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Comparison of Mechanical Properties of Bare and Stellite-21 Coated Aisi 316l, Sprayed By D-Gun Process

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ABSRACT
Present paper describes the mechanical properties of Stellite-21 coated AISI- 316LStainless steel. Specimens were coated using Detonation Gun thermal spray process,with different coating thicknesses of Stellite-21 ranging from 150 μm to 250 μm.Afterwards their properties like tensile strength and impact strength and were evaluatedon the basis of the results obtained from the experimentation. For comparison of substrate andcoated material, graphs were plotted. The coated specimens exhibited superior impactstrength,than that of the bare specimens, whereas the tensile strength of coated specimens decreased marginally with the increase in coating thickness.
Keywords: Thermal spray coating; Tensile strength Charpy impact test; Stellite-21 alloy;

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I. INTRODUCTION

Coating a material with another material is to done to obtain a combination ofproperties that combine the properties of the base material with other necessary properties that give corrosion resistance, wear resistance, better thermal or electrical conductivity etc found bySingh and Handa.[1]. In a wide variety of applications, mechanical components have to work under drastic conditions, such as high load, speed or temperature and hostile chemical environment. Thus, their surfaces have to be modified in order to protect them against various types of degradation reported by sidhu et al.[2].Thermally sprayed coatings are used in various applications often dedicated to corrosion and wear protection. Pores and other coating imperfections reduce corrosion and wear resistance andlor necessitate highercoating thicknesses found by B. Wielage et al.[3]. AISI 316L austenitic stainless steel is widely used in corrosive environments as it has high corrosion resistance. However, its wear, cavitation and erosion resistances are poor due to low hardness (220 HV), which restricts its use in many industrial applications reported by Viswanathan et al.[4].Austenitic stainless steel exhibits and stick chemical composition of clad layers which was controlled by mixing powders of Stellite 21 and AISI 316L SS in predetermined ratios found by Ganesh et al.[5]. Stellite 21 - A low carbon, molybdenum strengthened, cobalt-chromium alloy. Its "-Excellent high temperature strength and stability are responsible for its use as a hot die material, while its inherent resistance to galling (under self-mated conditions), cavitation erosion, and corrosion have made it a popular fluid valve seat facing alloy.this paper.This paper manages impact of stellite-6 coating on AISI 3016 stainless steel and on mechanical properties specifically. tensile strength and impact strength.

II. EXPERIMENTAL MATERIAL & PROCEDURE

Stellite-21 consists of a CoCrMo alloy matrix containing dispersed hard carbides or grain type powder show in Table 1.

AISI 316L Stainless Steel is extra low carbon version of 316 steel alloys. The low carbon content in AISI 316L Stainless Steel prevents the formation of carbide on the surface when material comes in contact of heat. This can be usedfor bearings which operate in corrosive environments such as running inside liquids. But this steel has slightly lower mechanical properties. This steel fails mainly due to wear and elevated temperatures.The chemical composition and physical properties of Stellite-6 are shown in the Table 2.

2.1 Experimentation of Charpy impact test specimens

On milling machine the sample for Charpy impact test were completed and took measurements as indicated by standard of ASTM A370. Primarily the specimens were generally cut and after that were ground on a surface grinder to make the sides perpendicular. There were 3 samples with the measurements of (10x10x 55) mm and these samples were also arranged in order to keep up repeatability of test reports. The notch was made with 2 mm depth

and 45˚ of included angle. Figure 1 shows the impact test specimen.

Fig.1.Impact Test Specimens.

2.2 Experimentation of tensile test specimens

The sample turned on lathe machine. The sample were prepared as per standard ASTM E8. There were 3 samples and each of them were coated and arranged in order to keep up repeatability of test reports. The measurement of gauge length was kept 12.5 mm for the uncovered sample. For the sample which were coated, the length of gauge were measurements were with 12.4 mm, 12.3 mm and 12.2 mm for coating thickness 100-150 µm, 150-200 µm and 200-250 µm individually. Figure 9 demonstrates the tensile test samples preceding coating.

Fig.2.Tensile test specimen

2.3 Coating of specimens

Awaaz Detonation Gun available at M/s SVX Powder M Surface Engineering Pvt.Ltd.,Greayer Noida (India).The Technical specification of the detonation gun is given in Table 3.The process parameter for thermal spray Stellite-21 before coating on the sample sand blast operation had done on bare piece, using alumina powder (Al2O3) to make the particular surface rough so the coating can adhere to the surface effectively Fig.4 show different coated specimens.

a) Charpy impact test specimen

b) Tensile test specimen

***Fig.3** Different coating Specimens.*

Table1

The chemical compositionof Stellite-21

Element	C	Si	Mn	Fe	S	Ni	Cr	Mo	Co
wt. %	0.26	1.88	0.65	1.4	-	2.8	26.3	5.53	Bal.

Table 2

Chemical composition of AISI 316 L

Element	C	Si	Mn	P	S	Ni	Cr	Mo	Fe
wt. %	0.02	0.43	1.32	0.026	0.03	10.27	16.57	2.01	Bal.

Table 3

Technical Specification of Awaaz Detonation Gun.

Working Gases	Oxygen, Acetylene, Nitrogen and Air
Consumption of Powder per Shot	0.02-0.05g/ shot
Water Consumption Rate	15-25 litres/minute
Firing Rate	1-10 Hz
Coating Thickness per Shot	5-25 µm
System Control	Manual/ Semi auto
Dimensions (L X B x H) mm	1200 x 500 x 1500
Sound Pressure Level	150 dB

Table 4: *Process parameters for Stellite-6 coating by D- gun thermal spray process.*

Parameter	Value
Oxygen Flow Rate	3120 SLPH (Standard Litres Per Hour)
Pressure	0.2 MPa
Acetylene Flow Rate	2400 SLPH (Standard Litres Per Hour)
Pressure	0.14 MPa
Nitrogen Flow Rate	1040SLPH(Standard Litres Per Hour)
Pressure	0.4MPa
Spray Angle	90˚
Spray Distance	150mm
Power	450VA

2.4 Testing of Specimens

Charpy Impact Test:The coated specimens for charpy impact test machine was available at CITCO-IDFC Testing LaboratoryIndustrial Area sector-1,Chandigarh. The impact testing method was tested on FIE make impact testing machine with the range of 1 to 300J.Fig 4 shows the specimens after Charpy impact test.

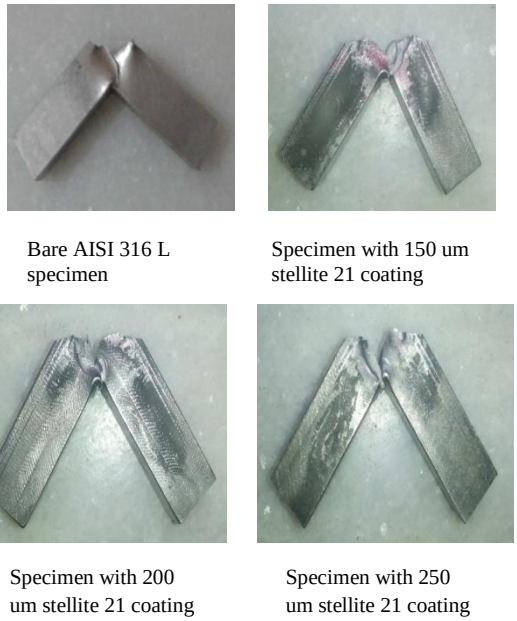

Fig 4. Specimens after charpy impact test.

Tensile Test:The coated specimens for Tensile test were tested on FIE make universal Tensile machine (UTE-100) of 100 ton capacity, available at CITCO-IDFC Testing Laboratory Industrial Area sector-1, Chandigarh. The tensile testing was done using ASTM E8/E8M standard. The gauge length was kept 60mm and gauge point were marked by using dot punch.The dumbbell shaped specimen were tightened in the jaws of the UTM.The load was applied gradually and reading were taken in Fig 5 show the specimen after tensile test.

Fig 5: Different Specimens after Tensile Test

III. RESULTS AND DISCUSSION

3.1 Charpy impact test

The energy consumed by the bare specimen was 156 kJ of energy which is lower than the coated specimen, whereas the specimens with 250µm Stellite-21 coating absorbed 218 kJ of energy. Therefore distinct behaviour was observed. The bare specimens showed less impact strength and the coated specimens showed better impact strength. The crack was made to propagate first through the Stellite-21 coated section followed by substrate. The impact strength went on increasing with the increase in coating thickness. The test results of Charpy impact test are represented graphically in figure 6.

3.2 Tensile test

The results of the test revealed that the bare AISI 316L specimens showed ductile failure.Necking took place in the gauge section and the specimen failed at a high value of UTS.However the specimens with Stellite-21coating showed different behavior. The coating on the specimens showed a brittle fracture and coating got detached from substrate thereby exposing the bare stainless steel beneath. This was followed by ductile failure

of the substrate. The tensile strength went on decreasing with increase in coating thickness. But the decrease is only marginal. The specimens with coating thickness of 250 µm had an average tensile strength of 0.758 N/mm2 whereas the bare specimens of AISI had an average tensile strength of 0.726 kN/mm2. This may be due to the effect of heat during surface treatment which may have resulted in microstructural changes in the material. The test results of tensile test are represented graphically in figure 7.

III. CONCLUSION

In the light of the results obtained during the course of present investigation, it is inferred that-

- The Stellite-21coating, on AISI 316L, done by D-gun process resulted in great increase in micro hardness which can be attributed to Co-Cr matrix formed in the coated section.
- The impact strength also improved as the thickness of Stellite-21 coating went on

Increasing .This is due to the crack propagation through the coating section

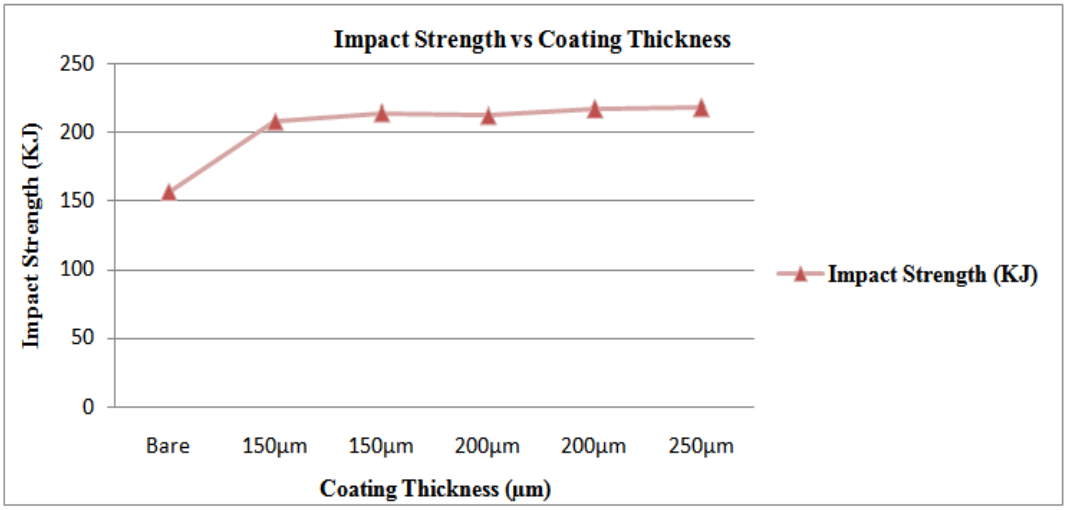

Figure 6: *Graphical representation of Charpy Impact Test*

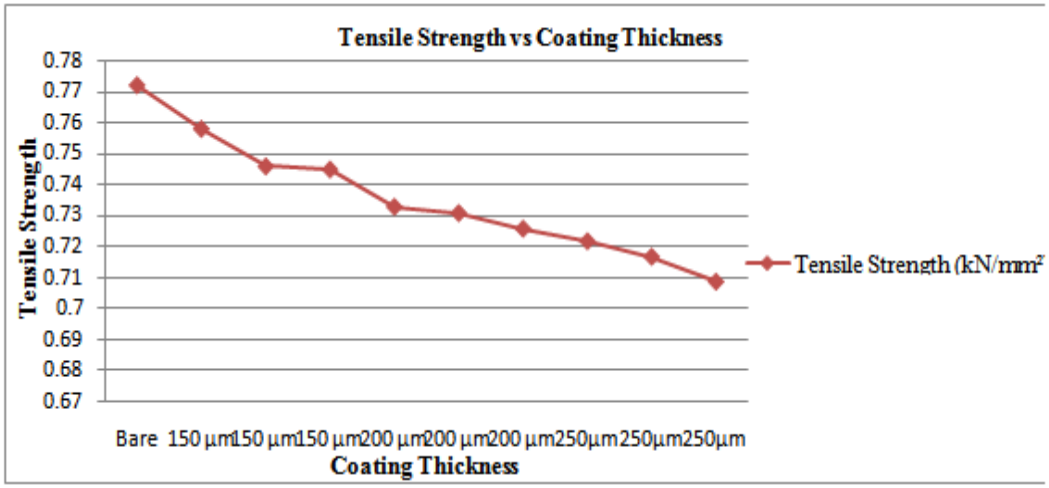

Figure 7: Graphical representation of tensile test on UTM

first and then going through the stainless steel substrate region.

- The increase in thickness of Stellite-21 had negligible effect on tensile strength. Detachment of the coating material occurred which exposed theductile substrate material. Therefore application of an interlayer or bond coat was suggested.

REFERENCES

[1]. Pushpinderjit Singh, Amit Handa,2016"mechanical properties of stellite-6 coated aisi 316l stainless steel" 2015, Vol. 22 Issue 4, p173-179. 7p.

[2]. Sidhu, B.S., Puri, D. and Prakash, S., 2005, "Mechanical and metallurgical properties of plasma sprayed and laser remelted Ni-20Cr and Stellite-6 coatings", Journal of Materials Processing Technology, pp.347-355.

[3]. Wielage.B, Hofmann.U,Steinhauser.S & Zim mermann.G "Improving wear and corrosion resistance of thermal sprayed coatings" Pages 136-138,2013P.

[4]. Viswanathan, A., Sastikumar, D., Kumar, H., Nath, A.K., 2009, "Formation of WC-iron Silicide (Fe5Si3) composite clad layer on AISI 316L stainless steel by high power (CO2) laser", Surface & Coatings Technology, pp. 1618-1623.

[5]. Ganesh P, Kaul R , Mishra S, Bhargava P, Paul C.P, Prem Singh Ch, P. Tiwari, S.M. Oak and R.C. Prasad., 2010, "Laser rapid manufacturing of bi-metallic tube with Stellite-21 and austenitic stainless steel" April 2009, pp. 169-174

[6]. Paul, C.P, Gandhi B.K,Bhargava.P, Dwivedi D.K, and Kukreja L.M "Cobalt-Free Laser Cladding on AISI Type 316L Stainless Steel for Improved Cavitation and Slurry Erosion WearBehavior"December 2014, Volume 23, Issue 12, pp 4463–4471

[7]. Krzysztof Piotr Sołek, Łukasz Rogal, and Platon Kapranos "Evolution of Globular Microstructure and Rheological Properties of Stellite 21 Alloy after Heating to Semisolid State" january 2017, Volume 26, Issue 1, pp 115–123

[8]. Ganesh P., Moitra, A., Tiwari Pragya, Sathyanarayanan, S., Kumar, Harish, Rai, S.K., Kaul, Rakesh, Paul, C.P., Prasad, R.C., Kukreja, L.M., 2010, "Fracture behaviour of laser-clad joint of Stellite 21 on AISI 316L stainless steel", Material Science and Engineering A, pp. 3748-3756.

[9]. Ganesh P., Moitra, A., Tiwari Pragya, Sathyanarayanan, S., Kumar, Harish, Rai, S.K., Kaul, Rakesh, Paul, C.P., Prasad, R.C., Kukreja, L.M., 2010, "Fracture behaviour of laser-clad joint of Stellite 21 on AISI 316L stainless steel", Material Science and Engineering A, pp. 3748-3756.

[10]. Mishra, N.K., Rai, A.K., Mishra, S.B. and Kumar, R., 2014, "Hot corrosion behavior of detonation gun sprayed Stellite-6 and Stellite-21 coating on boiler steel SAE 431 at 900˚C", International Journal of Corrosion, Vol. 2014, 4 pages

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