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MICROWAVE-ASSISTED CLADDING OF EN-8 STEEL USING NI-BASED COLMONOY-88 FOR ENHANCED WEAR AND CORROSION RESISTANCE

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Abstract: **Surface degradation in engineering components caused by wear and corrosion is a persistent challenge, especially in aggressive high-temperature environments. This study explores the potential of hybrid microwave heating (HMH) to develop Colmonoy-88 (a nickel-based alloy) cladding on EN-8 steel substrates to enhance surface properties. The cladded samples were characterized using advanced techniques like SEM, XRD, and microhardness testing. Tribological properties were evaluated using pin-on-disc tests under dry sliding conditions. Results demonstrate significant improvement in hardness, wear resistance, and corrosion resistance compared to the unmodified EN-8 substrate, confirming the viability of microwave-assisted cladding as a cost-effective surface engineering technique.**

I. INTRODUCTION

Surface degradation of engineering components due to wear and corrosion is a significant challenge, particularly in aggressive industrial environments. High-temperature operations, necessary for enhancing machine efficiency as per Carnot's theorem, exacerbate this degradation through oxidation, wear, and chemical reactions with environmental elements [1]. Wear mechanisms, such as abrasive and adhesive wear, result in material loss, leading to equipment failure and economic losses. Corrosion, particularly high-temperature oxidation, accounts for substantial financial losses globally, including an annual $300 billion loss in the United States alone [2].

Preventing wear and corrosion often involves surface engineering techniques like coatings, which enhance surface properties without altering the bulk material. Among these, nickel-based alloys, particularly Colmonoy, are known for their excellent wear and corrosion resistance, high-temperature strength, and ability to form protective oxide layers [3-4]. Colmonoy-88, a nickel-chromium-based alloy, is particularly effective due to its composition, which includes borides and carbides that enhance hardness and resistance to wear and corrosion.

Conventional cladding techniques like laser cladding and thermal spraying have been extensively studied for applying Colmonoy-88 [5-6]. However, these methods are often costly and require significant energy inputs. Hybrid microwave heating (HMH) has emerged as a novel and energy-efficient alternative for surface modification. HMH combines microwave energy with traditional heating mechanisms, enabling rapid and uniform heating and facilitating the formation of metallurgical bonds between the substrate and cladding material [7].

This study investigates the application of HMH to deposit Colmonoy-88 cladding on EN-8 steel substrates, focusing on microstructural, mechanical, and tribological properties. By leveraging the unique advantages of microwave heating, this research aims to provide a cost-effective and sustainable solution to surface degradation in engineering components

II. MATERIAL AND METHODS

2.1 Materials EN-8, a medium-carbon steel known for its machinability and strength, was selected as the substrate. The Colmonoy-88 powder, composed of Ni, Cr, W, Si, Fe, B, and C, was used for cladding. The chemical compositions of the materials are presented in Table 1. The process parameters employed in the experiments are detailed in Table 4.2.

Table 1. Chemical compositions of the materials

Steel substrate	C	Cr	Mn	P	Si	S	Mo	Fe
EN8 or 080M40	0.42	0.03	0.60	0.07	0.21	0.04	0.11	Balance

Table 2. Process Parameters for cladding of Colmonoy-88 on substrate EN-8.

Process Parameter	**Descriptions**
Microwave applicator	VB Ceramics, Chennai
Working frequency and maximum power rating.	2.45 GHz and 1.1kw
Exposure time	900 sec
Work-piece material	EN-8
Susceptor material	Fine graded charcoal powder
Separator material	98% pure zirconia with 1 mm thickness
Interfacial Powder	Colmonoy-88

2.2 Microwave-Assisted Cladding

Hybrid microwave heating was utilized to deposit Colmonoy-88 on EN-8. The process involved spreading Colmonoy-88 powder uniformly over the substrate, with charcoal powder serving as a susceptor. The setup was heated using a 2.45 GHz industrial microwave for varying exposure times to achieve optimal cladding conditions. A metallurgical bond between the clad and substrate was formed through localized melting and diffusion. Figure 1 illustrates the hybrid microwave heating mechanism employed in this research to deposit Colmonoy-88 cladding onto EN-8 substrate materials.

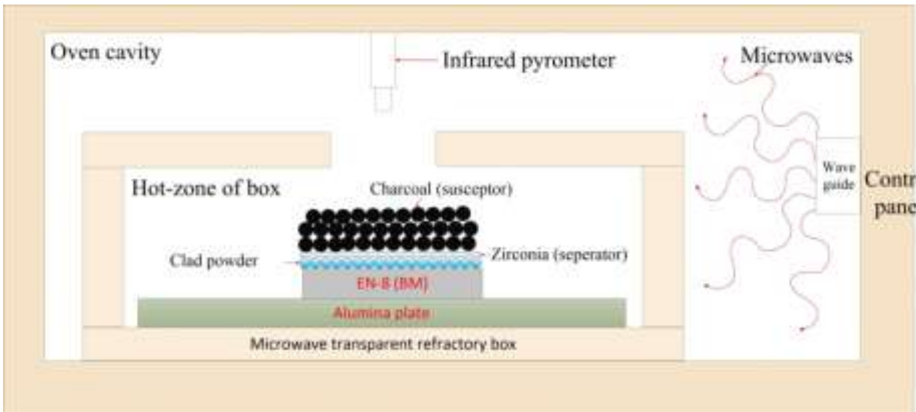

Figure 1. Schematic of the experimental setup used to modify the surface of EN-8 with Colmonoy-88 powders using hybrid MH technique.

2.3 Characterization Techniques

1. **Microstructural Analysis**: The microstructure of the cladded specimens was examined using SEM and EDS. XRD was employed to identify the phases present in the cladding.
2. **Hardness Testing**: Microhardness was measured across the cross-section of the cladded layer using a Vickers hardness tester.
3. **Wear Testing**: Dry sliding wear tests were conducted using a pin-on-disc tribometer following ASTM G99 standards. Weight loss was recorded at intervals up to a total sliding distance of 5000 meters.

III. RESULTS AND DISCUSSION

3.1 Microstructure and Phase Analysis The particles that constituted the Ni-based colmonoy 88 alloy powder had a mainly spherical morphology as shown in Figure 2. The SEM analysis revealed a dense and uniform microstructure with dendritic formations of a γ-Ni matrix interspersed with carbides and silicides. XRD analysis confirmed the presence of Ni_3Si, Cr_7C_3, and other complex carbides and borides, which contributed to the enhanced hardness and wear resistance of the clad layer.

3.2 Microhardness The average microhardness of the cladded layer was measured at 750 HV, significantly higher than the 180 HV observed for the EN-8 substrate. This improvement is attributed to the formation of hard intermetallic phases and a strong metallurgical bond.

3.3 Wear Resistance Figure 3a illustrates the calculated sliding wear coefficient for all specimens (EN-8 base material and Colmonoy-88 modified clads). From Fig. 3b, it has been deduced that the sliding wear coefficient of clad specimen is significantly less than as compared to the EN-8 substrate material. The cladded samples exhibited excellent wear resistance, with weight loss reduced by 70% compared to the unmodified EN-8. The wear mechanism was primarily abrasive for the EN-8 substrate, whereas the clad layer demonstrated minimal material removal due to the protective carbide phases.

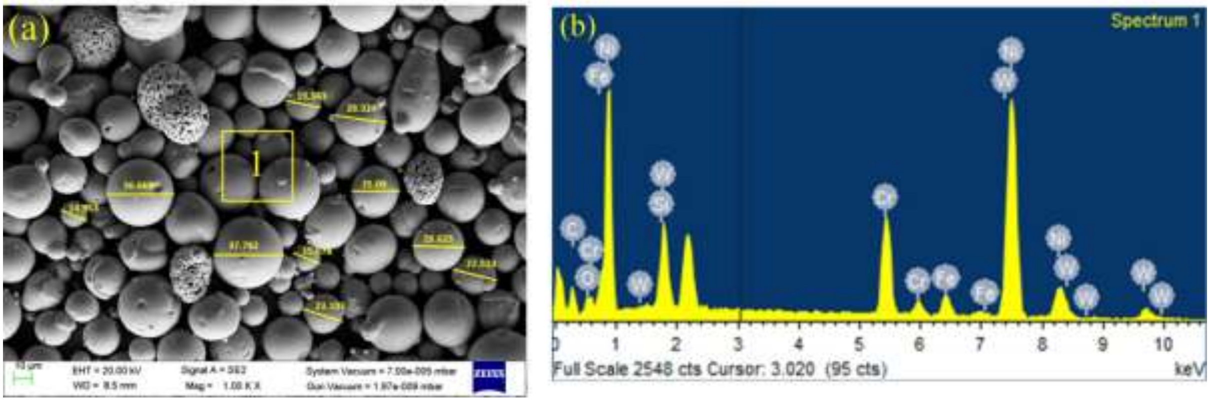

Figure 2. SEM micrograph illustrates the morphology of colmonoy-88 powder, (b) EDS spectrum corresponding to selected area of spectrum 1.

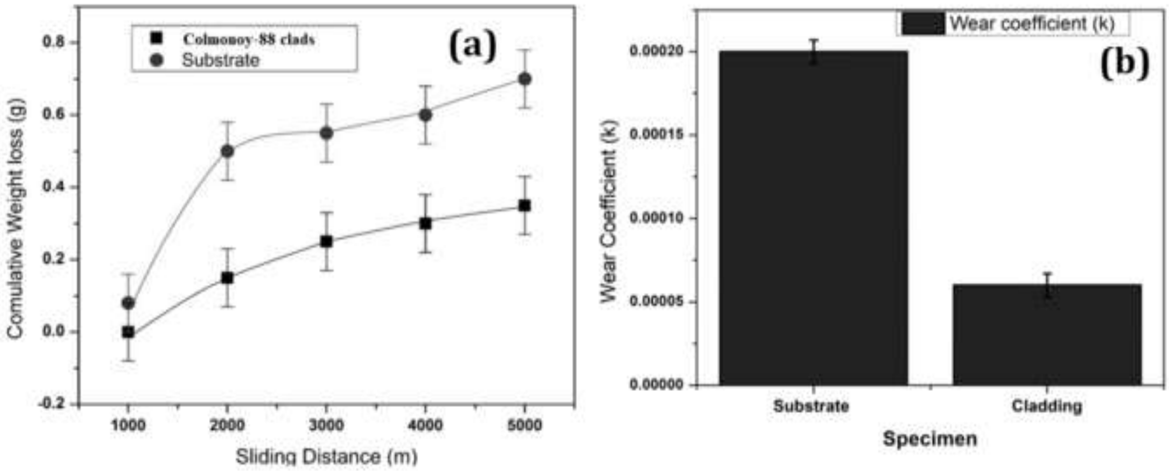

Figure 3. Cumulative weight loss against sliding distance for EN-8 base material and Colmonoy-88 modified clads and, (b) sliding wear coefficient for tested EN-8 base material and Colmonoy-88 modified clads.

3.4 Corrosion Resistance The cladding provided superior protection against high-temperature oxidation and chemical corrosion, as evidenced by the formation of a stable chromium oxide layer. This characteristic is particularly advantageous for components operating in aggressive environments.

IV. CONCLUSION

The present study investigated the microstructural characteristics and sliding wear behavior of Colmonoy-88 hard-facing alloy deposited on EN-8 steel using a hybrid microwave heating approach. The Ni-based Colmonoy-88 alloy was successfully deposited with a metallurgical bond free from cracks or defects. The cladded layer displayed a thickness of 550–650 μm and exhibited dendritic microstructures with complex carbides and borides of chromium, tungsten, nickel, and iron, as well as Ni-based silicides. The average microhardness of the cladded layer was 680 ± 40 HV, approximately 3.4 times higher than the EN-8 substrate, resulting in improved wear resistance. The porosity in the modified layer was low (1–1.5%), attributed to uniform volumetric heating. The wear tests revealed significantly lower weight loss in the cladded samples compared to the substrate, with a reduction of 35.71% under identical conditions. These enhancements are primarily due to the presence of hard carbide and silicide phases within the Fe-Ni matrix, which improved hardness and wear resistance.

V. REFERENCES

[1]. Mondal, A., Upadhyaya, A. and Agrawal, D., 2009. Microwave sintering of W-18Cu and W-7Ni-3Cu alloys. Journal of Microwave Power and Electromagnetic Energy, 43(1), pp.11-16.

[2]. Kou, S., (2002). Welding Metallurgy, 2nd Ed, A Wiley-Interscience Publication, New Jersey.

[3]. Heath, G. R., Heimgartner, P., Irons, G., Miller, R. D., & Gustafsson, S. (1997). An assessment of thermal spray coating technologies for high temperature corrosion protection. In Materials science forum (Vol. 251, pp. 809-816). Trans Tech Publications Ltd

[4]. Sidky, P. S., & Hocking, M. G. (1999). Review of inorganic coatings and coating processes for reducing wear and corrosion. British Corrosion Journal, 34(3), 171-183

[5]. Lim, L. C., Ming, Q., & Chen, Z. D. (1998). Microstructures of laser-clad nickel-based hardfacing alloys. Surface and coatings technology, 106(2-3), 183-192.

[6]. Gupta, D., & Sharma, A. K. (2011). Development and microstructural characterization of microwave cladding on austenitic stainless steel. Surface and Coatings Technology, 205(21-22), 5147-5155

[7]. Hebbale, A.M. and Srinath, M.S., 2016. Microstructural investigation of Ni based cladding developed on austenitic SS-304 through microwave irradiation. Journal of materials research and technology, 5(4), pp.293-301.

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