Implementation of Stainless Steel Buffer Layer for Reducing Crack Propagation on Regulating Valve Disc

Kora T Sunny
Assistant Professor
Department of Mechanical Engineering
Mar Athanasius College of Engineering
Kothamangalam, Kerala, India

Nevin Paul Zacharia
Student (B.Tech),
Department of Mechanical Engineering
Mar Athanasius College of Engineering
Kothamangalam, Kerala, India

Nikhil Dinesh
Student (B.Tech),
Department of Mechanical Engineering
Mar Athanasius College of Engineering
Kothamangalam, Kerala, India

Rosh V
Student (B.Tech),
Department of Mechanical Engineering
Mar Athanasius College of Engineering
Kothamangalam, Kerala, India

Rosh Luckose
Student (B.Tech),
Department of Mechanical Engineering
Mar Athanasius College of Engineering
Kothamangalam, Kerala, India

***Abstract*- Valves are devices that control or regulate the flow of fluid. Regulating disc is a critical component in valve which is subjected immense amount of pressure and temperature. Valves used for supercritical applications use F-91 grade disc in order to withstand the high temperature and pressure of the steam. Due to its specific operational conditions, it is hard-faced with technique employed to improve surface resistance of a component or part to abrasion, impact, corrosion and heat. The hard-facing process has certain inherent anomalies which lead to increased rejection and high cost factor In order to overcome the problems associated with hard-facing, a buffer layer was introduced into the disc. Buffer layers are intermediate deposits between the base material and the actual hard-facing weld metal Modified regulating disc were manufactured and tested. The discs are tested by various non destructive testing methods.**

Keywords: Regulating Disc, Supercritical applications, Stellite-6, Hard-facing, Buffer Layer, Non destructive Testing Methods.

1. INTRODUCTION

A power plant which operates above the critical condition is a super critical power plant. Cycle efficiency of a typical subcritical plant is 38% whereas today's supercritical technology increases this to around 45-47%. So super critical power plants are more beneficial. Supercritical power plants can generate huge amount of power in the range of 600MW. The valves employed in these power plants must be made with materials of superior mechanical properties to withstand high temperatures and pressures. For a valve with a bonnet, the disk is one of the principle pressure boundary. With the disk closed, full system pressure is applied across the disk if the outlet side is depressurized. Disc is the part of the plug that contacts the seat and seals off the fluid flow. Disk being a very critical component of the valve, it is hardfaced with stellite-6 to improve its wear and corrosion resistance. But these hardfacing causes surface defects and crack propagation and leads to increased rejection rate and high cost factor.

Table 1. Chemical Composition of Base Metal

Material	Basic element							
	C	Si	Mn	Cr	V	N	Nb	Mo
F-91 Stainless steel	0.08-.12	0.2-0.5	0.3-0.6	8.0-9.5	.18-0.25	.03-0.07	0.06-0.1	0.85-1.05

11. HARD FACING AND CRACK PROPAGATION

Fig 1 shows the regulating valve disk. Hard facing is a technique employed to improve surface resistance of a component or part to abrasion, impact, corrosion and heat. The advantages of hard facing are that the surfaces can be deposited on relatively much cheaper base metal to give the wear resistance or other qualities exactly where required with a great saving in cost[1]. Many hard-facing deposits contain cracks. They are not harmful to the hard-facing but there is a danger that, under heavy impact or flexing, the cracks will propagate into the base material and thus damage the component. Since the regulating disc of the valve is hardfaced with stellite-6, crack propagation will severely affect the proper functioning of the valve. The use of a tough buffer layer will prevent this crack propagation thus protect our component[2]. The problems associated with the hardfacing of the regulating disc for supercritical application involves frequent detection of crack and in the weld which leads to increased rework and more fatigue for labourers results in more rejections more cost and time loss.

Fig 1. Regulating valve disk

III. STUDY OF MATERIALS USED

3.1: Base metal

The raw material of the regulating disc is AS182 F-91, the alloy exhibit excellent high-temperature properties based on the formation of a particular microstructure containing sub microscopic carbides, and the alloy is also much more resistant to thermal fatigue that the austenitic stainless steel because of its lower thermal expansion rating and higher thermal conductivity. Chemical compositions of F-91 are shown in above table 1.

3.2: Stellite Coating

Stellite6 is a cobalt base alloys which consist of complex carbides in an alloy matrix. They are resistant to wear, galling and corrosion and retain these properties at high temperatures. Their exceptional wear resistance is due mainly to the unique inherent characteristics of the hard carbide phase dispersed in a Co-Cr alloy matrix. Stellite-6 is the most widely used of the wear resistant cobalt based alloys and exhibits good all-round performance. It is regarded as the industry standard for general-purpose wear resistance applications, has excellent resistance to many forms of mechanical and chemical degradation over a wide temperature range and retains a reasonable level of hardness up to 500°C (930°F). It also has good resistance to impact and cavitation erosion. Stellite-6 is ideally suited to a variety of hardfacing processes and can be turned with carbide tooling.

Fig 2 shows the image of regulating disk coated with satellite 6. This coating has excellent resistance to thermal shock and resists most types of mechanical wear especially when in combination with corrosion and/or temperature. When self-mated, it has a very low coefficient of friction of and exceptional resistance to galling. Galling is a form of wear caused by adhesion between sliding surfaces. When a material galls, some of it is pulled with the contacting surface, especially if there is a large amount of force compressing the surfaces together. Galling is caused by a combination of friction and adhesion between the surfaces followed by slipping and tearing of crystal structure beneath the surface. This will generally leave some material stuck or even friction welded to the adjacent surface whereas the galled material may appear gouged with balled-up or torn lumps of material stuck to its surface. Galling is most commonly found in metal surfaces that are in sliding contact with each other. It is especially common where there is inadequate lubrication between the surfaces. However, certain metals will generally be more prone to galling, due to the atomic structure of their crystals. Galling is a common problem in most applications where metals slide while in contact with other metals. This can happen regardless of whether the metals are the same or of different kinds.

Fig 2 Disk coated with stelliite 6.

IV SELECTION OF BUFFER LAYER MATERIAL

Austenitic stainless steels are the most weldable of all stainless steels and these steels have a face-centred cubic structure with 16% to 30% chromium and 2% to 20% nickel for enhanced surface quality, formability and increased corrosion and wear resistance, and are nonhardenable by heat treating. The chromium and nickel content provide the material with excellent corrosion and malleable (workable) properties at room temperature. Austenitic stainless steel has low temperature toughness retain larger fraction of room temperature strength at high temperature[3]. Excellent weldability as it has less tendency to form martensite and because of their high alloy content, austenitic steels are usually corrosion resistant. The austenitic stainless steel generally contain Ni to stabilize the austenite at room temperature. They also contain other alloying element such as chromium for corrosion resistant. Here we are using E 309-16L grade stainless steel. Composition of E309-16L is shown in the table 2

Table 2 Composition of E309-16L

Cr	Ni	Mn	Si	C	Fe
22-24%	12-15%	2.0%	1.0%	2.0%	Bal

V SELECTION OF WELDING PROCESS

For the welding of the stainless steel E309 16L on to the F-91 the shielded metal arc welding process was found to be appropriate compared to other welding techniques. Because of the versatility of the process and the simplicity of its equipment and operation, shielded metal arc welding is one of the world's most popular welding processes. It dominates other welding processes in the maintenance and repair industry, and though flux-cored arc welding is growing in popularity, SMAW continues to be used extensively in the construction of steel structures and in industrial fabrication. The process is used primarily to weld iron and steels including stainless steel but aluminium, nickel alloys can also be welded with this method. For the welding of stellite 6 on stainless steel E309 16 L buffer layer the tungsten arc welding was found to be appropriate.

VI TESTING

Table 2 Test result

ITEMS MADE	SIZE	PASSED	FAILED	REJECTED RATE
9 PIECES	10 INCH	4	1	20%
	12 INCH	3	1	25%

6.1: *Non-destructive testing (NDT)*

Non-destructive testing (NDT) is a wide group of analysis techniques used in science and industry to evaluate the properties of a material, component or system without causing damage. The terms Non destructive inspection is also commonly used to describe this technology. Because NDT does not permanently alter the article being inspected, it is a highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research. Common NDT methods include ultrasonic, magnetic-particle, liquid penetrant etc. NDT is used in a variety of settings that covers a wide range of industrial activity, with new NDT methods and applications, being continuously developed.

6.2: *Weld verification*

In manufacturing, welds are commonly used to join two or more metal parts. Because these connections may encounter loads and fatigue during product lifetime, there is a chance that they may fail if not created to proper specification. For example, the base metal must reach a certain temperature during the welding process, must cool at a specific rate, and must be welded with compatible materials or the joint may not be strong enough to hold the parts together, or cracks may form in the weld causing it to fail. The typical welding defects (lack of fusion of the weld to the base metal, cracks or porosity inside the weld, and variations in weld density) could cause a structure to break or a pipeline to rupture. Welds may be tested using NDT techniques. In a proper weld, these tests would show clear passage of sound through the weld and back, or indicate a clear surface without penetrant captured in cracks[4].

6.3 *Detection Of Cracks By LPI Test*

Liquid penetrant inspection (LPI), also called as Dye penetrant inspection (DPI), is a widely applied and low-cost inspection method used to locate surface-breaking defects in all non-porous materials like metals, plastics, and ceramics. LPI is used to detect casting, forging and welding surface defects such as hairline cracks, surface porosity, leaks in new products, and fatigue cracks on in-service components. The test surface is cleaned to remove any dirt, paint, oil, grease The penetrant is then applied to the surface of the item being tested. The penetrant is allowed "dwell time" to soak into any flaws. The excess penetrant is then removed from the surface. After excess penetrant has been removed a white developer is applied to the sample. The inspector will use visible light with adequate intensity for visible dye penetrant

6.4 Detection of Crack Propagation By Ultra Sonic Inspection

Ultrasonic testing (UT) is a family of non destructive testing techniques based on the propagation of ultrasonic waves in the object or material tested. In most common UT applications, very short ultrasonic pulse-waves with centre frequencies ranging from 0.1-15 MHz, and occasionally up to 50 MHz, are transmitted into materials to detect internal flaws or to characterize materials. A common example is ultrasonic thickness measurement which tests the thickness of the test object, for example, to monitor pipe work corrosion. Ultrasonic testing is often performed on steel and other metal and alloys, though it can also be used on concrete wood and composites.

VII CONCLUSION

The F-91 grade discs are hardfaced with satellite -6 to bring desired properties into it. Hard facing is a technique employed to improve surface resistance of a component or part to abrasion, impact, corrosion and heat. This hardfacing is associated with cracks which run into the base material and thus damage the entire component. introduction of buffer layer can be an effective solution to this problem. Buffer layers are intermediate deposits between the base material and the actual hard-facing weld metal. The modified discs were then tested and the results were exemplary. With the new modification the rejection rate came down from 30% to 20%. The test data shows that there is significant decrease in rejection rate and the thus modification proves to be effective.

VIII REFERENCES

[1] K.Gurumoorthy, M.Kamaraj, K.Prasad Rao, A.Sambasiva Rao, S.Venugopal (2007), Microstructural aspects of plasma transferred arc surfaced Ni-based hardfacing alloy. *Materials Science and Engineering.* Vol 456, 11-19.

[2] Olivera Popovic , Radica prockic, Aleksander Sedmac, Aleksander Bukvic, Galip Buyukyildrim (2011), The Influence of Buffer Layer on the Properties of Surface Welded Joint of High-Carbon Steel. *Materials and Technology,* Vol 6, 579-584.

[3] Nathaniel G. Cofie and Richard E. Smith (2008), Effectiveness of Stainless Steel Buffer Layer to Address Hot Cracking During Weld Overlay Repair of Dissimilar Metal Alloy 82/182 Welds With Stainless Steel Piping. *ASME Paper No. PVP2008-61411,* pp. 43-52.

[4] Gopa Chakraborty , C.R. Das, S.K Albert, A.K Bhaduri, S.Das, A.K Tyagi, N. Kumar (2014), Study on microstructure and wear properties of different nickel base hardfacing alloys deposited on austenitic stainless steel. *Surface and Coatings Technology,* Vol 244, 180-188.