TuijinJishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No.4 (2023)

# Study on Solid Particle Erosion Studies of Super Co-605

**Prabhakaran D[1], Jegadeeswaran.N[2] Raju B T[3]Sunil Kumar Shetty[4]**

[1]*Research scholar,School of Mechanical Engineering, REVA University, Bangalore, Karnataka, India*

[2]*Professor, School of Mechanical Engineering, REVA University, Bangalore, Karnataka, India*

[3]*Professor, School of Applied Science, REVA University, Bangalore, Karnataka, India*

[4]*NMAM Institute of Technology (NMAMIT), Department of Mechanical Engineering, Nitte - 574110, India.*

***Abstract.***The present research investigates the feasibility of using HVOF sprayed cermet coating Stellite-6 on gas turbine material SuperCo-605. The coating is tested for its resistance to erosion under high temperature conditions at 750°C. Solid particle erosion studies were conducted using alumina sand as the eroding agent. Erosion studies were conducted with impact angles of 30°, 60° and 90°. The oxide and carbide coating performs better under sand erosion conditions. Stellite 6 coatings are damaged by the brittleness mode. The erosion behavior of the substrate materials is ductile and more resistant than the coating material. SEM microstructures were used for scars produced by the erodent at 30, 60, and 90degree impact angles. This also indicates that the material damage was due to the ploughing and trapping of alumina particles.

***Keywords: Erosion, HVOF, Alumina, SuperCo-605, Special Steel,Turbine materialsetc.,***

## Introduction

The increasing global demand for energy is an immense challenge for power producers around the world. Global energy consumption is expected to double in forthcoming years are the main drivers for increasing energy consumption are the for growing population and increasing urbanization in developing countries. Increasing energy demands combined with national and international regulations to reduce emissions have driven activities to increase plant efficiency, modernize plants using newer and better materials, use different types of fuel, etc. [1]. Today, gas turbines are used to generate electricity on a large scale to meet the needs of the electricity, chemical, pharmaceutical, fertilizer, etc. industries. An important area of development in gas turbines is the use of advanced materials to improve efficiency and reduce emissions [2]. There are additional requirements from the customer to the energy sector. Some of them are requirements for power to run at part load, to run with frequent starts, and the flexibility to run on different fuels.

Nowadays, there is a serious issue for gas turbine engines, which are faced with soil particle erosion. For aircraft, gas turbine engines are one of the most crucial and vital parts. According to the ASTM G76-02 abrasion resistance test, the aluminum coating is characterized as the most important and vital part[5]. The ASTM G76-02 abrasion resistance test resulted in the demonstration of the all properties of the aluminum-nickel material coatings and arc-sprayed aluminum. According to [5]. the two things help in industrial applications which include the corrosion-resistant coating properties, and erosion and, abrasion properties. Therefore, the high-temperature erosion studies as per ASTM G76-02 help to understand the mechanism. Thereafter the molten particles of powder are able to form a dense layer on the respective substrate to give protective coatings. On the other hand, [2]. mentioned that plasma spraying has been of immense use in a number of areas including petrochemicals, aeronautics, and astronautics with its immense benefits of exerting robust thickness.

The next step of the study will be the identification of the high-temperature erosion rates and the estimate of the behavior of the coatings is an increase in the eroding fluid has resulted in elevated levels of the amount of erosion. As per the point of view of [6]. coatings able to control erosion show high performance in providing protection against airborne particles and poor conditions. With the incorporation of appropriate and accurate coating, erosion can be prevented to a great extent. Coatings working in extreme temperatures and corrosion are seen to protect surfaces from erosion as well. Hence, the incorporation of the HVOF technique along with the tests will be an important approach to determining the durability of coatings. As per the comments of [4]. hot corrosion and degradation by high temperatures has been a drawback witnessed by the turbine industry.

Failure of different modes of components involving petrochemical installations, metallurgical furnaces, boilers, and gas turbines is highly affected by such harsh conditions. A combination of cyclic hot corrosion, cyclic erosion as well as oxidation has been done to present the comparative analysis of the coated and the uncoated alloys [2]. In contrast to this, the erosion test was conducted by taking alumina as an erodent. Erosion studies of 25% ($Cr_3C_2$-25(Ni20Cr)) + 75%NiCrAlY, and 10%$Al_2O_3$+CoCrAlTaY will be analyzed in order to understand their behavior. This will be presenting a comparison between the coating materials and the substrate along with an understanding of their durability [3]. Thus, the technique is significant to determine the extent to which harsh conditional influence the performance of equipment used in the turbine industry.

**Results and Discussion**

**Superco-605**

The photographs of the erosion scar produced on the Superco-605 sample, with 30º, 60º and 90º of erodent impact angle are shown in Fig. 1.1 a, b, c, respectively. The centre portion of the eroded scar (A) represents a localized region of material removal and it is surrounded by a region of elastic loading (B). Erosion rate and steady state volume erosion rate are estimated as explained The erosion rate curves along with the bar chart indicating the volumetric steady state wear loss are shown in Fig. 1.2. It is seen that the steady state volume erosion rate is highest at 30° and least at 90º impact angle (Fig. 1.3b).

This is the characteristic behaviour of materials which exhibit ductile mode of erosion. Fig. 1.2 shows microstructural details in the scar produced on uncoated Superco-605 using 30° impact angle. The microstructures show damage in the form of ploughing (Fig. 1.2a), entrapment of debris (Fig.1.2b) and groove formation (Fig. 1.2c). Similarly, Fig. 7.9 shows microstructural details in the scar produced using impact angle of 60º. It also shows material damage in the form of ploughing (Fig. 1.3a), groove formation (Fig. 1.3b) and craters (Fig. 1.3c). Possibly, craters are formed due to falling off of entrapped erodent particles. Fig. 1.4 shows micrographs presenting the type of material damage during the 90º impact of erodent. Here also, the material damage by ploughing (Fig.1.4a), crater formation (Fig. 1.4b) and entrapment of erodent particles is observed.

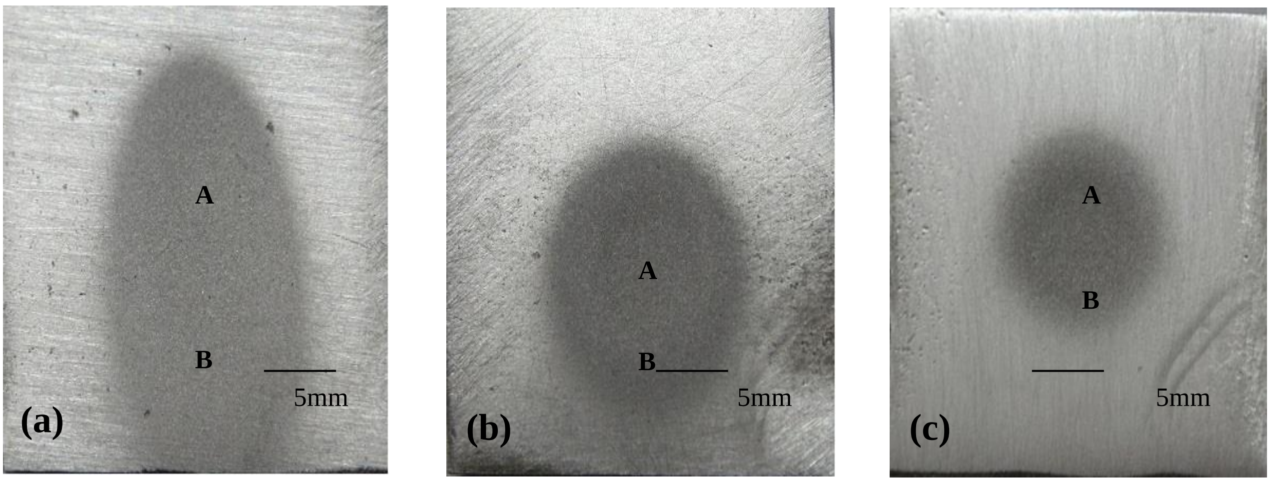


**Fig. 1.1 Macrographs of uncoated Superco-605 superalloy impacted by silica erodent at different angles. (a) Impact angle of 30º (b) Impact angle of 60º (c) Impact angle of 90º .**

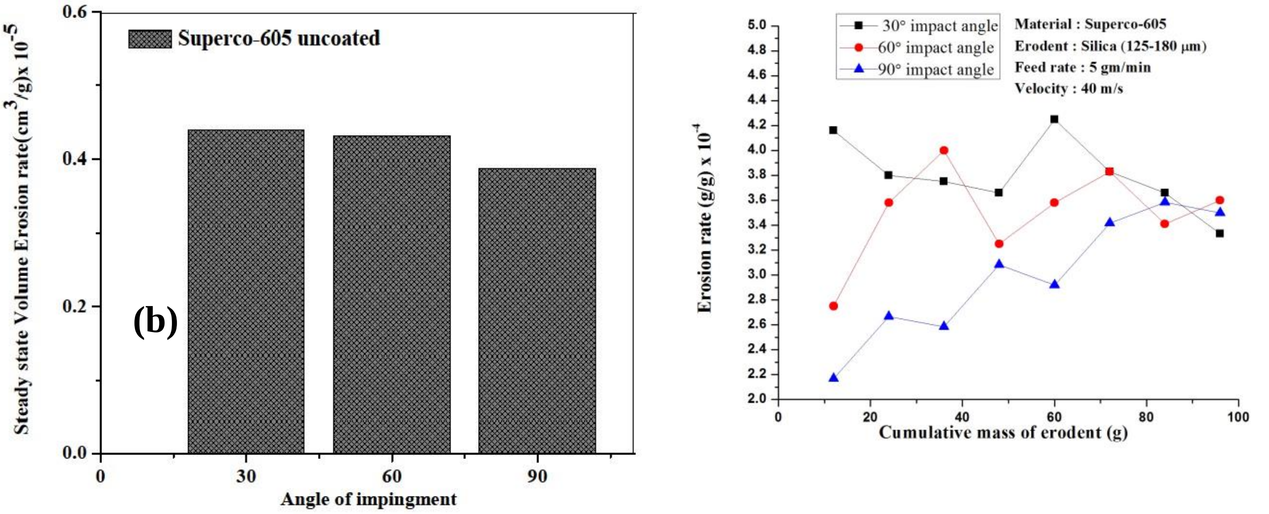


**Fig. 1.2 Plot of erosion rate of uncoated Superco-605 superalloy impacted at 30º, 60º and 90º impact angle. (a) Variation of the erosion rate (b) Histogram illustrating the steady state volume erosion rate.**

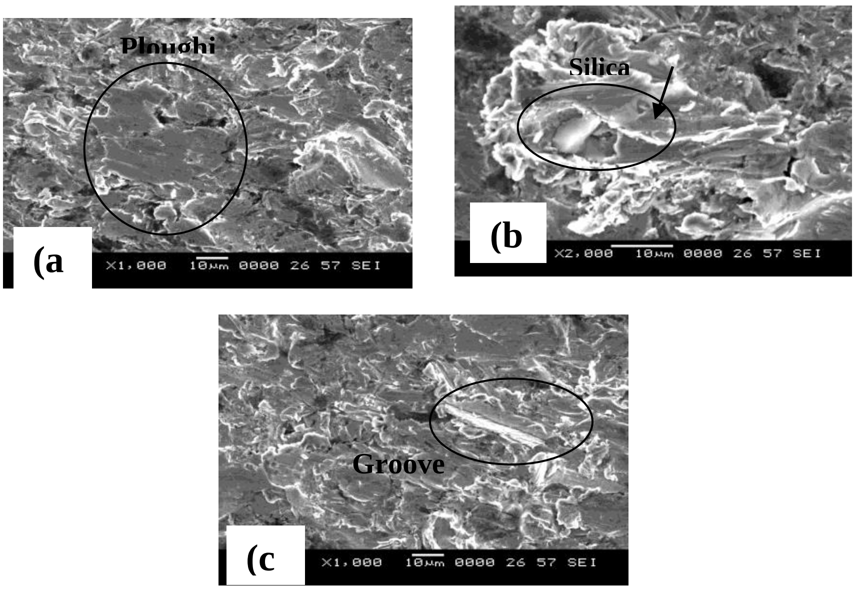


**Fig. 1.3.SEM micrographs showing the morphology of eroded surfaces on uncoated Superco-605 with an impact angle of 30º.**

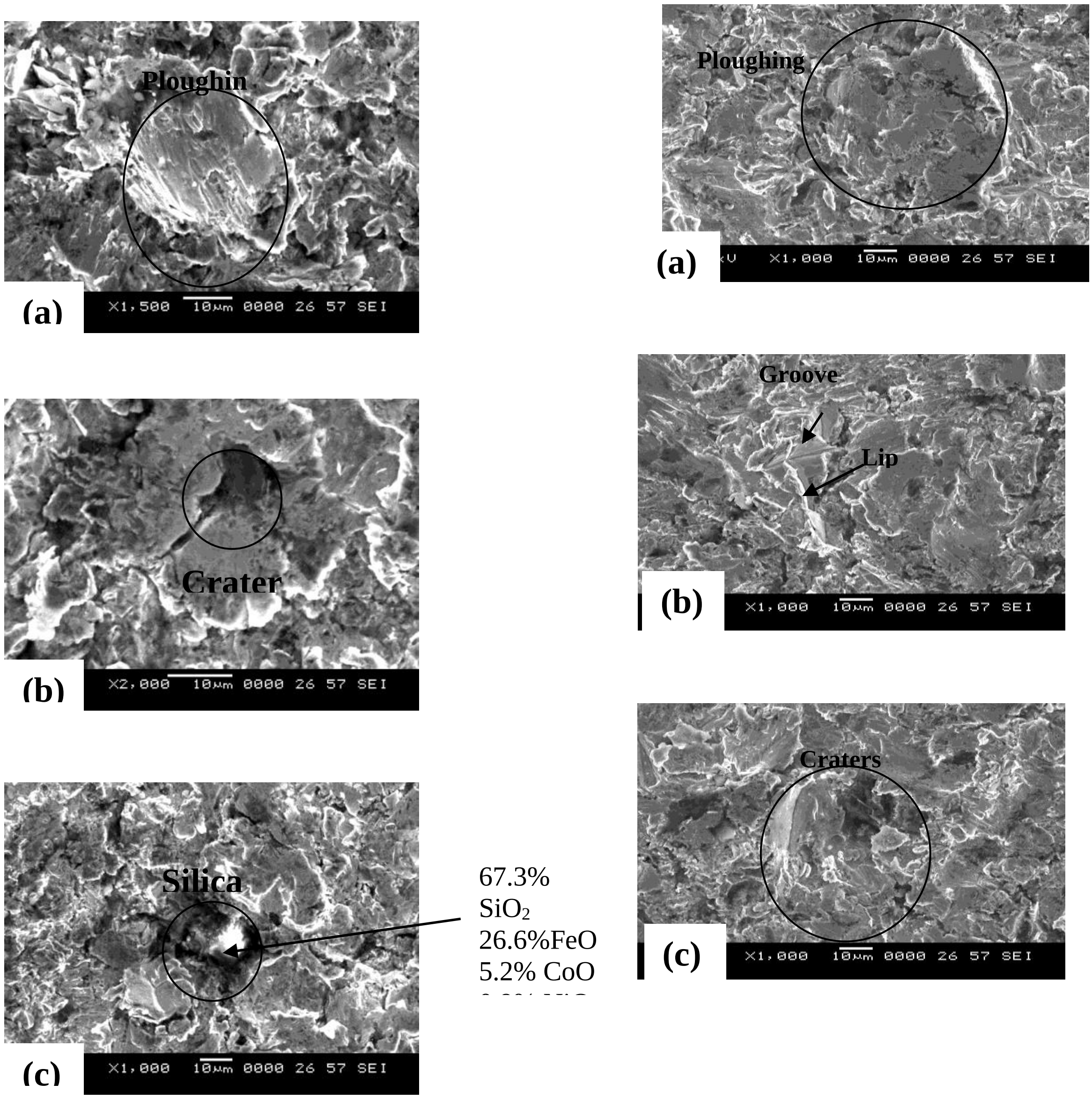


**Fig. 1.4 and Fig1.5 SEM micrographs showing the morphology of eroded surfaces on uncoated Superco-605 with an impact angle of 60°and 90° respectively.**

**Summary**

1. The high temperature erosion resistance of the oxide coating. The plot of erosion rate as a function of eroded mass shows that for all samples (Superco-605 and MDN-121) the erosion rate for the case of erosion is maximum at 30° impact angle. The erosion rate is minimal for the case of an impact angle of 90°. The plots of steady-state volume erosion rate versus impact angle also show that the steady-state volume erosion rate is minimum at 90° impact angle and maximum at 30° impact angle for all uncoated samples. A similar behavior is reported for high temperature materials and is explained in terms of the relative hardness of eroding particles and the sample to be eroded.

2. At impact angles of 60° and 90°, the erosion loss is lower compared to an impact angle of 30°. This is due to the embedding of silica particles (erodent) in the target material and this tends to occur at a higher angle of incidence. This acts as a protective shield against further impacting particles

3. The morphology of the eroded surface shows craters, groove formation in binder matrix and carbide particle pull-out as the prevailing erosion mechanism.

**4.** Substrate alloys exhibit lower steady state volume erosion rate in comparison to all the HVOF coatings under similar test conditions. The higher hardness ratio between alumina erodent particle and substrate alloys lead to the penetration of silica particles into the surfaces which bestow some shielding effect against impacting particles leading to lower wear loss. Also, the uncoated alloys being ductile in nature, plastic deformation and strain hardening contributes to increased erosion resistance.

**References**

[1] Oskarsson, H.. Material challenges in industrial gas turbines. Proc., of Sino-Swedish Structural Materials Symposium,(2007) 11-14.

[2] Wright, I.G. and Gibbons, T.B.. Recent developments in gas turbine materials and technology and their implications for syngas firing. Int. Journal of Hydrogen Energy, 32 (2007) 3610-3621.

[3] Sidhu, B.S., Puri, D. and Prakash, S.. Mechanical and metallurgical properties of plasma sprayed and laser remelted Ni-20Cr and satellite-6 coatings. Journal of Materials Processing Technology, 159 (3) (2005) 347-355.

[4] Sidhu, T.S., Malik, A., Prakash, S. and Agarwal, R.D. Oxidation and hot corrosion resistance of HVOF WC-NiCrFeSiB coating on Ni- and Fe- based superalloys at 800 ºC. J. Thermal Spray Technol., 16(5-6) (2007) 844-849.

[5] Kosel, T.H.. Friction, lubrication and wear technology. ASM Handbook, 18 (1992) 199-205.

[6] Jegadeeswaran N, Characterization of Stellite-6 HVOF Coatings on Titanium Alloy"Journal of Mines, Metals and Fuels, 12A (2021) 20-23.

[7] N.Jegadeeswaran, K.Anand Babu, B.S.Raju L.H.Manjunath B.Somasundaram, Room temperature erosion studies on titanium alloy and stellite-6 coatings, Materials Today Proceedings 45 (2021) 365-371.

[8] 8.Mondal, K., Nuñez III, L., Downey, C. M., & Van Rooyen, I. J. (2021). Thermal barrier coatings overview: Design, manufacturing, and applications in high-temperature industries. Industrial & Engineering Chemistry Research, 60(17), 6061-6077. Retrieved on 16th March, 2023 from: https://www.osti.gov/pages/servlets/purl/1805720