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# Study on Arc and Drop Transfer Behaviors of DCEN MAG Welding

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**Abstract.** By means of the high speed camera, the arc and drop transfer behaviours of direct current electrode negative MAG welding process are researched. The influences of luminous arc ball on the stability of MAG welding process are analyzed. On this basis, the process interval of DCEN MAG welding is determined. And the influences of wire polarity on wire melting coefficient are compared. By using the shield gas 98%Ar + 2%$O_2$, the stable drop transfer manner can be divided into two kinds: dropwise transfer with low current, and streaming transfer with high current.

## Introduction

MAG welding process is applied more and more widely in industry manufacturing and other fields, therefore, it is important to raise its welding efficiency, there is practical significance. Manufacturers scream for the less cost and higher efficiency welding process in order to strengthen their competition. As we know, the continuous and high current welding is the key to the high efficiency arc welding. But, as for a specific wire, the process will become instable with the welding current increasing. Then the rotating transfer, the larger spatter and bad bead profile will appear, which makes it impossible to be applied in the industry[1]. Restricted by High-Speed Camera Technique level, study on drop transfer of MAG welding starts relatively late. Up to now for to, the research related to high current density MAG welding and DCEN MAG welding still has been lack of the thorough study.The stability of MAG arc is relatively weak compared with non-consumable gas arc shielded welding, for which includes many factors: welding parameters, shielded gas component, welding wire material and diameter, wire extension, wire melting, droplet transfer etc.

DCEN MAG welding means that wire is connected to the negative pole. Wire is cold cathode materials, and cathode drop is much higher than anode[2]. So in the same current condition, cathode should generate more heat than anode, which can accelerate the wire melting. The shielding gas of DCEN MAG welding is (Ar) 98%+ (O2 ) 2%. If wire feed rate and arc voltage cooperate well, we can obtain relatively stable high current density MAG welding, and the mode of melting metal transfer is streaming transfer. The mechanism of the DCEN MAG welding is analyzed using the high velocity camera.

## Experiment Condition

Diagrammatic sketch of the test system is as shown in Fig. 1. Welding power source adopts Inverter Gas Metal Arc Welding Machine NBC-500 whose open circuit voltage is 85 V, the regulating range of output voltage is 15~60 V, the maximum output current is 600 A, the wire feed rate is stepless regulation from 0.5~ 50 m/min, travel mechanism rate is 0~1m/min. High-Speed Camera made in

America is FASTCAM Super 10K, the top frame rate of which can reach 10 000 frames/s. In this paper the frame rate is 3000 frames/s. The wire is H08Mn2SiA with diameter of 1.2 mm, the workpiece is Q235 with thickness of 6 mm, the shielding gas adopts 98%Ar+2%$O_2$**.**

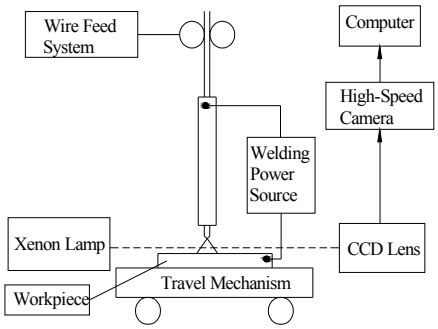
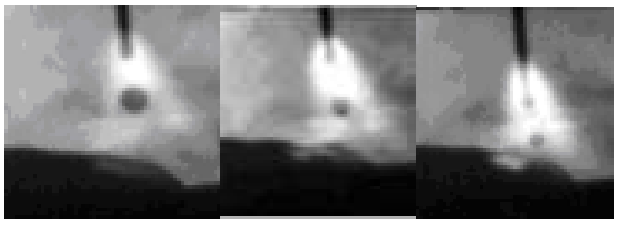



Fig. 1 Diagrammatic sketch of the test system

**Low Current DCEN MAG Welding**

The test parameters are listed as follows: wire feed rate $v_f$ = 8 m/min, Welding voltage $U_a$ = 29 V, wire extension $L_e$ = 18 mm, shielding gas flow rate is 15 L/min, welding speed $v_w$ = 0.4 m/min. Fig.2 shows the high-speed video pictures.



（a）$I$<160A （b）$I$=160~180A （c）$I$=180~230A

Fig.2 Effect on droplet transfer of DCEN MAG welding of welding current

When welding current I ≤ 230A, the melting metal transfer mode of DCEN MAG welding is a little simpler, which is basically droplet transfer. Because arc force is smaller, the main forces that act on the liquid metal jet are gravity and surface tension[3]. Only when the droplet volume gathered in large ball drops, the surface tension can not maintain its gravity, the droplets break away from the end of wire and transit to molten pool. With the increase of welding current, the droplet dimension reduces and the drop transfer frequency increases. The higher welding current is, the higher droplet transfer frequency gets. Then droplet volume gets smaller. All of these phenomena are accordance with the DCEP MAG welding, there is not too much to explain.

**High Current DCEN MAG Welding**

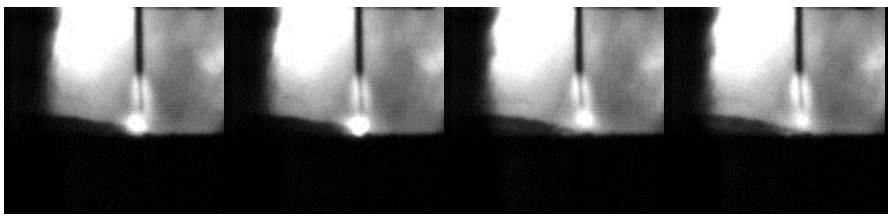


Fig.3 DCEN MAG welding when welding current is between 230A and 350A

The test parameters are listed as follows: wire feed rate $v_f$ = 15 m/min, welding current $I$ = 280 A or so, Welding voltage $U_a$ = 35 V, wire extension $L_e$ = 20 mm, shielding gas flow rate is 20 L/min, welding speed $v_w$ = 0.5 m/min. Fig.3 shows the high-speed video pictures.

When DCEN MAG welding current I ≥ 230A, the transfer mode of melting metal is streaming transfer, nevertheless, which is different from DCEP MAG welding. We observe that welding current is shunted. The luminous area of arc is divided into two series connection parts: one is the upper arc that presents as bunchiness, and always covers liquid metal cone and most liquid metal jet; the other is the lower arc that is luminous and presents as ball, only covering with the ends of the liquid metal jet. We called the latter arc luminous ball. The arc shape model of DCEN MAG welding with high current density shows as Fig.4.

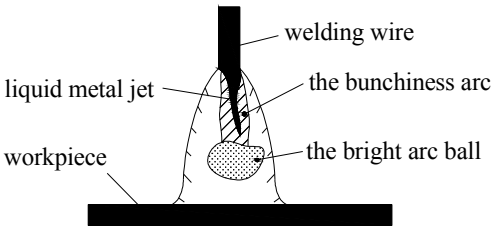



Fig.4 Arc shape model of DCEN MAG welding with high current density

**The Process Interval of High Current DCEN MAG Welding**

As the Fig.5 shows.Under this premise of fixed wire feed rate, with the welding voltage increased, the brightness of bunchiness arc has darkened, and it not only coats all liquid metal jet, but also coats some of solid welding wire. The range of arc luminous ball bouncing up and down has been wider. In the meantime，droplet transfer manner changes from Streaming transfer to large drop repulsion transfer.

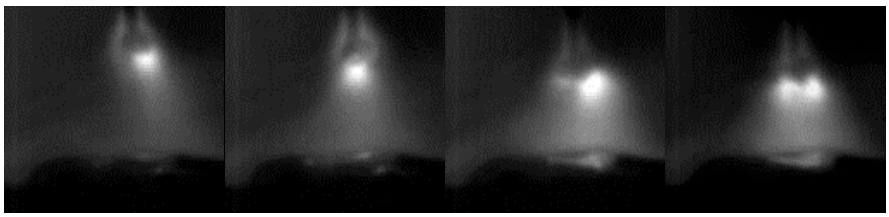


Fig.5 DCEN MAG welding with high current density when the arc voltage is too high

While turning down the welding voltage, the length of bunchiness arc decreases, and the shrouding range of the arc luminous area is reduced slightly. Even if the welding voltage is low to some degree, it is difficult to distinguish bunchiness arc from bright arc ball.

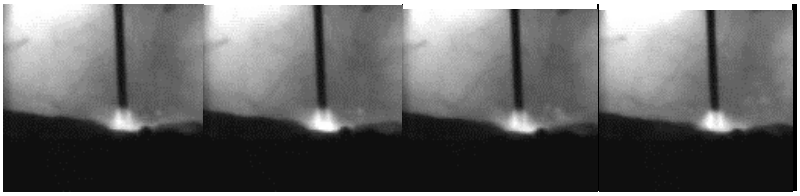


Fig.6 DCEN MAG welding with high current density when the arc voltage is too low

Welding voltage is too low to make the short-circuit of molten pool and liquid metal jet occur, the short-circuit spatter will be increased obviously [4]. Arc luminous ball that is characteristic of bouncing up and down motion has not been changed radically. As Fig.6 shows.

Based on the above analysis, only make sure that the welding process parameters lie in streaming transfer region, we could get relatively stable high current DCEN MAG welding. As can be seen from Fig. 7, the area with section line is relatively stable Streaming transfer region, the upper area is large drop repulsion transfer region, the lower area is molten pool and liquid metal jet short-circuit transfer region.

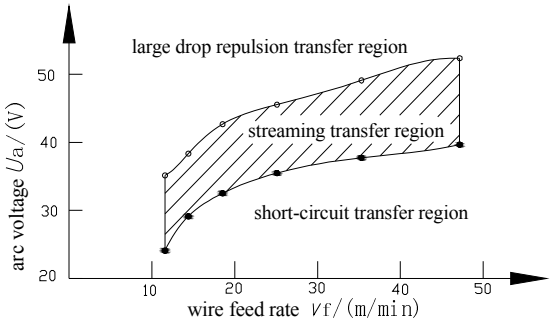



Fig.7 Reasonable process intervals of DCEN MAG welding with high current density

## Conclusion

(1) Arc behavior of DCEN MAG welding in different current condition is researched. The optimal process parameter interval of the high current streaming transfer DCEN MAG welding bases on the shielding gas of 98%Ar and 2%$O_2$ is given.

(2) For low current DCEN MAG welding, the melting metal transfer mode of DCEN MAG welding is a little simpler, which is basically droplet transfer. The higher welding current is, the higher droplet transfer frequency gets.

(3) When wire feed rate and arc voltage cooperate well, we can obtain relatively stable high current density DCEN MAG welding. And its wire melting coefficient is increased by 30% or so compared to DCEP MAG welding, and its melting metal transition mode is streaming transfer.

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