meeting point for two volt-ampere curves. Current and Voltage is represented by horizontal and vertical axis respectively. A decline of arc length and arc voltage is noticeable with moderate current increase at constant power supply. Generally for manual welding processes such as SMAW this kind of power sources is used. The steeper curve starts from the highest maximum open circuit voltage (OCV) whereas from minimum OCV less steep curve starts. It is observed that OCV is always considerable higher than the actual voltage drop across the arc. Change in current with respect to change in voltage on the steep curve is represented by dark area. Within the dark area boundary the current would remain constant. Minimum current change for voltage extrusion is allowed by selection of highest OCV and related steeper curve. That is helpful for flat position welding with small size electrodes.

More remarkable current variation indicated by larger current interval is produced by same voltage change by operating power source depends upon selection of lower OCV. This could be helpful for flat or horizontal welding with large electrodes. Welder would encounter more heat input and more current thus high deposition rates by decreasing arc length (and vice versa)

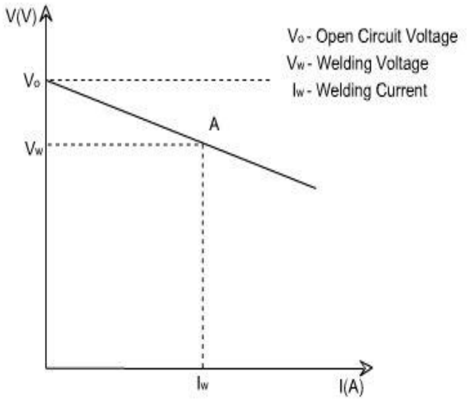

Figure 5-Constant Potential or Constant Voltage or Flat Characteristic.

Figure 5 demonstrates the constant voltage power source diagram, representing that a minimal but noticeable voltage decreases with current increases. This is the typical output used for DC SMAW, where weld pool is fed by wire form electrode. The system is self-regulating in automatic process if the wire is fed at constant speed. If the voltage decreases, that is torch is far away from the work, the feed and the current tends to increase.

When the current increases electrode melting rate also increases, restoring arc length and voltage near to the set point. In fact arc current is directly proportional to feed current. Power sources combination in a single unit is possible to design using electronic controls. Either constant current or constant voltage, depending on the welding process at hand. Single

phase AC input and output from small power sources (80-250 A) are available for users with limited requirement. Slightly larger (175 to 350 A) single phase AC input may have selectable AC or DC output. Most Power sources have three phase input for industrial applications and greater current requirements.
Output characteristics are suitable for selected processes as needed. Further classification of Power-Sources is that delivering waveform controlled output. Modern electronic controls, epically inverters supplies are used to achieve this. Manipulation the welding current in pulses is permitted by welding control whose characteristics are fully specified. Each parameter can be selected by turn, or predetermined optimized programs saved in computer memory can be run. The important control parameters are:

- Polarity,
- waveform shape (either sinusoidal or square),
- peak and background current,
- frequency, and
- duration of each phase.

The versatility of waveform control is a major achievement of power source developers and manufacturers. To enable the exploitation of such advanced capability however, the personnel in charge of utilizing the sophisticated equipment must have sufficient training. They should get also the opportunity to develop experience by trying, testing and collecting results. Otherwise the over-choice risks to cause only confusion. A major progress was achieved with the introduction of inverter based Power-Sources. They are smaller, lighter and much more efficient.AC input from the line grid at 50 or 60 Hz is rectified to dc.A solid state device circuit converts dc to high frequency ac in the range of 20 to 100 kHz. Voltage is then reduced with a step down transformer and then output current is rectified and smoothed for arc welding.

Duty Cycle

Duty Cycle is an important limiting factor to be taken into account while selecting a definite power source. It represented by percentage, without over heating when the source can deliver its maximum rated power. The rest of the time is needed for cooling down of the sensitive elements to a safe temperature. Equipment intended for continuous operation should be capable of delivering the rated maximum output at 100% Duty Cycle.

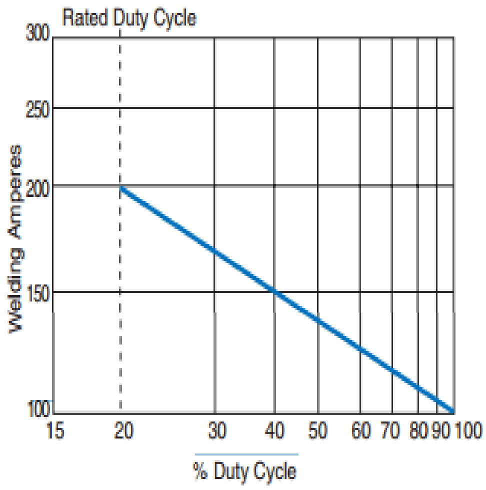

Figure 6-Duty cycle

II. OBJECTIVE

Power source break down during overnight and continuous production:
Possible solution for this problem is greatly needed as power source break down suspends welding process for certain time. This delay in welding time can be reduced by providing another power source in standby in case of breakdown. Transformer they are using is of constant current type which will provide constant current over varying arc voltage. Providing number of transformers is increasing their investment cost. So we are supposed to give them a solution which will remove the necessity of standby transformer by preventing the breakdown of existing one while using it for overnight and continuous production in case of higher demand. Therefore, study regarding factors affecting DUTY CYCLE of transformer needs to be carried out in order to improve DUTY CYCLE.

III. METHODOLOGY

Methodology for Prevention of power source breakdown Power source used in SMAW process is transformer.
Breakdown of transformer occurs due to excess amount of heat accumulation due to high heat generation than dissipation. Heat generation in transformer is directly proportional to welding time, welding current and resistance. Mathematical equation for heat generation inside transformer is given by:

$$Q_g = I^2 Rt \qquad (1)$$

Amount of heat dissipation in transformer can be given by

$$Q_d = h A \Delta T \qquad (2)$$

So for prevention of breakdown of transformer it becomes necessary to keep heat generation lower than heat dissipation. While using transformer in industry the rest time must be provided for dissipation of accumulated heat. So, the percentage of time during which the arc is on without overheating the vital element of welding equipment is known as duty cycle. For example, if transformer needs 2 hours' rest after continuously operated for 6 hours, the duty cycle of the transformer will be 75%. As the welding current increases heat generation inside transformer increases accordingly, this result in increment of heat accumulation which in turns requires longer rest time. Hence the duty cycle of transformer decreases.

So we can say that heat generation inside Transformer is directly proportional to welding current and inversely proportional to the duty cycle.

$$Q_g \, \alpha \, I^2$$

$$\alpha \, \frac{1}{D} \qquad (3)$$

So we can say that $I_r^2 D_r = I_d^2 D_d$ (4)

Hence we can obtain desired duty cycle of transformer by setting optimal current (Id)

IV CONCLUSION

Shielded Metal Arc Welding (SMAW) is a welding technique in which the base metals are heated to fusion with the help of an electric arc. The arc is made between a covered metal electrode and the base metal. The shielding gas is made as the flux covers on the electrode melts. The flux than solidifies and forms a slag. That slag protects the weld metal when it cools. The melting electrode wire provides filler metal to the weld. When the current flows from the electrode to the base metal, it is termed as direct current electrode negative or direct current straight polarity. When current flows from the base metal to the electrode, it is termed as direct current electrode positive or direct current reverse polarity. Direct current flows only in one direction. Alternating current reverses direction at a set frequency, usually 60 cycles per second. A welding outfit consists of the equipment required to actually create a weld. A welding station also includes supplies, tools, and other items required to make welding comfortable and safe as well. Arc welding machine used for Shielded Metal Arc Welding Process produces a constant current. The electrical cable which connects the electrode holder to a welding machine is generally the electrode lead. The work piece lead is an electrical cable that generally connects the base metal to the welding machine.As observed in SMAW process as current increases, heat is generated, heat accumulated and rest time increases while duty cycle decreases. Parameters responsible for unstable arc length were studied and solution for stable arc is obtained. Formula for optimum arc length has been obtained which could be give max power. Formula for desired duty cycle is obtained which can be controlled by setting optimal current. This work will help for improve the productivity of welding transformer and reduce the shutdown period.

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