Vol. 06, No. 3 (2024) 933-940, doi: 10.24874/PES06.03.005

Proceedings on Engineering Sciences

www.pesjournal.net

HIGH VELOCITY OXY - FUEL COATINGS TRIBOLOGY: A CRITICAL REVIEW

Balachandra P Shetty
G J Naveen[1]
Shailesh Rao A

Received 02.09.2023.
Received in revised form 12.10.2023.
Accepted 16.11.2023.
UDC – 539.92

Keywords:

Tribology, HVOF, Coatings, Microstructure, Review

A B S T R A C T

High velocity oxy-fuel (HVOF) coating is a widely used thermal spray technique for applying wear-resistant coatings on metallic surfaces. The primary objective of this review is to provide an overview of the tribological properties of HVOF coatings. The review starts with a brief introduction to HVOF coatings, followed by a discussion of the various types of HVOF coatings and their microstructural characteristics. The tribological properties of HVOF coatings, including hardness, wear resistance, friction coefficient, and adhesion, are then discussed in detail. The influence of various parameters, such as coating material, substrate material, and testing conditions, on the tribological behaviour of HVOF coatings is also reviewed. A review of HVOF coatings tribology would cover the latest research on the subject, including the types of coatings available, their properties, and the methods used to evaluate their performance. It would also examine the challenges and opportunities in the field, such as developing new coatings for extreme environments or improving the coating-substrate adhesion. Finally, the review concludes with a summary of the key findings and suggestions for future research directions. Overall, this review highlights the potential of HVOF coatings to improve the tribological performance of metallic components in various industrial applications.

1. INTRODUCTION

Due to its great benefits, such as affordability and simplicity of usage, thermal spraying has become a popular modern surface engineering technology in a variety of industries. As it enables the application of coatings and surface modifications to extend the life, improve performance, and improve the aesthetics of materials used in the manufacture of engineering components, the use of thermal spray technology has grown in significance (Ramezani et al., 2023; Varis,2023). This technology was created to stop parts from deteriorating or breaking down as a result of exposure to different conditions, such as liquids or gases. It is feasible to enhance component performance by selectively applying coatings that perform particular activities without reducing the advantages of the underlying material (Jonda et al., 2023; Sauceda et al., 2023). The three main techniques for thermal spraying-flame sprays, electric arcs, and plasma arcs-all entail melting or semi-melting thin film materials that are in powdered, wire, or rod form (Turunen et al., 2006). The resulting heated particles are then fired by atomization jets or process gases towards the direction of the prepared surface, where they collide and join the surface to thicken it and create a lamellar structure. Extremely rapid cooling of the thin "splats" takes place, frequently exceeding 106 K/s for metals (Sun et al., 2022). Improved thermal spray coatings for metals, ceramics, metallic amorphous

[1] Corresponding author: G J Naveen
Email: gj_naveen@yahoo.co.in

materials, and cermets have been the subject of research in recent years. These coatings can shield a variety of components (mechanical, electrical, and civil) from surface contact situations that involve severe erosion, corrosion, and wear. Due to their capacity to increase the wear resistance of industrial components, High Velocity Oxy Fuel (HVOF) coatings have grown in importance (Mutairi et al., 2015; Knight & Smith, 1998). In the HVOF process, a powdered feedstock material, such as metals or ceramics, is heated and accelerated at high speeds using a mixture of oxygen and fuel gases, often propane or hydrogen. A dense, tightly-bonded covering with a high adhesion strength is created when the high-velocity particles strike the substrate surface (Zhou et al., 2022; Lv et al., 2022). Studying and improving the performance of these coatings heavily relies on tribology, the science and technology of friction, wear, and lubrication. In order to comprehend the most recent advancements and difficulties in the industry, a comprehensive analysis of HVOF coatings tribology is required (Qiao et al., 2021). This critical review's objective is to give a thorough summary of the state of HVOF coatings tribology at the moment. It will go over the many coating kinds that are offered, their characteristics, and how well they operate in various situations, including corrosive ones, high pressures, and high temperatures (Wang et al., 2021). In numerous applications, including the aerospace, automotive, and marine industries, the tribological characteristics of HVOF coatings have been thoroughly researched. HVOF coatings have been proven to have more wear resistance than other thermal spray coatings like plasma and flame spray (Abbas et al., 2021). HVOF coatings are perfect for applications where wear and abrasion are key problems because to their high hardness, and they are also suited for hostile environments due to their outstanding corrosion resistance qualities. HVOF coatings are a viable surface modification technology for different engineering components due to their high-performance tribological characteristics (Liu et al., 2021). The most recent studies on the assessment and improvement of HVOF coatings will also be looked at in this review, including approaches such microhardness testing, wear testing, and scratch testing (Keshvari et al., 2023). The problems and prospects in the field of HVOF coatings tribology will also be covered in this critical examination, including the creation of new coatings for harsh environments, enhancing coating-substrate adhesion, and lowering the cost and environmental effect of the HVOF process. There will also be a focus on the prospective uses of HVOF coatings in a number of industrial areas, including energy production, automotive, and aerospace.

2. LITERATURE REVIEW AND DISCUSSION

HVOF Coating Microstructure (Su,2021).

Microstructural analysis is used to look at the coating's composition and structure as well as how effectively it adheres to the substrate (Picas et al., 2023). X-ray diffraction (XRD), transmission electron microscopy (TEM), and scanning electron microscopy (SEM) methods are used to study the microstructure of the coating. While TEM offers high-resolution images of inside microstructures, SEM provides information on surface topography and shape. The crystalline phases that are present in the coating are identified by XRD analysis (Ebler et al., 2023). The tribological characteristics of HVOF coatings are significantly influenced by their microstructure. The substance of the feedstock, the spray process parameters, and the substrate material all have an impact on the microstructure of HVOF coatings. Depending on the material's melting point and the spray parameters, the microstructure of the coating is determined by the composition of the feedstock material and can either be crystalline or amorphous.

By affecting the degree of particle melting and the cooling rate, spray process parameters including the oxygen-to-fuel gas ratio, the spray distance, and the particle velocity have an impact on the microstructure of the coating. For instance, raising the oxygen-to-fuel gas ratio raises the temperature and particle velocity, which causes a greater amount of melting of the particles and results in a denser coating with less porosity. Similar to how reducing the spray distance leads to a finer microstructure and a faster cooling rate (Palanisamy et al., 2022). The thermal conductivity and coefficient of thermal expansion of the substrate material have an impact on the microstructure of the coating as well. A coating may cool quickly on a high thermal conductivity substrate, producing a finer microstructure, while cooling more slowly on a low thermal conductivity substrate may produce a coarser microstructure (Varis et al., 2023).

HVOF Coatings' Mechanical Characteristics:

The tribological performance of HVOF coatings depends heavily on their mechanical attributes, such as hardness, toughness, and adhesion strength (Naveen et al., 2023) HVOF coatings are suited for situations where wear and abrasion resistance are crucial since their normal hardness ranges from 800-1200 HV. The dense microstructure of HVOF coatings, which reduces the formation of microcracks and porosity, is thought to be the cause of their high hardness (Meghwal,2022). In applications where the coating is subjected to high impact loads, the HVOF coatings' robustness is especially crucial. The microstructure of HVOF coatings affects their toughness, which can be increased by optimizing the spray parameters to reduce the likelihood of flaws like cracks and porosity (Kiilakoski et al., 2018). The substrate material, the surface preparation, and the coating microstructure are some of the variables that affect the adhesion strength of HVOF coatings. For the coating to be long-lasting and wear-resistant, there must be a strong adhesion between it and the substrate. Because of their tight microstructure and solid metallurgical bond with the substrate, HVOF coatings often have a high adhesion strength (Varis et al., 2020).

HVOF Coatings Wear Behaviour (Geng et al., 2015)

The wear resistance of HVOF coatings is evaluated using wear testing. Coating performance is assessed using a number of industry-standard wear tests, including the ASTM G65, ASTM G99, ASTM B611, and ASTM F1470. These tests replicate many types of wear, including abrasion, erosion, and sliding wear. The tests gauge the coating's wear resistance by measuring different factors such wear rate, coefficient of friction, and surface roughness (Wu et al., 2021; Rukhande et al., 2022). One of the most important aspects that determines whether HVOF coatings are suitable for different tribological applications is their wear behaviour. Excellent wear resistance has been demonstrated with HVOF coatings in a number of wear types, including sliding wear, abrasion, erosion, and fretting wear. In many technical applications, sliding wear is a frequent mechanism of wear, and HVOF coatings have been demonstrated to have better wear resistance than alternative thermal spray coatings. The high hardness and low coefficient of friction of HVOF coatings, which lessen the likelihood of wear and decrease the surface area in contact with the substrate, are credited with their wear resistance (Priyana & Hariharan, 2014).

Another typical form of wear in many industrial settings, including mining and construction, is abrasion. The corrosion resistance of HVOF coatings is assessed using corrosion testing. To assess the performance of coatings, a number of corrosion tests, including ASTM G48, ASTM B117, and ASTM G85, are utilised. These tests replicate various corrosion settings, including immersion corrosion, cyclic corrosion, and salt spray corrosion. The tests gauge the coating's corrosion resistance by measuring many factors such corrosion rate, corrosion morphology, and coating adhesion (Ahmed et al., 2018).

Other approaches:

Hardness, adhesion, and fatigue testing are further techniques for assessing the efficacy of HVOF coatings. In contrast to adhesion testing, which gauges the coating's bond strength with the substrate, hardness testing gauges the coating's resistance to indentation or penetration. The coating's resistance to cyclic loading conditions is assessed via fatigue testing.

The existing research on the tribology of HVOF coatings offers important insights into the variables that can affect the tribological characteristics of these coatings. To completely comprehend the underlying principles and create new coating materials and deposition procedures that can further enhance the tribological properties of HVOF coatings, additional study is nonetheless required.

High density, toughness, and resistance to abrasion, corrosion, and erosion are among qualities associated with HVOF coatings. Additionally, they are utilised to repair worn-out or broken parts, enhance the functionality of new parts, and act as a barrier against environmental influences.

In HVOF testing, the coating's thickness, hardness, adherence, and other physical and mechanical characteristics are routinely measured. The outcomes of these tests can be used to judge the coating's quality, its suitability for particular uses, and any modifications that must be made to the HVOF procedure (Dobbins et al., 2003).

Industrial application of High Velocity Oxy Fuel (HVOF) coatings is widespread due to their superior wear resistance, corrosion prevention, and heat properties. Tribology, the study of friction, wear, and lubrication, is crucial to the performance and long-term viability of HVOF coatings. We will address the current level of knowledge in HVOF coatings tribology and point out areas that need more investigation in this critical evaluation. The microstructure of the coating is one of the most crucial elements impacting the tribological characteristics of HVOF coatings. By changing spray parameters including particle size, velocity, and temperature, the microstructure can be managed. In general, coatings with a thick and consistent microstructure have superior wear resistance and a lower coefficient of friction. More study is required in this area because it is currently difficult to properly regulate the microstructure of HVOF coatings. The kind of material utilised has a significant impact on the tribological characteristics of HVOF coatings. HVOF coatings have been made from a variety of materials, each with unique benefits and drawbacks, such as metals, carbides, and ceramics. For instance, carbide coatings have great wear resistance but may have trouble sticking to the substrate.

Ceramic coatings, on the other hand, might be more brittle and prone to breaking but may have higher adherence. Another crucial element is the testing procedure used to assess the tribological characteristics of HVOF coatings. There have been many testing techniques employed, including pin-on-disk, ball-on-disk, and scratch testing. Each technique has pros and cons of its own, and no single technique can give a thorough analysis of the tribological characteristics of HVOF coatings. In conclusion, the study of HVOF coatings tribology is a challenging and significant field that calls for interdisciplinary cooperation among material scientists, mechanical engineers, and tribologists. To better understand the underlying causes of wear and friction in HVOF coatings and to provide better testing procedures and coating materials, more study is required. The coating-substrate interface is a significant aspect that can have an impact on the tribological characteristics of HVOF coatings. According to reports, a weak contact between the coating and substrate can cause the coating to break before its time. In order to achieve superior tribological properties, the coating substrate contact must be optimized.

3. BACKGROUND FOR HVOF COATINGS TRIBOLOGY

A significant development in the field of tribology, a multidisciplinary discipline concerned with the study of friction, wear, and lubrication, is represented by High-Velocity Oxygen Fuel (HVOF) coatings. The development of coating technologies and the desire for improved surface qualities and longer component lifespans in a variety of sectors are intertwined in the history of HVOF coatings in tribology. The initial obstacle on the path is minimizing wear and friction, two problems that have plagued engineering systems and machinery throughout history. The need for reliable solutions to lower friction-related losses, avoid wear-induced failures, and maximize efficiency became critical as industries became more and more dependent on machines and mechanical parts. Traditional tribology methods employed lubricants and materials with built-in wear resistance. These systems, while partially effective, have drawbacks, particularly in applications exposed to harsh conditions like high temperatures, corrosive environments, or strong mechanical loads. A more adaptable and dependable technique to safeguard surfaces and improve tribological performance became necessary. The development of thermal spray technology was a key step forward in this endeavor. In thermal spraying, protective coatings are applied to surfaces using a variety of methods, including as flame spraying, arc spraying, and plasma spraying. These techniques significantly increased surface protection and wear resistance, but they were still hindered by the porosity, adhesion, and microstructure of the coatings. Here we have the High-Velocity Oxygen Fuel (HVOF) coating, a revolutionary advancement in thermal spray technology. HVOF, which was created and improved over many years, significantly changed the possibilities of tribology and surface engineering. A converging-diverging nozzle is used to ignite and accelerate a fuel-oxygen mixture to supersonic velocities in HVOF, which is the secret to its success. Coating materials, often in the form of fine powders, are propelled onto the substrate surface with immense kinetic energy by this supersonic jet of hot, high-pressure gas. These particles strike the substrate, leaving behind a coating layer that is extremely dense, tenacious, and well-bonded. HVOF is superior to preceding thermal spray techniques because of the high coating quality, which makes it especially suitable for demanding tribological applications. There are several important elements that contributed to the creation and widespread use of HVOF coatings in tribology, including: Outstanding Hardness and Wear Resistance: HVOF coatings provide outstanding hardness, frequently outperforming the parent material. These coatings are perfect for parts that come into touch with sliding, rolling, or abrasive materials due to their inherent hardness, which offers superior wear resistance. Low Porosity and High Adhesion: Excellent Coating Adhesion and Minimal Porosity are ensured by the high kinetic energy of HVOF-sprayed particle. As a result, a nearly impermeable barrier protects the substrate from abrasion, corrosion, and the effects of the environment. A wide variety of materials, including metals, ceramics, and carbides, can be applied as coatings using HVOF. Due to their adaptability, coatings can be customized by engineers for particular purposes, improving both performance and longevity. Consistency and Accuracy: Surface finish, homogeneity, and coating thickness can all be precisely controlled with HVOF methods. To maintain tight tolerances and obtain the appropriate tribological qualities, consistency is essential. Benefits for the Environment: HVOF coatings frequently have a lower environmental effect than some alternative coating processes since they generate little waste and emissions. Broad Applications: HVOF coatings are used in a wide range of fields, including manufacturing, aerospace, automotive, oil & gas, and power generation. The improved tribological qualities that these coatings bestow assist components like engine parts, seals, bearings, and cutting tools. Research and development: Ongoing projects in this area are broadening the potential applications for HVOF coatings in tribology. Further advancements in performance and applicability are being driven by innovative techniques, advanced materials, and computational modeling. In conclusion, the history of HVOF coatings in tribology is evidence of human inventiveness and the pursuit of engineering excellence. HVOF coatings have evolved as a game-changing answer to a range of problems, from the early problems with friction and wear to the current demands of high-performance sectors. The dynamic interplay between technology and tribology in our contemporary environment is highlighted by their exceptional hardness, endurance, and versatility, which make them vital in the search for more effective, dependable, and long-lasting mechanical systems.

4. CONCLUSION

Because of their high hardness, thermal stability, and corrosion resistance, HVOF coatings have outstanding tribological qualities that make them commercially feasible for usage in a variety of industries. The selection of the best spray parameters and the feedstock powder are just two examples of the variables that have an impact on the microstructure and performance of these coatings. The crystalline/amorphous structure of the starting powder and the spraying circumstances, which might impact the coating's amorphous/crystalline phases, must both be taken into account while producing crystalline alloy coatings. Even though HVOF coatings have improved wear resistance in a promising way, more research is still required to assess whether or not they are appropriate for various wear scenarios and situations. HVOF coatings have been proven to outperform other thermal spray coatings such detonation gun spray, plasma spray, arc spray, and flame spray, which are some of the most significant means of surface modification. As seen in SEM and microstructure analysis, the coating created by the HVOF process has a uniform thickness and a continuous layer of coating, which is advantageous for engineering surface applications needing excellent wear resistance. One of the most crucial methods of surface modification is thermal spray painting, notably HVOF. HVOF coatings have been found to perform better than other thermal spray coatings such as plasma, arc, detonation gun, and flame spray. For engineering surface applications needing great wear resistance, the HVOF method's homogeneous thickness and continuous coating layer are advantageous. The tribological characteristics of High Velocity Oxy Fuel (HVOF) coatings, such as wear resistance, hardness, and corrosion resistance, have been thoroughly researched. HVOF coatings have been utilised to increase the performance and longevity of engineering components and are economically feasible. The feedstock powder and spray parameters are just two examples of the many variables that can affect the microstructure and performance of HVOF coatings. Crystalline alloy coatings have showed potential in increasing component wear resistance. To assess the applicability of these coatings for various wear situations and environments, additional testing is necessary.

Overall, the review's findings indicate that HVOF coatings have a substantial potential for improving the tribological characteristics of engineering components. Additional study is needed to enhance their functionality and broaden their range of applications.

Acknowledgement: The authors extend their appreciation to the Management and Principal of Nitte Meenakshi Institute of Technology, Bangalore, for their invaluable financial support in presenting the paper.

References:

Abbas, M., Smith, G. M., & Munroe, P. R. (2021). Microstructural study of HVOF sprayed Ni particles on a grit-blasted stainless-steel substrate. *Surface and Coatings Technology*, *409*, 126832. https://doi.org/10.1016/j.surfcoat.2021.126832.

Ahmed, R., Vourlias, G., Algoburi, A., Vogiatzis, C., Chaliampalias, D., Skolianos, S., Berger, L. M., Paul, S., Faisal, N. H., Toma, F. L., Al-Anazi, N. M., & Goosen, M. F. A. (2018). Comparative Study of Corrosion Performance of HVOF-Sprayed Coatings Produced Using Conventional and Suspension WC-Co Feedstock. *Journal of Thermal Spray Technology*, 1-15. https://doi.org/10.1007/s11666-018-0775-2

Al-Mutairi, S., Hashmi, M. S. J., Yilbas, B. S., & Stokes, J. (2015). Microstructural characterization of HVOF/plasma thermal spray of micro/nano WC–12%Co powders. *Surface and Coatings Technology*, *264*, 175-186. https://doi.org/10.1016/j.surfcoat.2014.12.050.

Dobbins, T. A., Knight, R., & Mayo, M. J. (2003). HVOF thermal spray deposited Y2O3-stabilized ZrO_2 coatings for thermal barrier applications. *Journal of Thermal Spray Technology, 12*(2), 214-225. https://doi.org/10.1361/105996303770348320

Ebler, J., Woelk, D., Utu, D., & Marginean, G. (2023). Influence of the powder feed rate on the properties of HVOF sprayed WC-based cermet coatings. *Materials Today: Proceedings*, *78*(Part 2), 227-234. https://doi.org/10.1016/j.matpr.2022.11.120.

Geng, Z., Li, S., Duan, D. L., & Liu, Y. (2015). Wear behavior of WC-Co HVOF coatings at different temperatures in air and argon. *Wear*, 330–331, 348-353. https://doi.org/10.1016/j.wear.2015.01.035

Jonda, E., Latka, L., Godzierz, M., & Maciej, A. (2023). Investigations of microstructure and corrosion resistance of WC-Co and WC-Cr_3C_2-Ni coatings deposited by HVOF on magnesium alloy substrates. *Surface and Coatings Technology*, *459*, 129355. https://doi.org/10.1016/j.surfcoat.2023.129355.

Keshvari Tabatabaei, F. S., Ghasemi, B., Mirzaee, O., & Adabifiroozjaei, E. (2023). The effect of WC-CoCr content on hardness and tribological properties of NiCrBSi coatings fabricated by the HVOF process. *Surface and Coatings Technology*, *466*, 129506. https://doi.org/10.1016/j.surfcoat.2023.129506.

Kiilakoski, J., Musalek, R., Lukac, F., Koivuluoto, H., & Vuoristo, P. (2018). Evaluating the toughness of APS and HVOF-sprayed Al_2O_3-ZrO_2-coatings by in-situ- and macroscopic bending. *Journal of the European Ceramic Society*, *38*(4), 1908-1918. https://doi.org/10.1016/j.jeurceramsoc.2017.11.056

Knight, R., & Smith, R. W. (1998). Thermal Spray Forming of Materials. In *Powder Metal Technologies and Applications*, *7*, 408–419. *ASM Handbook*.

Liu, S., Wu, H., Xie, S., Planche, M. P., Rivolet, D., Moliere, M., & Liao, H. (2021). Novel liquid fuel HVOF torches fuelled with ethanol: relationships between in-flight particle characteristics and properties of WC-10Co-4Cr coatings. *Surface and Coatings Technology*, 408, 126805. https://doi.org/10.1016/j.surfcoat.2020.126805.

Lv, J., Wu, Y., Hong, S., Cheng, J., Chen, Y., Cheng, J., Wei, Z., & Zhu, S. (2022). Effects of WC addition on the erosion behavior of high-velocity oxygen fuel sprayed AlCoCrFeNi high-entropy alloy coatings. *Ceramics International*, 48(13), 18502-18512. https://doi.org/10.1016/j.ceramint.2022.03.120.

Meghwal, A., Singh, S., Anupam, A., King, H. J., Schulz, C., Hall, C., Munroe, P., Berndt, C. C., & Ang, A. S. M. (2022). Nano- and micro-mechanical properties and corrosion performance of a HVOF sprayed AlCoCrFeNi high-entropy alloy coating. *Journal of Alloys and Compounds, 912*, 165000. https://doi.org/10.1016/j.jallcom.2022.165000.

Naveen, G. J., Kumaran, P. Sampath, Sathyanarayanaswamy, A., Bindagi, P. T., & Mukunda, P. G. (2023). Microstructure Characteristics and Properties of NiCrFeS HVOF Coating for SAE 1008 Cold Rolled Steel. *Journal of Mines, Metals & Fuels*, *71*(3), 450-455. https://doi.org/10.18311/jmmf/2023/33758.

Palanisamy, K., Gangolu, S., & Antony, J. M. (2022). Effects of HVOF spray parameters on porosity and hardness of 316L SS coated Mg AZ80 alloy. *Surface and Coatings Technology*, *448*, 128898. https://doi.org/10.1016/j.surfcoat.2022.128898.

Picas, J. A., Menargues, S., Martin, E., & Baile, M. T. (2023). Cobalt free metallic binders for HVOF thermal sprayed wear resistant coatings. *Surface and Coatings Technology*, *456*, 129243. https://doi.org/10.1016/j.surfcoat.2023.129243

Priyana, M. S., & Hariharan, P. (2014). Wear and Corrosion Resistance of Fe-Based Coatings by HVOF Sprayed on Gray Cast-Iron for Automotive Application. *Tribology in Industry*, *36*(4), 394-405.

Qiao, L., Wu, Y., Hong, S., Long, W., & Cheng, J. (2021). Wet abrasive wear behavior of WC-based cermet coatings prepared by HVOF spraying. *Ceramics International*, *47*(2), 1829-1836. https://doi.org/10.1016/j.ceramint.2020.09.009.

Ramezani, M., Mohd Ripin, Z., Pasang, T., & Jiang, C.P. (2023). Surface Engineering of Metals: Techniques, Characterizations, and Applications. *Metals*, 13(7), 1299. https://doi.org/10.3390/met13071299

Rukhande, S. W., Rathod, W. S., & Bhosale, D. (2022). High-temperature tribological investigation of APS and HVOF sprayed NiCrBSiFe coatings on SS 316L. *Tribology - Materials, Surfaces & Interfaces*, *16*(2), 98-109. https://doi.org/10.1080/17515831.2021.1898887

Sauceda, S., Lascano, S., Nunez, J., Parra, C., Arevalo, C., & Bejar, L. (2023). Effect of HVOF processing parameters on Cr3C2-NiCr hard coatings deposited on AISI 4140 steel. *Engineering Science and Technology*, an *International Journal*, 39, 101342. https://doi.org/10.1016/j.jestch.2023.101342.

Su, W., Zhang, J., Zhang, J., Zhou, K., Niu, S., Liu, M., Dai, H., & Deng, C. (2021). Microstructure of HVOF-sprayed Ag-BaF_2·CaF_2–Cr_3C_2–NiCr coating and its tribological behavior in a wide temperature range (25°C to 800°C). *Ceramics International*, 47(1), 865-876. https://doi.org/10.1016/j.ceramint.2020.08.199.

Sun, Y. J., Yang, R., Xie, L., Li, Y. B., Wang, S. L., Li, H. X., Wang, W. R., & Zhang, J. S. (2022). Interfacial bonding and corrosion behaviors of HVOF-sprayed Fe-based amorphous coating on 8090 Al-Li alloy. *Surface and Coatings Technology*, 436, 128316. https://doi.org/10.1016/j.surfcoat.2022.128316.

Turunen, E., Varis, T., Gustafsson, T. E., Keskinen, J., Falt, T., & Hannula, S.-P. (2006). Parameter optimization of HVOF sprayed nanostructured alumina and alumina-nickel composite coatings. *Surface and Coatings Technology*, *200*(16-17), 4987-4994. https://doi.org/10.1016/j.surfcoat.2005.05.018.

Varis, T., Suhonen, T., Jokipii, M., & Vuoristo, P. (2020). Influence of powder properties on residual stresses formed in high-pressure liquid fuel HVOF sprayed WC-CoCr coatings. *Surface and Coatings Technology*, *388*, 125604. https://doi.org/10.1016/j.surfcoat.2020.125604

Varis, T., Makela, A., Suhonen, T., Laurila, J., & Vuoristo, P. (2023). Integrity of APS, HVOF, and HVAF sprayed NiCr and NiCrBSi coatings based on the tensile stress-strain response. *Surface and Coatings Technology*, *452*, 129068. https://doi.org/10.1016/j.surfcoat.2022.129068.

Varis, T., Lagerbom, J., Suhonen, T., Raami, L., Terho, S., Laurila, J., Peura, P., & Vuoristo, P. (2023). Effect of heat treatments on the wear resistance of HVAF and HVOF sprayed tool steel coatings. *Surface and Coatings Technology*, *462*, 129508. https://doi.org/10.1016/j.surfcoat.2023.129508.

Wang, Y., Zhang, W., Chen, D., Liu, X., Hu, W., Liu, L., Yan, J., & Xiong, X. (2021). High temperature friction and wear performance of TiB2-50Ni composite coating sprayed by HVOF technique. *Surface and Coatings Technology*, *407*, 126766. https://doi.org/10.1016/j.surfcoat.2020.126766.

Wu, M., Pan, L., Duan, H., Wan, C., Yang, T., Gao, M., & Yu, S. (2021). Study on Wear Resistance and Corrosion Resistance of HVOF Surface Coating Refabricate for Hydraulic Support Column. *Coatings*, *11*(12), 1457. https://doi.org/10.3390/coatings11121457

Zhou, Y.-k., Kang, J.-j., Zhang, J., Zhu, S., Fu, Z.-q., Zhu, L.-n., & She, D.-s. (2022). Effect of nitriding on microstructure and wear behavior of HVOF sprayed AlxCoCrFeNi (x= 0.4, 0.7, 1.0) high-entropy alloy coatings. *Intermetallics*, *151*, 107709. https://doi.org/10.1016/j.intermet.2022.107709.

Balachandra P Shetty
Nitte Meenakshi Institute of Technology
Bengaluru, Karnataka
India
pb.shetty@nmit.ac.in
ORCID 0000-0003-2539-5240

G J Naveen
Sambhram Institute of Technology
Bengaluru, Karnataka
India
gj_naveen@yahoo.co.in
ORCID 0000-0003-0360-9455

Shailesh Rao A
Nitte Meenakshi Institute of Technology
Bengaluru, Karnataka
India
shailesh.rao@nmit.ac.in
ORCID 0000-0001-6190-9857