INFLUENCE OF PULSE PARAMETERS ON TIG ARC EFFICIENCY

by

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ABSTRACT

Experimental investigations have been carried out to study the influence of various pulse parameters on TIG arc efficiency. L-shaped water cooled copper block as work piece and calorimetric set-up for collecting the heat through the flowing water from the copper block were used, for determination of arc efficiency.

From the investigations it has been revealed that different parameters such as mean current, pulse current, background current, pulse frequency, arc gap, torch angle and gas flow rate influence arc efficiency. Except for gas flow rate, decreasing trends in arc efficiency have been generally observed with the increase of pulse / welding parameters.

INTRODUCTION

Pulsed TIG welding offers many advantages over the steady current TIG welding. One of the major advantages is reduction in the heat input to the work piece which in turn reduces weld distortion, grain size, weld bead width and reinforcement. However, penetration and melting efficiency are increased. Further, weld defects are also reduced (1,2).

Both low frequencies of the order of few Hz and high frequencies of the order of kHz, have been used for pulsed TIG investigations. No marked advantage is observed with high frequency while low pulse frequencies yielded reduced heat affected zone (HAZ) i.e. the lower the pulse frequency, the narrower the HAZ and the wider the fused zone (1,3,4). Smallest HAZ was obtained with 1.0 Hz frequency (3). However, Vilkas (5) reported that with high frequencies in the range of 1-20 kHz, better arc stability and deeper penetration are obtained.

The weld bead geometry and mechanical and metallurgical characteristics of weldments shall be dependent on the amount of heat entering the work piece. Only a fraction of heat enters the work piece and remaining is lost through radiation, convection and conduction. The fraction of total heat entering into the work piece is responsible for melting the metal and thus the formation of weld pool. This fraction of heat is termed as welding or arc efficiency (4,6,7).

In pulsed arc welding 20-30% less heat is transferred into the metal than in continuous welding i.e. the pulse efficiency is lower than the steady current (8). Fuerschbach (9) reported that TIG arc efficiency remains to be constant at a value of around 80% for both pulsed and continuous current conditions. However, others found it either in lower range around 50% or to vary from 50-10% (7,10,11).

In the present investigations efforts have been made to study the influence of various pulse parameters and gas flow rate on TIG arc efficiency with low frequency system.

EXPERIMENTAL PROCEDURE

A water cooled L-shaped copper block was used as work piece. Heat collected by the work piece was measured by collecting the water flowing through the block in a calorimetric set-up.

Welding torch was mounted on a clamping device to obtain a constant arc length. Argon was used as shielding gas and the arc was struck between the copper block and 4 mm tungsten electrode. Water was made to flow through copper block into the calorimeter. After 180 seconds arc was extinguished and water flow was stopped. From the quantity and temperature rise of the water collected in the calorimeter, amount of heat collected was calculated. Arc efficiency has been taken as the ratio of heat collected to the energy input. For each set of welding parameter three observations were made and average values have been recorded. The welding variables were selected as follows :

Electrode polarity	– Negative
Background current	– 60-180 A
Pulse current	– 100-300 A
Pulse frequency	– 1.0-5.0 Hz
Gas flow rate	– 6,9,12,15, Lit Min^{-1}
Arc Length	– 10, 15, 20 mm
Torch angle	– 0°, 20°, 40° from vertical

RESULTS AND DISCUSSIONS

Influence of mean current

The arc efficiency decreases with the increase in mean current for all the pulse frequencies as shown in **Fig. 1**. This is almost similar trend as has been observed by other investigators (11,12) in the case of steady current TIG arc.

This decrease in the arc efficiency with the increase in mean current in case of pulsed TIG can be attributed to the reason that the increase in pulsed current leads to relatively higher temperature of the arc causing more radiation losses if frequency and the background current are kept constant. If background current is increased or both background and pulse currents are increased for increasing the mean current then again temperature of the arc will increase in both the cases either during the base current period or during the whole cycle. This shall result into higher heat losses leading to decrease in the arc efficiency.

Influence of pulse and background currents

Fig. 2 shows the influence of pulse current on the arc efficiency for 60 A background current.

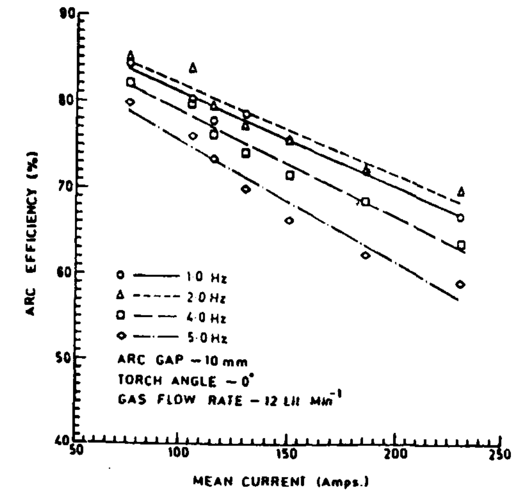

Fig. 1 : Influence of Mean Current on Arc Efficiency at different Pulse Frequencies

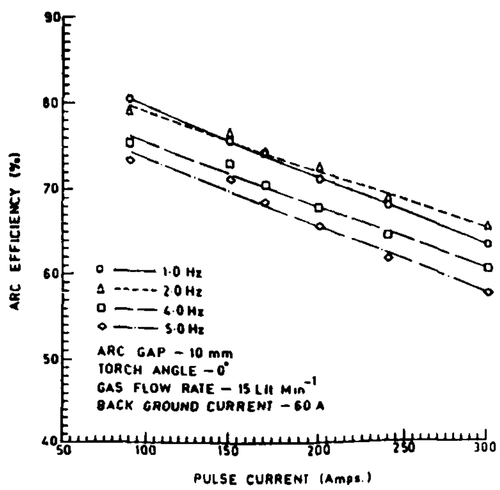

Fig. 2 : Influence of Pulse Current on Arc Efficiency at different Pulse Frequencies

From the Figure it can be observed that the arc efficiency decreases with increase in pulse current similar to mean current. For a particular value of background current if pulse current is increased then naturally the mean current shall also increase leading to lower efficiency. **Fig. 3** depicts the influence of background current on the arc efficiency. The influence of background current is similar to mean current and pulse current. This is because of the reason that if background current is increased keeping the pulse current constant then the mean current increases. This results into reduced efficiencies with the increasing background current.

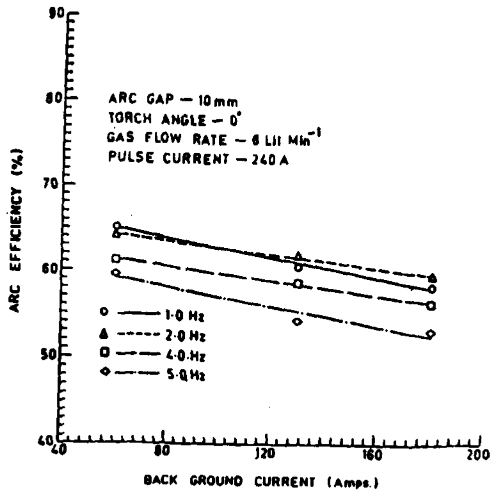

Fig. 3 : Influence of Back Ground Current on Arc Efficiency at different Pulse Frequencies

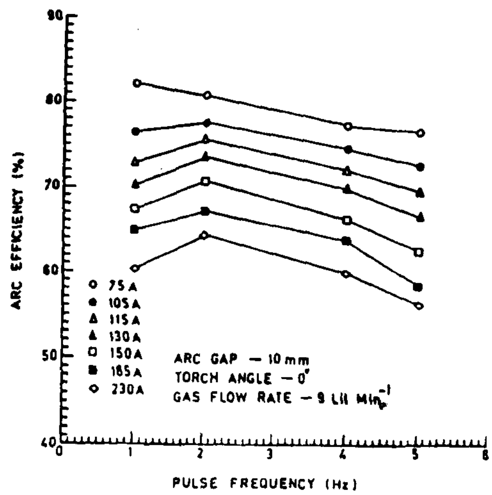

Fig. 4 : Influence of Pulse Frequency on Arc Efficiency at different Mean Currents

Influence of pulse frequency

Fig. 4 depicts the variation of arc efficiency with pulse frequency at different mean currents. It can be observed from the above Figure that the efficiency normally increases with the increase in pulse frequency upto 2.0 Hz and then decreases.

When the number of pulses per second are increased then the pulse time reduces, decreasing the radiation loss per pulse. However, the total radiation losses per second shall be the product of heat loss per pulse and the number of pulses. In addition to this after certain number of pulses the pulsation effect shall increase leading to the disturbance in the arc plasma resulting into more convective losses. The total of radiation and convection losses of heat may increase or decrease depending on the number of pulses and other parameters. Perhaps these losses may be normally increasing after 2.0 Hz frequency, and therefore, beyond this level the efficiency invariably decreases with the increase in the pulse frequency for all mean currents and gas flow rates, although the decrease may not be significant.

Influence of torch angle

The investigations have been carried out with the water cooled L-shaped copper block instead of flat block for the influence of torch angles. The arc efficiency decreases with increase in torch angle from vertical over the entire range of mean current and pulse frequency. **Fig. 5** shows the variation for 4 Hz pulse frequency.

losses occur. Due to increased heat loss to atmosphere the arc efficiency is bound to decrease with the increase in arc gap. This trend remains unaffected with the change in either mean current or pulse frequency.

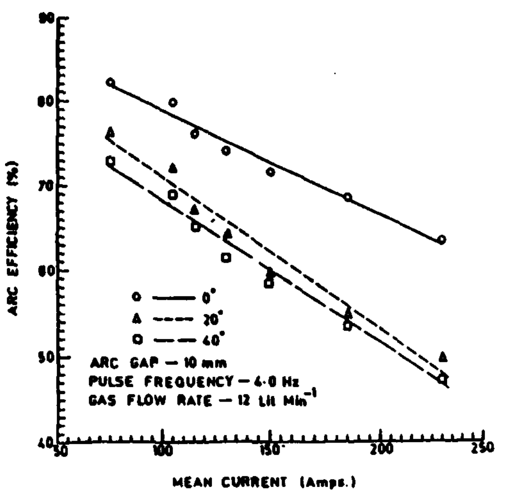

Fig. 5 : Influence of Mean Current on Arc Efficiency at different Torch Angles from Vertical

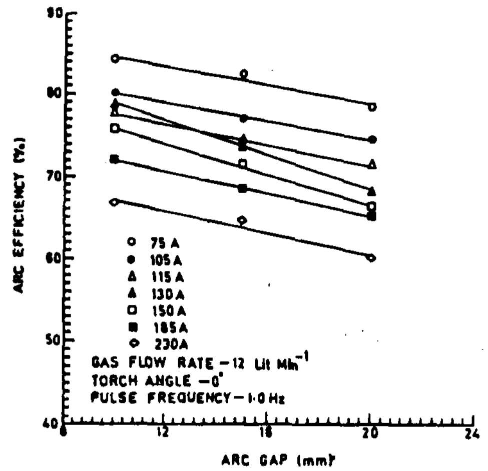

Fig. 6 : Influence of Arc Gap on Arc Efficiency at different Mean Currents

As the torch angle is increased, keeping the same arc gap from the surface of block, the effective arc length increases with the increase in torch angle which leads to higher surface area of the arc exposed to atmosphere leading to higher heat losses resulting into reduced efficiency.

Influence of arc gap

The arc efficiency decreases with the increase in arc gap for all mean currents and pulse frequencies. **Fig. 6** depicts a representative case for pulse frequency of 1.0 Hz.

When the arc gap i.e. the arc length is increased then the arc envelope increases and this leads to increase in surface area of the arc through which more radiation and convection heat losses occur. Due to increased heat loss to atmosphere the arc efficiency is bound to decrease with the increase in arc gap. This trend remains unaffected with the change in either mean current or pulse frequency.

Influence of gas flow rate

Fig. 7 depicts the influence of gas flow rate on arc efficiency at different mean currents for 2 Hz pulse frequencies.

From the Figure it can be observed that the arc efficiency invariably increases with the increase in gas flow rate upto 12 Lit min^{-1} and then decreases with further increase in gas flow rate. This trend remains unaffected with either change in mean current or pulse frequency.

It seems that gas flow rate of 6 Lit Min^{-1} is inadequate to provide proper envelope to the arc leading to higher heat losses. When the gas flow rate increases, although the gas envelope increases leading to increased arc surface, the convective and radiative losses may be reduced due to higher thermal gradient between the arc core and the outer layer of arc envelope as the thermal conductivity of argon is relatively low. This improves arc efficiency. The peak value of flow rate seems to be around 12 Lit Min^{-1} under the conditions of investigations for the selected gas nozzle size of 14 mm diameter and 4 mm electrode. But actually calculated value is 13 Lit Min^{-1} taking Reynold's number

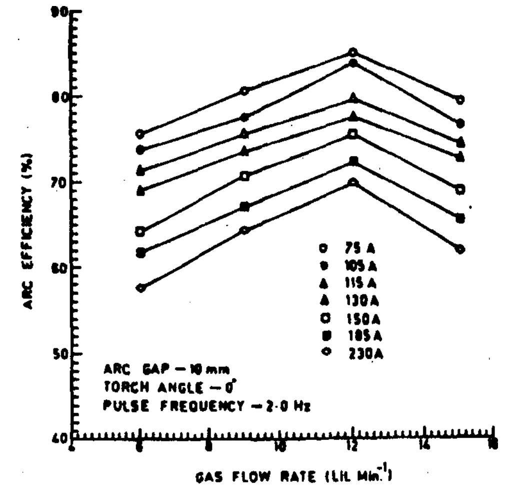

Fig. 7 : Influence of Gas Flow Rate on Arc Efficiency at different Mean Currents

into consideration. If flow rate is further increased then the gas flow no more remains laminar and becomes turbulent which shall lead to unstable conditions and thus more heat losses resulting into lower efficiencies as have been observed with 15 Lit Min^{-1} gas flow rate. If we change the shielding gas then most probably we may get different trends.

CONCLUSIONS

Within the range of experimental investigations it has been observed that the arc efficiency invariably decreases with the increase in mean current, pulse current, background current, torch angle, arc gap and pulse frequency beyond 2 Hz. However, arc efficiency increases with the increase in the argon gas flow rate upto certain level which is 12 Lit Min^{-1} in the present case and beyond this gas flow rate the efficiency goes down.

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