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HARDFACING OVERLAY SURFACE OF AISI 410 MATERIAL USING PAW PROCESS

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ABSTRACT

In this project, an experimental study has been conducted on Stellite 6 weld overlays deposited on the surface of AISI 410 martensitic stainless steel of OFE Valve components using Plasma Transferred Arc Welding (PTAW) technique.The coatings were then investigated to reveal their microstructure using scanning electron microscope (SEM), Liquid Penetrant Test is conducted to identify surface defects and hardness using Vickers micro hardness (HV0.3). In addition, wear tests were carried out using pin-on-disk testing apparatus (Tribometer) at the temperature of 400^{o}c in order to study the wear resistance of coatings. Worn surfaces and debris obtained from the wear tests were investigated by SEM

INTRODUCTION

Valve is a device that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways. Valves are technically fittings, but are usually discussed as a separate category. In an open valve, fluid flows in a direction from higher pressure to lower pressure. The word is derived from the Latin *valva*, the moving part of a door, in turn from volvere to turn, roll. The simplest, and very ancient, valve is simply a freely hinged flap which drops to obstruct fluid (gas or liquid) flow in one direction, but is pushed open by flow in the opposite direction. This is called a check valve, as it prevents or "checks" the flow in one direction. Modern control valves may regulate pressure or flow downstream and operate on sophisticated automation systems.Valves have many uses, including controlling water for irrigation, industrial uses for controlling processes, residential uses such as on/off and pressure control to dish and clothes washers and taps in the home. Even aerosols have a tiny valve built in. Valves are also used in the military and transport sectors.

FUNCTIONS OF VALVES

To stop or allow the flow of fluids in a pipe line. To act as safety device. To regulate the quantity or pressure of the flowing fluid. These two are interrelated and the controller gets the impulse for the purpose required. (Quantity regulating valve for attemperator spraying etc., pressure reducing valves in pressure reduction station etc.). Special valves for specific service conditions like Christmas tree valve for oil well, quick operating blow down valves for boiler blow down lines, special valves for pulp industries, steel plants, dredgers etc. From the above it can be clearly understood that valves play the vital part in the field of fluid control and a limit can never be reached to the varieties and types of valves.

VALVE AND ITS CONSTRUCTION

Valve components can be grouped mainly as:

- Body group
- Yoke, bonnet and cover group
- Disk, wedge group
- Stem group
- Gland group and
- Other parts.

AISI 410 MATERIALS

Grade 410 stainless steels are general-purpose martensitic stainless steels containing 11.5% chromium, which provide good corrosion resistance properties. However, the corrosion resistance of grade 410 steels can be further enhanced by a series of processes such as hardening, tempering and polishing. Quenching and tempering can harden grade 410 steels. They are generally used for applications involving mild corrosion, heat resistance and high strength. Martensitic stainless steels are fabricated using techniques that require final heat treatment. These grades are less resistant to corrosion when compared to that of austenitic grades. Their operating temperatures are often affected by their loss of strength at high temperatures, due to over-tempering and loss of ductility at sub-zero temperatures.

PROPERTIES OF AISI 410 MATERIAL

Table 1 Physical Properties of AISI 410 Material

Grade	Density (kg/m^3)	Elastic Modulus (GPa)	Mean Coefficient of Thermal Expansion (µm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0-100 °C (J/kg.K)	Electrical Resistivity (nΩ.m)
			0-100 °C	0-315 °C	0-538 °C	at 100 °C	at 500 °C		
410	7800	200	9.9	11	11.5	24.9	28.7	460	570

Table 2 Mechanical Properties

Tempering Temperature (°C)	Tensile Strength (MPa)	Yield Strength 0.2% Proof (MPa)	Elongation (% in 50 mm)	Hardness Brinell (HB)	Impact Charpy V (J)
Annealed *	480 min	275 min	16 min	-	-
204	1475	1005	11	400	30
316	1470	961	18	400	36
427	1340	920	18.5	405	#
538	985	730	16	321	#
593	870	675	20	255	39
650	300	270	29.5	225	80

PROCESS PARAMETER

Among various surfacing process parameters, the important process parameters which influence the quality of hardface gate valve were identified. These are Arc current, voltage, Travel speed, Powder feed rate, gas flow rate etc.

Table 3 Operational PTAW parameters

PARAMETERS	VALUES
Pilot arc current	8.4 Amp
Main arc current	141 Amp
Pilot voltage	2.9
Main voltage	32
Shielding gas & flow rate	Ar,10.2 lpm
Plasma gas & flow rate	Ar,1.6 lpm
Powder gas & flow rate	Ar,8.0 lpm
Nozzle plate distance	5mm
Feed rate	25 g/min
Travel speed	164 mm/min
Overlap	4 mm
Powder used	CoCrA
Particle size	53-150 µM
Preheat temp.	250°C for 1hrs.
Inter pass temp.	350°C
PWHT	630°C for 2hrs.

EXPERIMENTAL PROCEDURE

The gate valve on which Stellite 6 is deposited by PTAW hardfacing process is cleaned properly and use liquid dye penetrant test to ensure that there is no surface defects like cracks, surface pores etc. After that because of martensitic stainless steels has limited weldability due to its hardenability. So special considerations are required to avoid cold cracking. So the gate valve is preheated at 250°C for 1hrs in electric furnace. Using plasma transferred arc welding system, Stellite 6 powders deposited onto the preheated gate valve by hard facing technique are as follows. The available area for depositing Stellite 6 on work piece is deposited, by following string bead. With the help of non-consumable tungsten electrode of 4 mm diameter, the first linear bead was deposited for 117 mm length. At the end of first bead, second bead was started with 40 % overlap (i,e., 4 mm) and deposited. Similar procedure was followed for depositing the remaining area with same overlap. The interpass temperature 350°C maintained throughout the whole deposition and after each pass proper cleaning with the wire brush.

Fig 1 Stellite 6 Coated workpiece

After completing deposit on one side, keep the work piece inside the furnace for stress relief at temperature 630°C for 2hrs. After that again preheat for 250°C and starts hardfacing on opposite side of the work piece with same parameters again. Then kept the work piece inside the electric furnace at temperature 630°C for 2hrs. for stress relief followed by slow cooling inside the furnace.

MACHINING OPERATION

Make sure that the work piece cooled to room temperature before machining to avoid the chances of distortion. Now with the help of grinding machine, surface finish done and produce a flat hardface layer on the gate valve.The 5.4mm gate valve thickness after machined.

RESULT AND DISCUSSION

LIQUID PENETRENT TEST

Hence from the above experimental procedure and test we find that there is no significant defect occur on the hard face surface by following the above parameters.

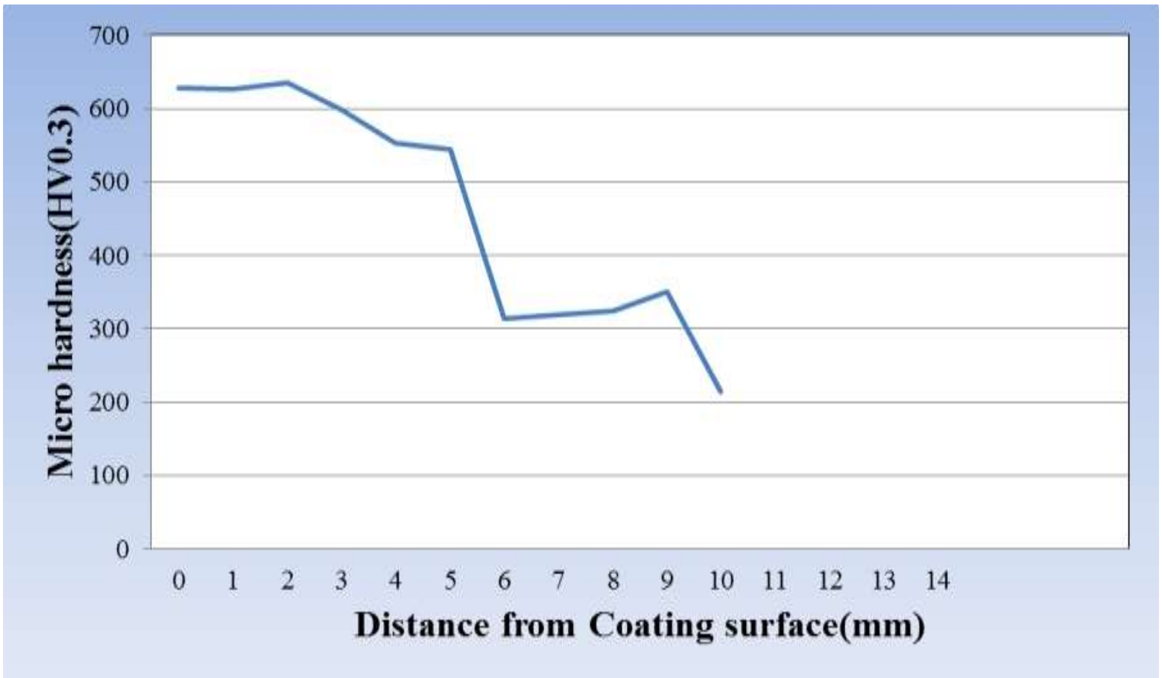
Table 5 Vickers Hardness Number of Base Material

SL.NO	DISTANCE FROM TOP SURFACE (in mm)	VICKERS HARDNESS NUMBER HV0.3
1	0	314
2	1	319
3	2	324
4	3	350
5	4	336
6	5	298

Table 6 Vickers Hardness Number of Stellite 6 coated Workpiece

SL.NO	DISTANCE FROM TOP SURFACE (in mm)	VICKERS HARDNESS NUMBER HV0.3
1	0	608
2	1	629
3	2	627
4	3	536
5	4	598
6	5	554

COMPARISION BETWEEN THE HARDNESS OF STELLITE-6 AND STAINLESS STEEL



Graph 4.1 Hardness of Stellite 6 and Stainless Steel

MICROSCOPIC STRUCTURES OF SPECIMEN USING SEM

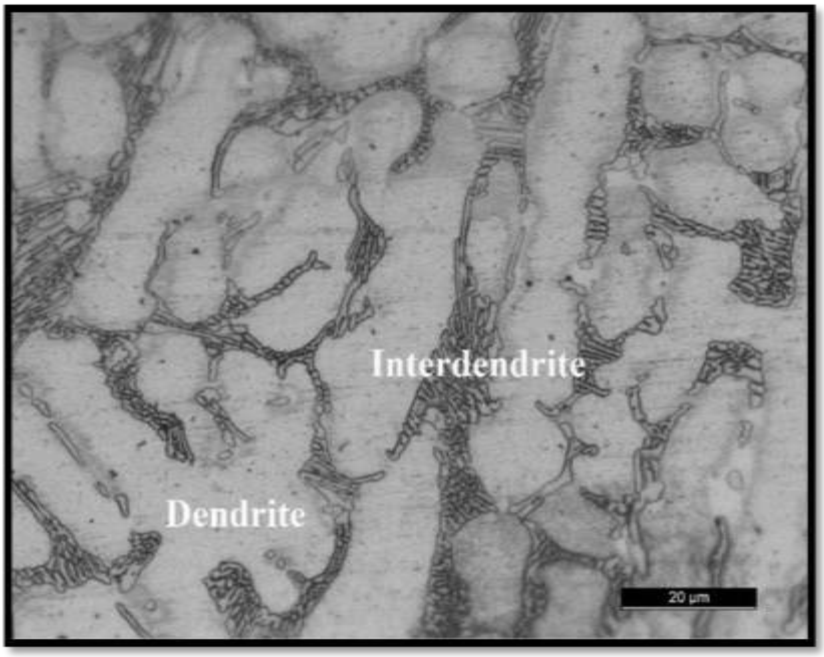


Fig 2 Microstructure of Stellite 6

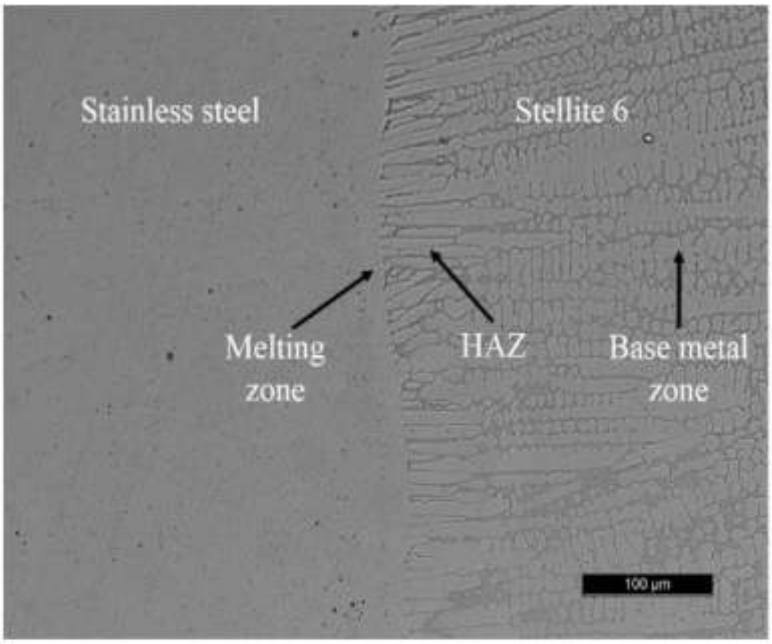


Fig 3 Microstructure of Stellite 6 and Stainless Steel

RESULT

The microstructure of Stellite 6 consisted of dendrites and interdendrites with eutectic carbides. The dendrites were planar, cellular and columnar, formed at the interface of the weld towards the top surface of coating. The HAZ was mini mum in Stellite 6 and the dendrites have formed from the HAZ itself. The alloying elements of coated Stellite 6 (Co , Cr & W) are comparatively higher than the nominal values.

CONCLUSION

Stellite 6 was coated on AISI 410 Martensitic steel by PTA welding process. It has been characterized using several techniques for microstructure hardness and its wear mechanism. The microstructure of Stellite 6 consisted of dendrites and interdendrites with eutectic carbides. The dendrites were planar, cellular and columnar, formed at the interface of the weld towards the top surface of coating. The HAZ was minimum in Stellite 6 and the dendrites have formed from the HAZ itself. The alloying elements of coated Stellite 6 (Co, Cr & W) are comparatively higher than the nominal values. High arc current in PTA process had increased the thickness of weldment more than 6.44 mm due to high weld deposition rate. Electron dispersive spectroscopy line scan analysis of alloying elements in Stellite 6 showed that there is sudden drop in iron towards the Stellite 6 fusion line in which indicates that the dilution of Stellite 6 into stainless steel is less. The hardness of Stellite 6 deposit was uniform from the coating surface and it reduces when it crosses the fusion zone and stainless steel base and the hardness near the HAZ of stainless steel is also minimum. The delamination and abrasive wear are the dominant wear mechanisms, as observed from the SEM micrographs of worn out Stellite 6 coating. It is evident that the PTA hardfacing process of Stellite 6 has good wear resistant.

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