HIGH SPEED STEEL CLADDING BY PTA - INFLUENCE OF PARAMETERS

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Abstract

PTA surfacing is widely used technology of increasing lifespan and wear resistant characteristics of machine components. There is a wide range of alloys which can be used as filler material; however, plasma cladding of High Speed Steel (HSS) is not yet frequently used. HSS's are the materials for fabrication of tools in machining, forming, forging and in other applications where high wear resistance is needed. The deposit tested in this study was cladded with three different frequencies of plasma current. Two-layer deposits were studied metallographically and tribologically. It was found that hardness of deposits is higher than 750HV, and structure contains finely distributed carbides of vanadium, chromium, molybdenum and tungsten. Tribological testing was performed on dry sand/rubber wheel apparatus and it was found that wear resistance depends on frequency of plasma current.

Keywords: Pulsed PTA, PTA surfacing, high speed steel, microhardness, tribology

1. INTRODUCTION

Weld overlays is a surface treatment improving wear resistance, corrosion resistance and allowing dimensional restoration by adding a surface layer or coating [1]. Different heat sources, such as laser, electric arc or plasma, can be used in order to melt both additive and base material and, consequently, create different kind of deposits. Plasma, as a heat source, is used in Plasma-Transferred Arc (PTA) process. This method can produce relatively thick weld overlays (typically 4 to 6mm in single pass). It is possible to achieve low penetration and low dilution levels with the appropriate selection of welding parameters PTA welding is usually automatized, which produces consistent overlays and achieves higher productivity than manual welding [2], [3]. Lower penetration and smaller melting pool can be achieved by use of pulsed PTA welding. Parameters of pulsation have an influence the penetration as well as microstructure and hardness of deposited material [4], [5].

High speed steels (HSS) are defined as complex iron-base alloys of carbon, chromium, vanadium, molybdenum, or tungsten, or their combinations, and in some cases substantial amounts of cobalt. The carbon and alloy contents are balanced to give high attainable hardening response, high wear resistance [6], high resistance to the softening effect of heat, and good toughness for effective use in industrial cutting operations [7]. There are many fabrication methods of HSS parts preparation such as metallurgy [8], [9], thermal spraying [10], laser cladding [11], etc. However, only few studies follow up PTA deposition of HSS [12].

2. EXPERIMENTAL

HSS23 was deposited by pulse-PTA on 15mm thick plates of mild steel S355. HSS 23 (Deutsche Edelstahlwerke, Germany) is molybdenum based high speed steel corresponding to AISI M3:2 with a good abrasive wear resistance and cutting edge retention with good toughness. It is suitable for demanding cold work applications like blanking of harder materials such as carbon steel or cold rolled strip steel and for cutting tools [13]. First layer of two-layers deposits was over welded on substrate at room-temperature, interpass temperature was maintained below 400°C. Chemical composition of HSS23 powder is listed in **Table 1**. Three sets of parameters were used: without pulsation, 77 Hz and 200 Hz. Welding current was 140 A and torch speed 3mm·s^{-1} with width of oscillation 20mm.

Figure 1 Plasma hardfacing automate PPC 250 R6 (KSK,sro, Czech Rep.)

Figure 2 Dry Sand/Rubber Wheel Apparatus for tribology testing [13]

Cladding of deposits was made by commercially available plasma surfacing automate PPC 250 R6 (KSK, s.r.o., Czech Rep.), (**Figure 1**). This apparatus is suitable for hardfacing of rotary and non-rotary parts, on the circumference, on the top. Feed range of torch, realized by digital servo motors is 260-260-490 mm with tilting of the torch in range 40°. It is possible to use oscillation, up to 200 mm in X as well as in Y axe. Ar 4.8 was used as shielding, plasma and carrier gas.

Properties of deposits were studied by metallography and optical microscopy (Zeiss, Germany), microhardness measurement (Buehler, Germany) and tribological behaviour was tested by dry-sand rubber wheel test [14]. Between two hardness and tribology measurements the samples were heat treated in an electric resistance furnace. Tempering temperatures 550°C, 550°C and 560°C.

Tribological testing was carried out following ASTM G65: Standard Test Method for Measuring Abrasion Using the Dry Sand/Rubber Wheel Apparatus [14] (**Figure 2**). Relative wear resistance was evaluated as a ratio between mass loss of etalon (carbon steel 12050, normalized) and mass loss of sample (1). Mass of samples was measured by laboratory scale (Sartorius) with precision of 0.001g. After each sample one etalon was measured in order to minimize influence of rubber wheel wearing.

Table 1 Chemical composition of HSS23 powder (wt%)

	C	Si	Mn	Cr	Mo	V	W	Fe
HSS23 No25584	1.30	0.36	0.20	4.05	5.19	3.18	6.07	bal.

$$\psi = \frac{\Delta m_e}{\Delta m} \qquad (1)$$

Δm_e - etalon mass loss [g]

Δm - sample mass loss [g]

3. RESULTS AND DISSCUSION

All deposits present uniform and similar weld appearance thanks to usage of the same welding programme (**Figure 3**). Thickness of weld overlays varied between 4 to 5mm. Microstructure (**Figure 4, 5**) of as welded samples consists of martensitic matrix with the rests of retained austenite and carbides of vanadium, molybdenum and tungsten. chromium is diluted in matrix [15], [16]. There is no major change in grain size with thickness of deposits. Two layers of deposits are difficult to recognize. Similar development was recognized in microhardness which is uniform along the thickness of deposit too.

Figure 3 Two-layer deposit of HSS23

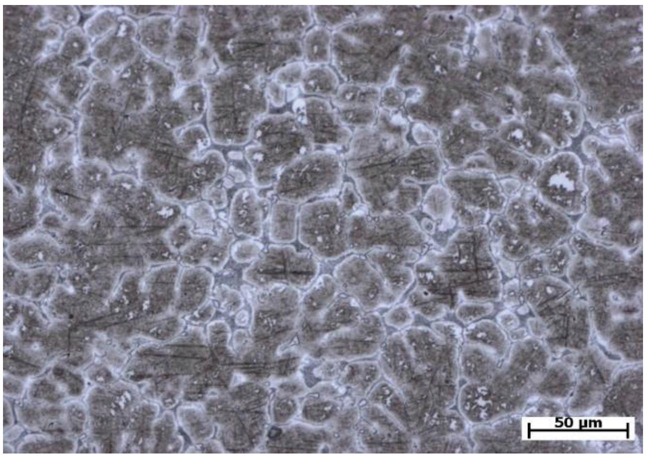

Figure 4 Without pulsation surfaced sample of HSS23, 200x

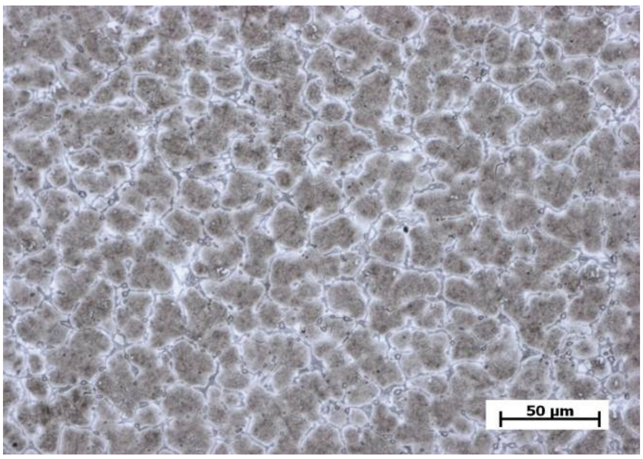

Figure 5 Sample deposited with frequency of plasma current 200Hz, 200x

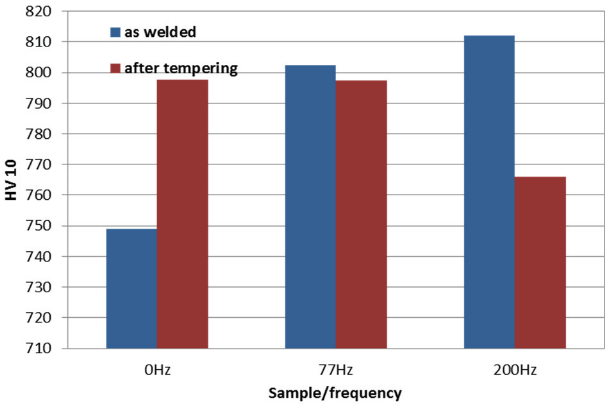

Figure 6 Microhardness 1mm under free surface. Samples welded by 0, 77 and 200 Hz of plasma current frequency.

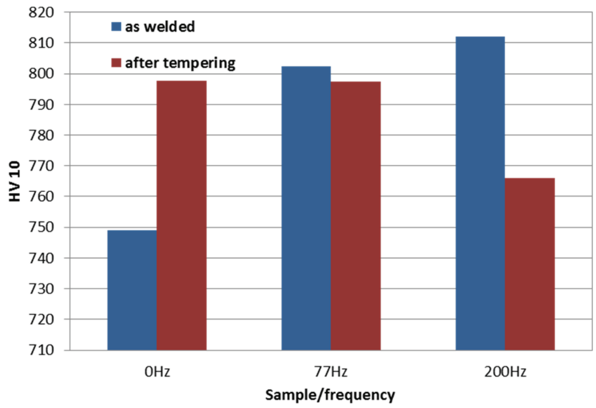

Figure 7 Relative wear resistance. Samples welded by 0, 77 and 200 Hz of plasma current frequency.

Samples surfaced with frequency of plasma current 200Hz present finer grains. Microhardness, which was taken as characteristic for the deposit, was measured 1mm under free surface of deposits and the results are listed in **Figure 6**.

Relative wear resistance is listed in **Figure 7**. Utilization of higher pulsation frequency increases relative wear resistance both before and after heat treatment. Similar influence on hardness was not observed. Microhardness decreases with higher frequency of pulsation of heat treated samples and increases in case of as welded samples. This discrepancy can be explained by transformation of martensite into more ductile structure phase during tempering. Resulted matrix can probably better maintain hard particles such as carbides of vanadium, molybdenum and tungsten.

4. CONCLUSION

HSS 23 is a promising material for PTA surffacing in metal fabrication. Plasma surfacing of HSS23 produces uniform, dense and hard deposits with high wear resistance. This resistance can be increased by usage of higher current pulsation frequency followed by heat treatment - tempering. Metallurgical bond between parent material and deposited layer and high wear resistance of HSS23 predetermine this technology in both fabrication and reparation of highly resistant industrial parts in wide range of various industrial sectors.

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