ARCHIVES
of
FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 11
Issue 3/2011

35 – 38

7/3

The influence of amperage of electric arc on microhardness in the area single and overlapping remeltings of HS 6-5-2 steel

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Received 06-04-2011; accepted in revised form 08-04-2011

Abstract

The present thesis depicts the microhardness of HV0,065 surface layer of high speed steel HS6-5-2 remelted with the electric arc. There were different surface layer variants of remelting used – the amperage was changed from 50 to 120A with the stable scanning speed of 300mm/min. There was also the influence of overlapping of the remeltings on the microhardness result. The highest average microhardness of the surface layer of high speed steel HS6-5-2 amounting 1100 HV0,065 was achieved by using the amperage of electric arc of 50 A. The overlapping of remeltings is connected with the possibility of occurence of the microhardness decrease in the area of overlapping of the heat influence zone of second remelting (another remelting) on the first remelting (the previous one).

Keywords: Heat Treatment – Mechanical Features – Metallography, High Speed Steel, Remelting, Microhardness, Overlapping Remeltings

1. Introduction

High speed steel HS6-5-2 belongs to the group of steel, of which the surface layer can be reinforced by remelting (partial melting), that will lead to quick cristalization to granularity of the structure and creating solid solutions, more saturated ones [1÷3]. Because that steel belongs to the group of ledeburite steels, that is the ones, that after casting consist of cristals surrounded by eutectic, the classical plastic processing recommends for that steel the usage of eutectic by forging [4]. By remelting of the surface layer of the steel by the electric arc, we receive the remelting zone, where depending on crystalization conditions, the cells are received, dendritic cells or dendrites surrounded by eutectic. There is a plate martensit and residual austenite inside the crystals [5]. As an effect of that unconventional processing, we receive hard, abrasion resistant surface layer within the malleable core. The only disadvantage of the received layer is lower impact strength, the reason of which is the presence of eutectic on the cells' border. The lowered impact strength can be slightly increased by conventional tempering conducted after the electric arc remelting. Another disadvantage that can take place and can influence during the hardening of bigger surfaces is the presence of microhardness drops in the areas of heat influence remeltings, and the microhardness drop can be also decreased here by conventional tempering [6].

2. Material and test methodology

The test material was the HS 6-5-2 high-speed steel in annealed condition. The surface layer of the steel was remelted with the electric arc using the FALTIG 315AC/DC device, used for welding with the GTAW method. Argon was used as a plasma-generating gas.

The process has been conducted at the Rzeszow Technical University, Founding and Welding Department. Microhardness measures were performed with the use of Vickers method using Hanemann microhardness tester, with the application of 65 g load and with 30 s as the time of load.

3. Results

Surface layer of HS6-5-2 steel was remelted by electric arc. Single and overlapping remelting was applied. A measurement of microhardness conducted on the 0,1 mm depth from material surface (Fig. 1). Microhardness measures were not performed on the surface, as because it required grinding, therefore to avoid this procedure the measurements were conducted in the above mentioned way.

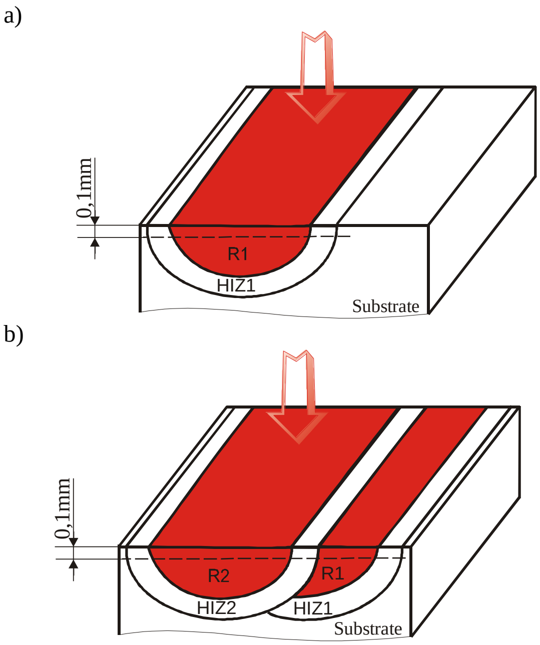

Fig. 1. Diagram of remelting surface layer of steel by electric arc obtained by the use of GTAW method; broken line indicates a track assigned in the distance of 0,1 mm from the surface. On the track the indentations were made every in the distance 0,05 mm; a) the cross-section of the single remelting, b) the cross-section of remelting overlappings; R1 – first remelting, R2 – second remelting, HIZ1 – the heat influence zone of the first remelting, HIZ2 – the heat influence zone of second remelting

There has been the influence of the electric arc amperage analysed in that thesis (with the stable speed of scanning) on the microhardness of the surface layer of the high speed steel HS6-5-2 for single and overlapping remeltings. The used variants of the processing have been presented in the table 1. In the Fig. 2 there has been the macrostructure of the high speed steel presented HS 6-5-2 remelted with the electric arc.

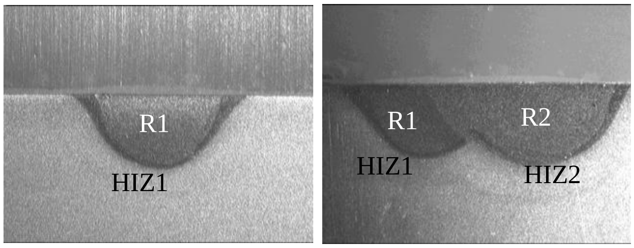

Fig. 2. The macrostructure of high speed steel HS 6-5-2 remelted with the electric arc (microsection in the perpendicular plain towards remelting; a) single remelting, b) overlapping remeltings; R1 – first remelting, R2 – second remelting, HIZ1 – the heat influence zone of the first remelting, HIZ2 – the heat influence zone of second remelting

Table 1.
Treatment variants the surface layer of HS 6-5-2 steel remelted with the electric arc

Treatment variants	Amperage of the electric arc, A	Scanning speed, mm/min
Single remelting	50	
Overlapping remelting	50	
Single remelting	70	
Overlapping remelting	70	300
Single remelting	100	
Overlapping remelting	100	
Single remelting	120	
Overlapping remelting	120	

The highest microhardness of the surface layer of high speed steel HS6-5-2, average 1100 HV0,065 has been received by using the single remelting with the amperage of the electric arc 50A (Fig.3a). By increasing the amperage of the electric arc up to 120A we receive the decrease of average microhardness of the surface layer of the steel below 1000 HV 0,065 (Fig. 3 b,c). The increase of the amperage of electric arc causes the melting of bigger volume of the material and as a consequence, slower crystalization, by which we receive bigger crystals in the remelting zone.

As a result of single remelting of the surface layer of the steel by electric arc with the amperage of 50A we receive the average microhardness at the level of 1100HV0,065 – Fig. 3a. The overlapping of the second remelting – fig. 4a – causes the decrease of the average microhardness to the level of 1000HV0,065. There is a visible decrease of microhardness in the area of overlapping of the heat influence zone of the second remelting (HIZ2) on the first remelting zone (R1). Similar effects are received for the amperage of the electric arc70A or 100A (Fig. 4 b,c). The worst situation is in case with the remelting of the surface layer of the electric arc amperage of 120 A. For the single remelting, the average microhardness is below 1000HV0,065 – Fig. 3c – and after overalpping second remelting, in the area of overlapping HIZ2 on R1 decreases below 900 HV0,065 (Fig. 5).

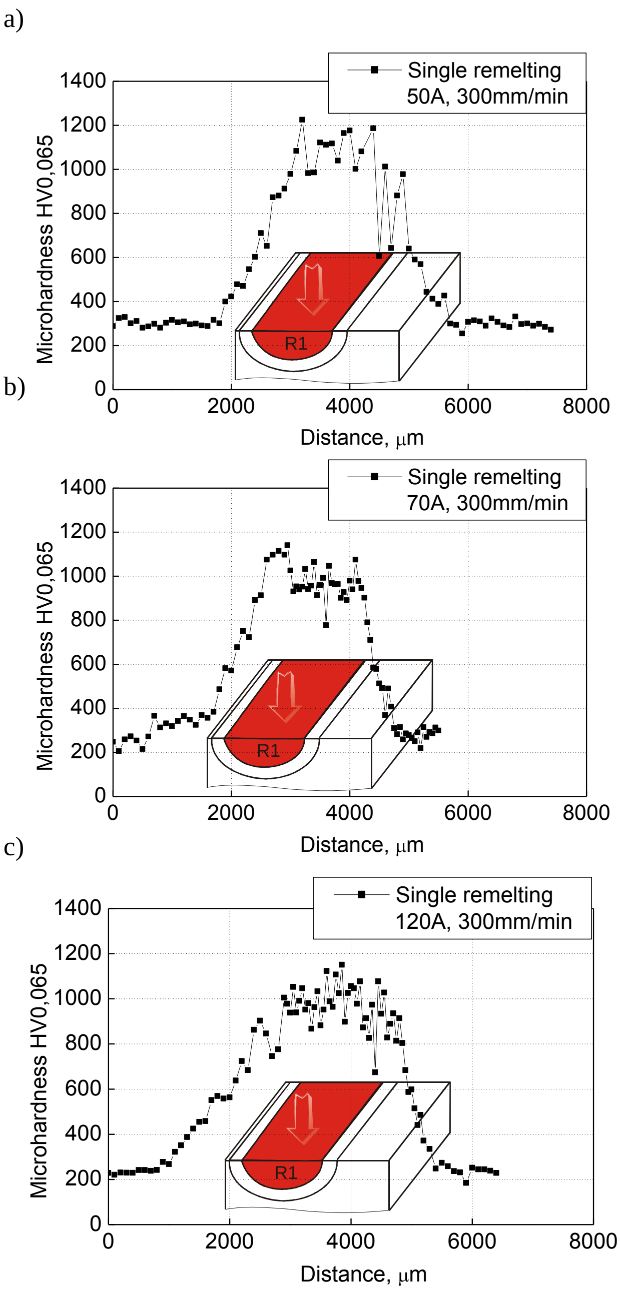

Fig. 3. The results of the measurement of the microhardness of the surface layer of the steel HS6-5-2 remelted with the electric arc; a) single remelting, I=50A, s=300 mm/min; b) single remelting, I=70A, s=300 mm/min, c) single remelting, I=120A, s=300 mm/min; R1 – single remelting

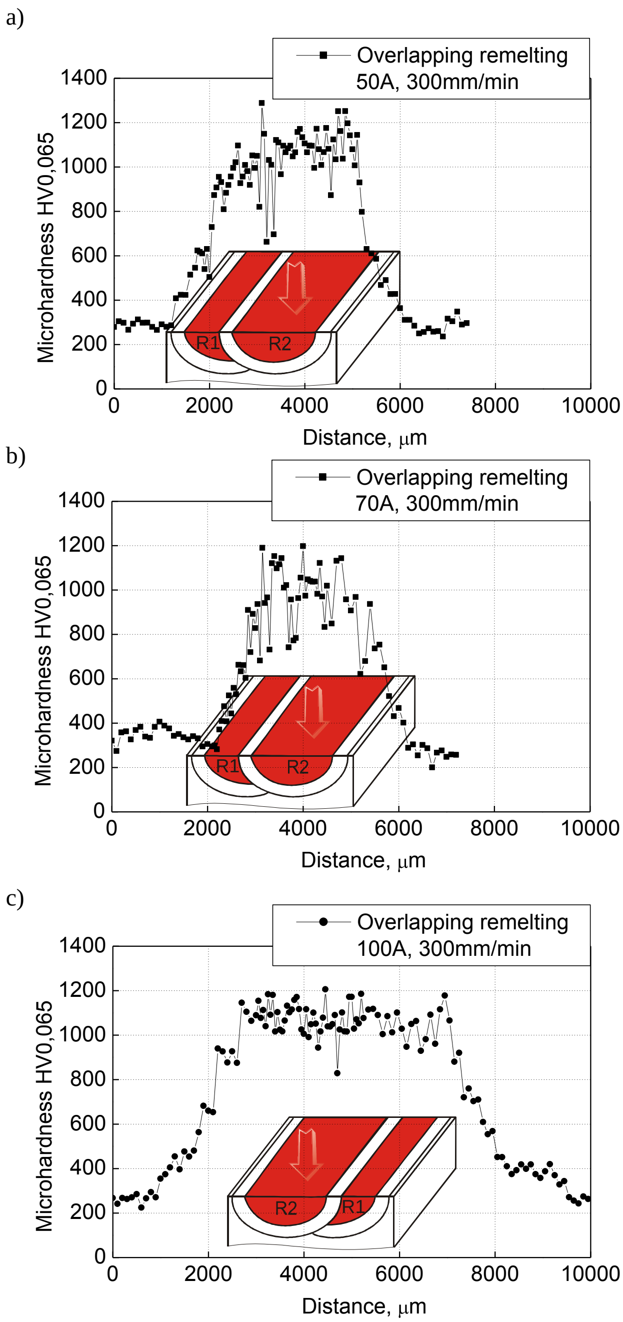

Fig. 4. The results of the measurement of the microhardness of the surface layer of the steel HS6-5-2 remelted with the electric arc; a) overlapping remelting, I=50A, s=300 mm/min, b) overlapping remelting, I=70A, s=300mm/min, c) overlapping remelting, I=100A, s=300 mm/min, s=300 mm/min; R1 – first remelting, R2 – second remelting

Fig. 4 and 5 present that overlapping of remeltings is connected with the possibility of appearing the decrease of microhardness in the area of overlapping of the heat influence zone of the second remelting (HIZ2) on the first remelting zone (R1).

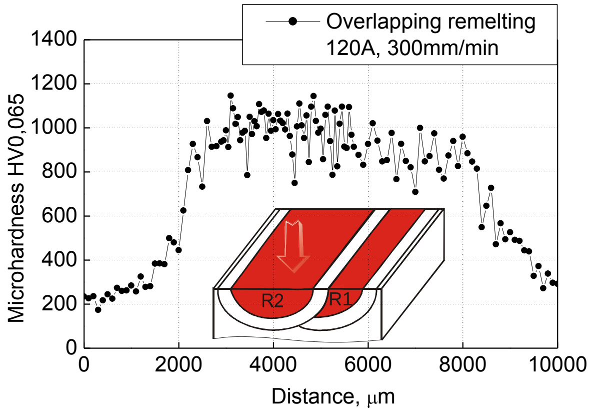

Fig. 5. Microhardness of the surface layer of the steel HS6-5-2 remelted with the electric arc; overlapping remelting, I=120A, s=300 mm/min; R1 – first remelting, R2 – second remelting

The microstructure in the area of overlapping of HIZ2 on R1 has been presented in the Fig. 6.

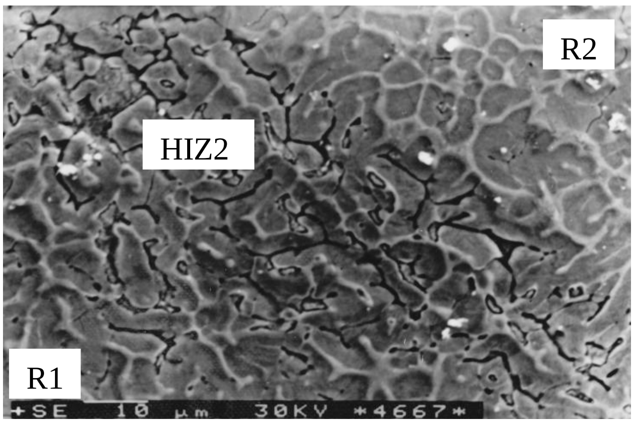

Fig. 6. The microstructure SEM of the steel HS 6-5-2 in the area overlapping of HIZ2 on R1; R1 – the first remelting , R2 – second remelting, HIZ2 – the area of heat influence of the second remelting

It is clearly visible, that the changes in the area of eutectic (dark-etched area surrounding cells); and from the eutectic structure, the alloy features depend [4]. Undoubtedly lower from solidus and higher than 560^0C temperature in the area of interaction of HIZ2 on R1 effected unfavourably on the structural ingredients within the cells. The highly tempered martensite has been created, which is characterised by lower hardness (Fig. 7). Both of these factors influence the presence of undesirable decreases of microhardness.

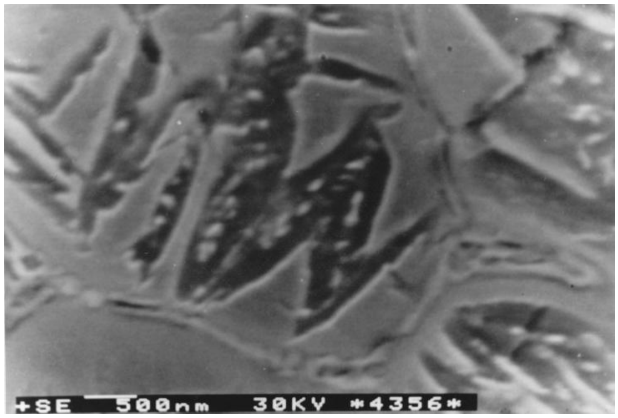

Fig. 7. Microstructure SEM of the steel HS 6-5-2 in the area of ovelapping of HIZ2 on R1, inside the cells, the visible plate martensite and carbides precipitates within the plate, on the border of the cells – eutectic

4. Conclusions

The increase of the amperage of the electric arc causes the decrease of the microhardness of the remelted surface layer of the HS6-5-2 steel. For the amperage of the electric arc of 50A, the average microhardness of the surface layer is 1100 HV0,065 and for 120A below 1000HV0,065.

Overlapping of the remeltings is connected with the influence of the heat influence zone of the second remelting on the first remelting, and as a result, there is a significant decrease microhardness.

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