HARDFACING OF VALVES FOR NUCLEAR APPLICATIONS

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Control valves for high pressure and abrasive service are hard faced with cobalt base alloys like stellite satisfactorily. Hard facing of SS Trims with stellite has been well established and at present no problems as far as quality and productivity are concerned.
However control valves for nuclear applications present a different scenario. Primary requisite is that cobalt base alloy is not advisable being radio active. Only Nickel base alloy like Colmcnoy and Deloro*** could be used. Since most of the Nuclear applications demand the use of SS 316 material, depositing nickel base alloy on SS will be difficult proposition considering the poor wettability between them. Stringent quality needs provide the chain of challenge. The challenge grows stiffer when facing smaller and inaccessible valve seating areas of hand operated bellows sealed valves which handles the heavy water constitute the major part of any nuclear control valve scheme.
This paper deals with the various techniques in depositing nicke based alloys on SS valve interiors, the problems encountered and the proven solutions to circumvent them to get optimum results in productivity without compromising the stringent quality & reliability requirements.

INTRODUCTION

Hard facing as we all know is a process of applying a layer, an edge or a point of wear resistant material on metal part to increase its resistance to abrasion erosion gailing or any form of wear and frequently used where the material used is inadequate to give the desired service life. This process is typically employed in case of valve internals (TRIMS) which are often subjected to galling and abrasion or erosion according to the nature of the service conditions. The generally used trim material in valves are austenitic stainless steel of grade AISI 316,304,316L AND 304L etc., and hard facing alloys used are cobalt and nickel base alloys which are matallurgically compatible and can take care of any form of wear. In case of nuclear applications the cobalt base alloys are not suitable because of its radio active nature. The only acceptable alloys are nickel base alloys which have high hardness very low ductility and very much prone to cracking. In this paper an endeavour is made to bring out the welding procedures tried to meet the requirements of Q.W.216 as specified in ASME Section IX and the process found most economical and suitable for valves particularly small ones like bellow sealed valves used in nuclear applications.

Selection of Process

The selection of the most suitable welding process and the welding technique are as important as selection of hard facing alloy is of group '4 B' cobalt free nickel base. The process is selected considering the following :

1. work piece factors
2. properties of the base metal
3. form and composition of hard facing alloy
4. quality requirements of the deposit
5. Welder skill and
6. cost

Work Piece Factor

The size, shape, weight and accessibility to the area where hard facing is required in order to take care of handling and pre-heating and post heating facilities are the important factors for selecting the process. In this case the size and weight does not pose any problem since they are small in size and light in weight hence any process could be adopted but according to the area to be hard faced and removal of slug and addition flux etc., are to be considered very seriously especially for the body seating area.

Properties of Base Metal

The properties of the base metal is one of the main factors to be taken into account while selecting the process like chemical composition, melting range, thermal expansion and contraction and also the process requirement like preheating and cooling rate should not add any determental effect on the base metal. In this particular requirement the base metal being Austenitic stainless steel of grade 316 304. The pre heating temperature should be as low as possible and also faster the cooling rate better the quality of the base metal is retained. But we all know in case of hard facing application higer the preheat temperature and slower the cooling rate can give crack free deposit.

Form and Composition of Hard Facing Alloys

Whatever the metallurgical compatibility between the base metal and hard facing alloy is proved, still the composition plays an important role selecting the process like weldability with the process same in the case with the available from. Generally the group 4B alloys are manufactured/available in powder and bare rod some manufacturers supply coated electrodes also.

Quality requirements of the Deposit

The quality requirements of hard faced areas in a valve are more stringent than any other applications like crushers for cement and sugar industries etc., where the defects like porosity, non-metallic inclusions and cracks etc. (Even in some cases, cracks are created intentionally) do not matter. Whereas in valve application, the hard faced area should be of defect free sound weld metal meeting the requirements like requisite hardness, liquid penetrant examination and chemical properties and also the service requirements like meeting the maximum permitted leakage value to the working pressure. There are valves for applications with a working pressure of as high as 250 kg/cm2 with maximum permitted leakage of 5cc/hour. Hence the process selected should be compatible of meeting the requirements for the intented service/application.

Welder Skill

It is the normal tendency to have the process which needs less skill in order to avoid the closer control of the welding operations. The quality requirements of the deposit is very much related to the process and the welder skill. The process like TIG welding and oxyacetylene requires more skill than arc welding but the dilution rate can not be controlled that easily.

Cost

Cost is also one of the criterion to be considered like consumption of gases, time and amount of hard facing alloys required. In case of oxyacetylene and TIG the deposition rate is very slow and the requirement of consumables also very high. By arc welding the deposition rate is very high. The material required for hard facing is also more compared Oxyacetylene process.

Process for Applications

The generally recommended and developed processes are as follows :

1) Spray Weld
2) Plasma transferred arc
3) Oxyacetylene
4) Gas tungsten arc welding and
5) Arc welding with coated electrodes.

Though all the above processes quality with merits and demerits, the most versatile and economical process found are Oxyacetylene, TIG and Arc welding especially for a ccntrol valves manufacturing industries where the variants are so high with trims having different contours. Typical components are shown in Fig. I,II,III and IV. Oxyacetylene and TIG welding processes were tried to qualify the procedures. The Arc welding with coated electrode had not been tried due to scarce availability of coated electrodes and fear of inevitable slag inclusions between the layers and difficulty in removal of slag which are inherent to this process considering the confined areas of the valve seats. Instead, Arc welding with un-coated electrodes was tried innovatively and the results obtained were quite encouraging The procedures tried and the results are given in table No.1.

Process recommendations and conclusion

To establish the most economical and efficient process all the three processes have been tried on mock up pieces(shown in fig. V and VI). The results revealed that i. The defects like non metallic inclusions & difficulties in additon of flux, backfire, poor visibility and thus poor manouerablity were noticed in case of oxyacetylene process. ii. Poor manouerability and poor accessibility were experienced in case of TIG Process though these processes otherwise qualified as stipulated in Q.W.216. Whereas this arc welding process with uncoated rods qualified without posing any such difficulties. The hardness and the chemical composition achieved are given in Table-II. The micro structures of the deposit and the fusion line are shown in fig. VII and VIII. Accessibility and manouerability were excellent and since no consumables like gas, and flux are required, this process proves to be economical too. Another factor worth mentioning is that the skill level required is not to that of TIG and Oxyacetelene process. These features make this process most economical and efficient.

TABLE - I PROCEDURES & RESULTS

PROCESS	OXYACETYLENE WITH FLUX	TIG	UNCOATED ELECTRODE BY ARC
Size of the filler	5 mm	5 mm	5 mm
No. of Layers Deposited	One	Two	Two
Pre-Heat Temp.	300°C	300°C	300°C
Cooling method	Air Cooling	F/C Cooling	Air Cooling
Current Characteristics & & Current	-	D.C/S.P.150A	D.C/R.P260A
Hardness	48 HRS at 2mm from the base	45-48 HRC 2m from the base	46-48 HRC 2mm from the base
Results of the LPI	Non Metallic inclusion	No significant defect	No Significant defect

TABLE-II CHEMICAL COMPOSITION AND HARDNESS

Cr.	C	Si.	Fe.	Ni.	Hardness HRC
11.8	0.5	3.2	4.8	Balance	49-51

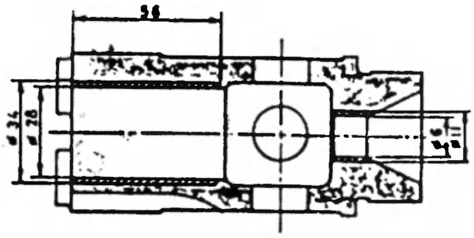

Fig : I Guide seat ring VST 1 High PR.

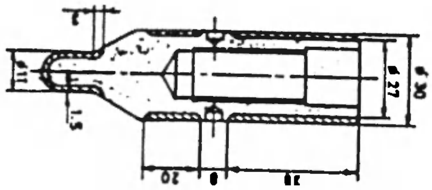

Fig : II Valve plug VST 1 High PR

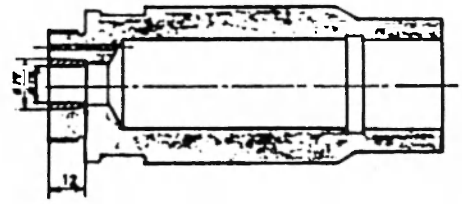

Fig . III Body Connector (BNM 10)

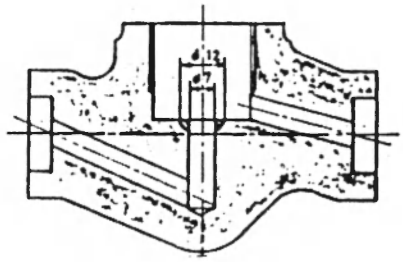

Fig : IV Valve Body (BNM 10)

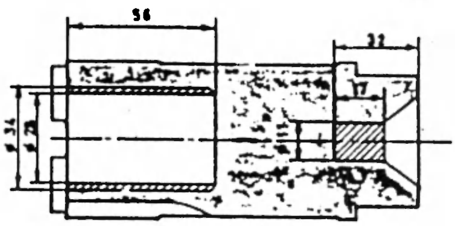

Fig : V Test piece for guided seat ring

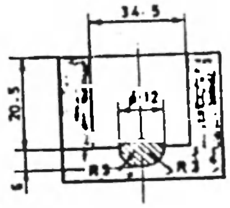

Fig : VI Test piece for valve body

Fig . VII

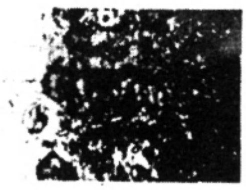

Fig : VIII