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ASSESSMENT OF CORROSION RESISTANCE IN Ni-Cr-BASED COATINGS FABRICATED VIA COLD SPRAY TECHNIQUE

BY

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Abstract. The Cold Spray deposition method differs from traditional thermal spray techniques in that it operates at lower temperatures, allowing particle deposition without melting the material. This preserves the intrinsic properties of the sprayed particles and minimizes thermal degradation, whereas thermal spray methods involve melting the particles, which can lead to oxidation, residual stresses, and changes in material structure upon solidification. In our study, we examined the corrosion resistance of 4340 steel coated with a Ni/chromium carbide (Ni/CrC) particle blend. Electro-corrosion testing confirmed that the deposited layer has a near-intact condition, with only minimal compound traces found in the electrolyte solution, indicating substantially lower oxidation in the coating than in the base material.

Keywords: Ni/CrC coating, Cold Spray deposition, corrosion resistance.

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1. Introduction

Cold spray (CS) represents a relatively recent solid-state deposition method, which has attracted growing interest over the last three decades due to its unique ability to produce both high-performance coatings and even bulk parts (Assadi *et al.*, 2016).

The principle of cold spray involves accelerating micron-sized powder particles (typically 1-50 μm) to supersonic velocities (300-1200 m/s) using a high-pressure, preheated gas - commonly nitrogen or helium - through a converging-diverging de Laval nozzle. Upon impact with the substrate, the particles undergo severe plastic deformation, enabling bonding through mechanisms such as adiabatic shear instability and metallurgical bonding at the interface (Singh *et al.*, 2012).

Compared to conventional thermal spray processes such as flame spray (Toma *et al.*, 2024), arc spray (Levarda *et al.*, 2025) and plasma spray (Chicet *et al.*, 2025), the cold spray technique offers several distinct advantages as well as some limitations. In flame spraying, the feedstock powder or wire is melted in an oxy-fuel flame and projected onto the substrate, resulting in coatings with relatively high porosity, moderate adhesion strength, and significant oxide content due to the exposure to high temperatures. Similarly, arc spraying uses an electric arc to melt the tips of two wires, with the molten droplets propelled by compressed air (Toma *et al.*, 2022), producing coatings with high deposition rates but also high oxidation levels and limited density (Haraga *et al.*, 2024). Plasma spray employs an ionized gas at extremely high temperatures to melt the particles before deposition, producing dense and hard coatings but with significant thermal input to the substrate, which can lead to undesirable phase transformations, residual stresses, and microstructural changes (Cristisor *et al.*, 2024).

In contrast, cold spray is a solid-state process where the powder remains below its melting point during deposition. This eliminates oxidation, phase transformations, and thermal stresses, resulting in dense, oxide-free coatings with wrought-like microstructures and excellent mechanical properties (Assadi *et al.*, 2016; Astaraee *et al.*, 2024). Furthermore, cold spray allows the deposition of temperature-sensitive materials, metastable phases, and even polymers or polymer–metal composites, which are difficult or impossible to process with molten-particle-based techniques (Han *et al.*, 2024; Abubakar *et al.*, 2025). However, the lower particle temperatures in cold spray mean that adhesion relies entirely on high-velocity impact and plastic deformation, making the process more sensitive to substrate preparation and to the ductility of the feedstock (Singh *et al.*, 2012, Abubakar *et al.*, 2025). Additionally, the equipment for high-pressure cold spray is more complex and costly compared to flame or arc spray systems.

CS technology is versatile in terms of materials, enabling the deposition of a broad spectrum of metals, such as copper, aluminum, stainless steel, nickel-based alloys, as well as their composites (Wei *et al.*, 2024; Wang *et al.*, 2024). It has also been successfully applied to advanced materials, including amorphous alloys (Han *et al*., 2024), high-entropy alloys (Harfouche *et al*., 2025) and metal-ceramic composites like WC-Co and WC-Ni (Wang *et al*., 2024; Harfouche *et al*., 2025). The substrates are equally diverse, encompassing not only metallic surfaces like aluminum and steels (Han *et al*., 2024; Wang *et al*., 2024) but also polymers such as PEEK, thus opening new possibilities for lightweight, multifunctional components (Abubakar *et al*., 2025).

Nevertheless, the process comes with certain limitations. Among the main challenges are its relatively narrow processing window, difficulties in ensuring strong adhesion on some substrates and constraints in depositing brittle materials without auxiliary measures such as preheating or reinforcing particles (Singh *et al*., 2012; Abubakar *et al*., 2025). Furthermore, the coatings may retain a degree of porosity and can sometimes require post-processing to optimize their mechanical properties Astaraee *et al*., 2024; Cortes *et al*., 2024).

Even with these drawbacks, the CS coatings have outstanding mechanical and physicochemical properties, which make them highly suitable for demanding applications. Typically, these coatings are dense and exhibit low porosity combined with high hardness, owing to the substantial plastic deformation and work hardening of the particles during impact (Astaraee *et al*., 2024; Wang *et al*., 2024). For instance, WC-Co and WC-Ni composites produced by this method exhibit a notable improvement in hardness and wear resistance compared to uncoated substrates, with hardness values exceeding 400 HV in certain cases (Wang *et al*., 2024). These high hardness levels, along with good interfacial adhesion (Han *et al*., 2024), contribute to enhanced fatigue performance under cyclic loading (Wang *et al*., 2024).

The wear resistance of CS coatings is also remarkable, performing well in abrasive and fatigue-prone environments. This is especially notable for metal–ceramic composites, such as WC-17Co/Ni, where the hard ceramic phase effectively reduces wear rates and mitigates fatigue damage (Wang *et al*., 2024). Similarly, high-entropy alloy coatings reinforced with hard phases achieve improved tribological behavior, benefiting from their strong matrix cohesion and stable oxide tribolayers that develop during use (Harfouche *et al*., 2025).

In addition to their mechanical robustness, CS coatings offer superior corrosion resistance. The process avoids melting and oxidation of the powders, resulting in a dense, uniform, and nearly oxide-free microstructure (Wang *et al*., 2024). For example, WC-17Co/Ni coatings applied to aluminum substrates exhibit excellent corrosion resistance due to the compact structure and chemical inertness of the hard phases (Wang *et al*., 2024). Likewise, stainless steel coatings produced by CS improve both corrosion and erosion resistance of carbon steel structures exposed to aggressive environments (Cortes *et al*., 2024). Moreover, coatings on polymers, such as Cu-Zn-Al_2O_3 applied to PEEK, capitalize on the antimicrobial and corrosion-resistant properties of the metallic phases, thereby broadening the range of viable applications.

The combination of high hardness, excellent wear resistance, and outstanding corrosion protection makes CS coatings highly advantageous for industries such as aerospace, automotive, marine, energy, and civil engineering, where components are frequently subjected to harsh mechanical and environmental conditions (Abubakar *et al*., 2025; Cortes *et al*., 2024). The ability of CS to produce coatings with wrought-like microstructures and minimal defects is crucial to ensuring long-term structural integrity and surface durability (Singh *et al*., 2012; Wang *et al*., 2024).

These features have enabled CS to become widely adopted in industrial applications, where its unique property profile meets stringent operational requirements (Singh *et al*., 2012; Astaraee *et al*., 2024). In the aerospace sector, for example, CS is commonly used for the repair and refurbishment of high-value parts, including landing gear, turbine blades, and structural components made of aluminum or titanium alloys. The dense, oxidation-free coatings restore worn or damaged surfaces while minimizing heat-affected zones, thereby preserving the original material properties (Assadi *et al*., 2016; Singh *et al*., 2012).

In the automotive industry, CS coatings enhance the wear and corrosion resistance of engine parts, gearboxes, and braking systems, where high performance under repeated loading is critical (Singh *et al*., 2012; Wang *et al*., 2024). Copper- and nickel-based CS coatings also exhibit good thermal and electrical conductivity, making them suitable for use in electrical connectors and heat exchangers in electric vehicles and power electronics (Astaraee *et al*., 2024; Cortes *et al*., 2024).

For civil infrastructure, CS provides an efficient way to protect steel structures against erosion and corrosion, particularly in bridges, pipelines, and offshore platforms operating in aggressive environments. Stainless steel coatings on carbon steel substrates extend service life and reduce maintenance needs for these essential structures (Cortes *et al*., 2024). Furthermore, the capability to carry out repairs quickly and with minimal downtime is a notable advantage in such large-scale applications.

In the energy sector, CS improves the reliability and longevity of power plant components, such as boiler tubes, heat exchangers, and fuel cell plates. Coatings like CuCrZr and stainless steel perform well under high temperatures and corrosive conditions (Cortes *et al*., 2024; Yang *et al*., 2024).

The biomedical field is another area where CS shows promise, enabling the creation of antimicrobial and biocompatible surfaces for medical devices, implants, and prosthetics. For example, Cu-Zn-Al_2O_3 coatings on PEEK combine the polymer's lightweight, chemical resistance, and mechanical strength with the metallic coating's antimicrobial and wear-resistant properties, making them suitable for surgical instruments and implants (Abubakar *et al*., 2025).

In the present study, we focused on evaluating the corrosion resistance of 4340 steel substrates coated by cold spray with a composite blend of nickel and chromium carbide (Ni/CrC) particles. The aim was to investigate the ability of this coating to provide enhanced protection against electrochemical degradation in aggressive environments, leveraging the well-known corrosion resistance of nickel and the high hardness and chemical stability of chromium carbide. To assess the performance of the coating, a series of electro-corrosion tests were performed under controlled laboratory conditions. The experimental results demonstrated that the cold-sprayed Ni/CrC layer maintained an almost intact surface condition after testing, with only negligible traces of dissolved compounds detected in the electrolyte solution. This outcome suggests that the coating significantly inhibits oxidation and corrosion processes compared to the uncoated steel substrate, thereby confirming the effectiveness of the cold spray deposition technique and the Ni/CrC material combination for corrosion-resistant applications.

2. Materials and methods

In the last decades, 4340 low-alloy steel has been extensively adopted in military, industrial, and aerospace applications, owing to its remarkable mechanical strength and fatigue resistance. Its alloying elements (Cr, Ni, V and Mo) contribute significantly to increased hardness and improved behavior under static and dynamic loading (Lupu *et al.*, 2023). Similar high-strength steels, such as AISI 4130, AISI 4140, 300M, and D6AC, are also widely used in the automotive and oil industries, where components are subjected to demanding mechanical conditions (Weng *et al.*, 2013). These materials are commonly used for critical parts like torsion bars, sprockets, crankshafts, and other highly stressed machine elements.

To further enhance the durability of 4340 steel in aggressive environments, recent studies have investigated different types of protective coatings applied through various deposition techniques (Sabelkin *et al.*, 2018; Maeng *et al.*, 2006). Special attention has been given to coatings designed to improve corrosion resistance at elevated temperatures, with some works focusing on the characterization of the coating–substrate interface, rather than on the fatigue crack initiation and propagation mechanisms (Voorwald *et al.*, 2005; Voorwald *et al.*, 2010).

Based on this background, the present experimental work was designed to evaluate the corrosion resistance of 4340 steel coated with a Ni/CrC composite layer deposited by cold spray. The materials, coating procedure, and testing methods employed in this study are detailed as follows.

The test samples were realized from 4340 steel (equivalent to 36CrNiMo4/1.6511 according to EN10250), coated with a mixture of chromium carbide and Ni powder using a VRC, Gen-III cold spray machine (VRC Metal Systems, LLC, SD, USA). As specified in a previous paper (Lupu *et al.*, 2024), the parameters used for spraying the mixture are presented in Table 1.

The powder mixture is known commercially as WIP-C1, and its morphology is shown in Fig. 1. Before the surface was coated with the WIP-C1 powder, a thin layer of WIP-BC1 bonding powder was applied to the surface with a nozzle orientation of 60 degrees.

The WIP-C1 powder is a chromium carbide with the composition Cr-31Ni-3C, whose composition is: 0.02%Co, 68.45%Cr, 0.08%Fe, 27.84%Ni, 0.01%W, 0.06%Al, 0.04%B, 0.01%Mo, 0.43%Si, 0.01%V, 3.00%C.

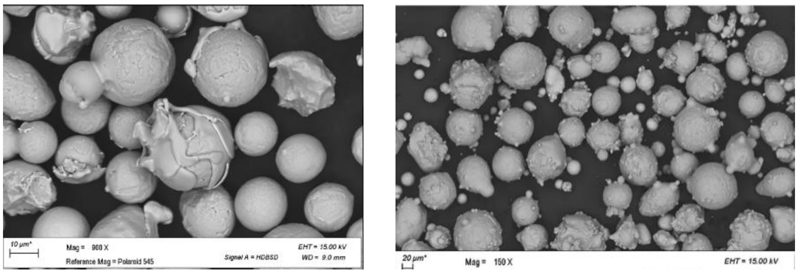
All electrochemical experiments were carried out on an electrochemical workstation Parstat 4000 type (Ametek, Sao Paulo, Brazil) potentiostat/galvanostat connected to the three-electrode setup. The solution used for the tests was simulated acid rain obtained in our laboratory from distilled water mixed with 0.5 mol/L H_2SO_4 and 0.5 mol/L HNO_3, with a pH of 3.4.

Samples characterization was performed using electron microscopy, which enabled the acquisition of secondary electron (SE) images of the coated surfaces both before and after exposure to the corrosive solution. The secondary electron images of the coatings before electro-corrosion were taken using a VEGA II LMH TESCAN electron microscope, operating in High Vacuum (HV) mode, with an accelerating voltage of 30 kV. The behavior of the coating and substrate after exposure to corrosion was quantified using EDX analyses, obtained with the Bruker semi-quantitative elemental chemical analysis module mounted on the same electron microscope.

Table 1

Cold Spray Ni-Cr coating deposition parameters (Lupu et al., 2024)

Parameter	Value
Gas	*Azot*
Pressure	*6.2 MPa (900 psi)*
Temperature	*675ºC*
Nozzle type	*WC NNZL0060*
Nozzle throat size	*2 mm*
Powder feeder speed	*8 rpm*
Powder feeder gas flow	*105 slm*
Standoff distance	*25 mm*
Spray angle	*90º*
Nozzle traverse speed	*250mm/s*
Nozzle step distance	*0.25 mm*
Target coating thickness	*0.508 mm*
Powder	*WIP – C1*
Bond coat powder	*WIP – BC1 și 60º*

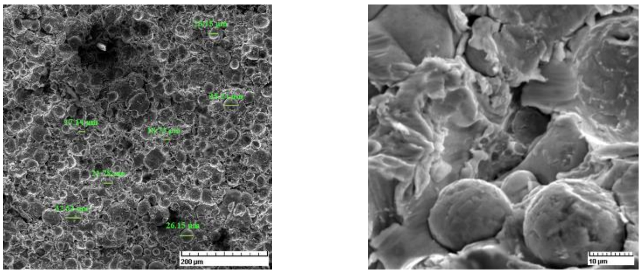


a) b)

Fig. 1 – SE images of: a) WIP-C1 powder (900x), b) WIP-BC1 powder particles (150x) (Lupu *et al.*, 2024).

3. Results and discussions

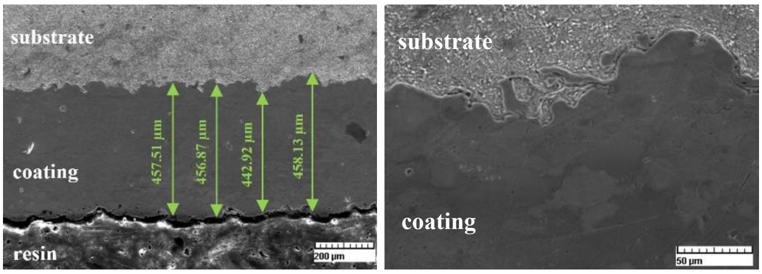
The first evaluation of the samples was conducted on the as-coated surfaces of the samples. Figure 2 shows the morphology of the WIP C1-Ni/CrC coatings by identifying characteristic particles at different magnifications on the surface of one of the analyzed samples. As presented in Fig. 2a, the particle size on the surface varies between 17 - 37.5 microns with a relatively uniform distribution.



a) b)

Fig. 2 – SE images of the WIP C1-Ni/CrC surface coating at different magnifications (in as-coated state).

Analyzing the morphology of this type of coating at higher magnifications, as shown in Fig. 2b, we observed that it is composed of spheroidal particles that did not deform upon impact, but which created „craters" in the areas where they collided with the substrate. It can also be seen that the particles in the final layer are deformed and have a lenticular appearance, while the cracks observed in Fig. 2a are merely the boundaries between the undeformed particles. These cracks do not have a greater depth than the average diameter of the sprayed particles and do not pose a risk of fracture or delamination of the coating, whose compact appearance is confirmed in the cross-sectional view (see Figs. 3 and 4).

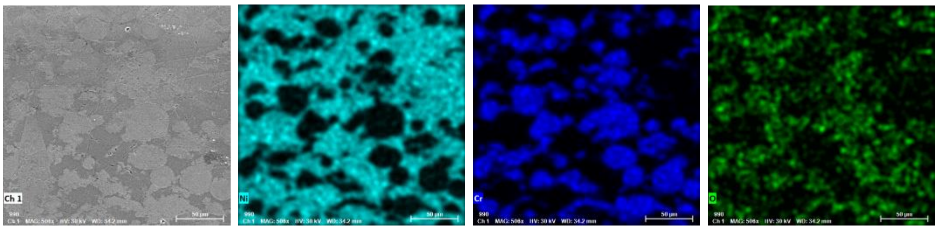


a) b)

Fig. 3 – SE images of the WIP C1-Ni/CrC cross–section coating at different magnifications (in as-coated state).

From the cross-sectional analysis shown in Fig. 3a, it can be observed that the layer has an average thickness of 450 µm ± 10 µm, ensuring uniform coverage and predictable behaviour at any point on the coating surface. It is observed that there are no adhesion defects at the coating-substrate interface, and the structure is continuous, uniform and sinuous, as emphasized in Fig. 3b. This contour was caused by local plastic deformation of the substrate to a depth of maximum 20 µm at the contact with the coating, as a result of the impact with supersonic accelerated particles during coating process. In the lower part of the image, the compact appearance of the coating can be observed, with no visible boundaries between the splats (as can be seen in various other coatings produced by flame spraying, electric arc, or atmospheric plasma spray).

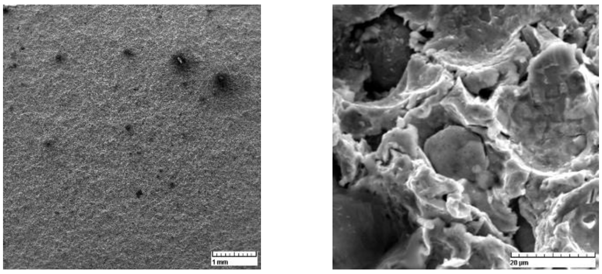
This aspect is also illustrated in Fig. 4, which shows both a secondary electron image of the coating cross-section (Fig. 4a) and the elemental distribution maps of its main chemical constituents: Ni (Fig. 4b), Cr (Fig. 4c), and oxygen (Fig. 4d).



a) b) c) d)

Fig. 4 – Distribution map of chemical elements on the coating section: a) SE image; b) Ni distribution; c) Cr distribution; d) O distribution.

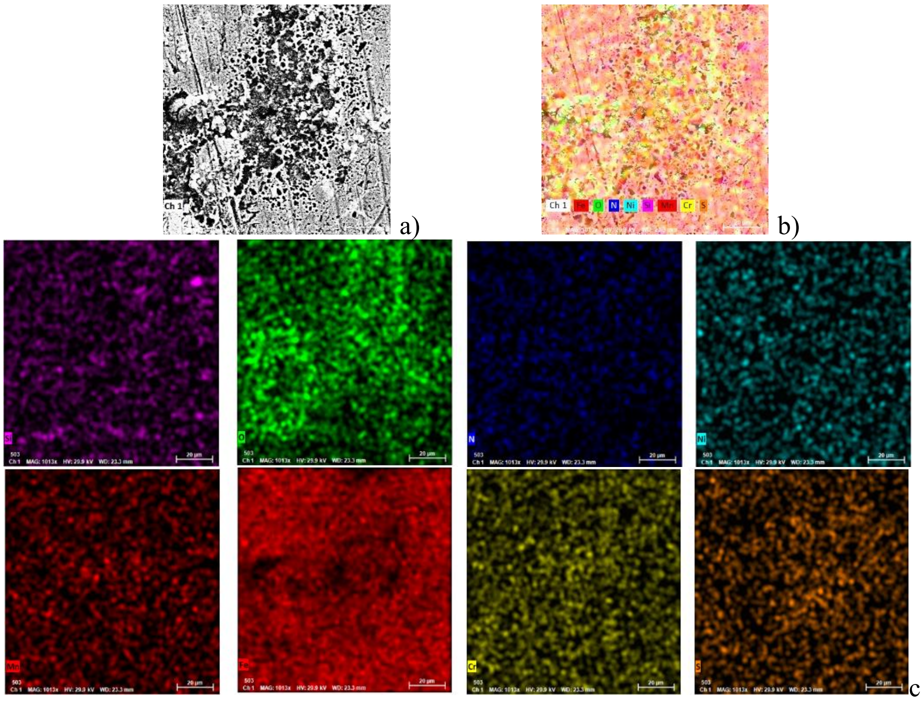
The structural delineation characteristic of the coating thus obtained is clearly evident, as indicated by the topographical overlap of Cr and O and their presence in regions where Ni is absent. It can also be observed that the Ni matrix exhibited greater plasticity, incorporating Cr particles that underwent less significant deformation at impact. As previously highlighted, the cross-sectional structure demonstrates excellent compactness of the coating, with no oxides or voids present - well-known advantages of coatings produced by the Cold Spray technique.



a) b)

Fig. 4 – SE images of the WIP C1-Ni/CrC surface coating at different magnifications, after the electrochemical tests.

After the electro-chemical tests, multiple corroded areas were observed on the surface of the 4340 steel sample (Fig. 5a).



a) b) c)

Fig. 5 – a) SEM images of the steel surface after open circuit potential (OCP), linear and cyclic potentiometry (LP and CP) and electro-impedance spectroscopy (EIS), b) elemental distribution map on the corroded surface c) elemental distribution on the corroded surface (separate elements: Si, O, N, Ni, Mn, Fe, Cr and S).

To investigate this phenomenon, the samples were analyzed using the EDX module, which identified corrosion products with a chemical composition different from that of the steel in its initial state (see Table 2), which probably are oxides and carbonates. Based on the identified chemical elements (Si, O, N, Ni, Mn, Fe, Cr and S) together with their distribution maps (Fig. 5b), the compounds appear to be generated from the metallic material and electrolyte solution interaction.

The surface of the coating (WIP_C1) deposited on the metallic sample is intact after the electro-corrosion tests at the macro-scale and presents only a few compounds from the electrolyte solution or as a result of solution interaction with the metal-ceramic system, as presented in Fig. 7a.

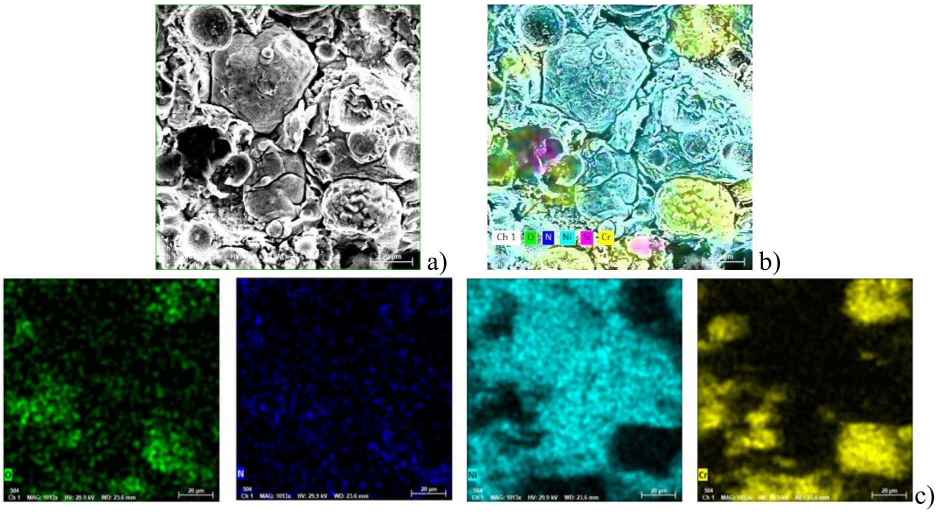


Fig. 6 – a) SEM images of the coating surface after OCP, LP / CP and EIS, b) elemental distribution map on the corroded surface, c) elemental distribution on the corroded surface (separate elements: O, N, Ni and Cr).

Table 2

Chemical composition of the samples after electro-chemical tests

Sample type	*steel (i*)*	*steel surface (c**)*	*coating (i*)*	*coating surface (c**)*
Element	*wt %*	*wt %*	*wt %*	*wt %*
Iron	*bal.*	*bal.*	-	-
Oxygen	-	*3,17*	*1,81*	*1,17*
Nitrogen	-	*2,11*	-	*4,63*
Nickel	*1,85*	*1,49*	*70,71*	*66,71*
Silicon	*0,25*	*1,19*	-	*0,90*
Manganese	*0,75*	*1,08*	-	-
Chromium	*0,80*	*1,03*	*27,45*	*26,57*
Sulfur	*0,04*	*0,17*	-	-

Element	*wt %*	*wt %*	*wt %*	*wt %*
Iron	*bal.*	*bal.*	-	-
Oxygen	-	*3,17*	*1,81*	*1,17*
Nitrogen	-	*2,11*	-	*4,63*

*i – represents the initial state of the material

**c – represents the state of the sample after electrochemical tests

At micro-scale, few non-metallic compounds were observed on the surface. EDX chemical composition analysis identifies other elements apart from the original layer (Cr, Ni, Si and C) like nitrogen, oxygen and sulfur, in very small amounts, as presented in Table 2. Compared with the metallic material, a lower quantity of oxygen is identified on the WIP C1-Ni/CrC coating surface, overlapped on the Cr as in the as-coated case (Fig. 4), so it can be appreciated that the oxidation is minor in this case.

4. Conclusions

This study has examined the current progress and prospects of thermal spray coatings, placing particular focus on the Cold Spray (CS) technique. CS has become an attractive solid-state deposition method, distinguished from conventional thermal spraying methods (such as flame, arc, or plasma spraying) by its ability to produce dense, oxidation-free coatings without exposing the substrate to high temperatures. This characteristic makes it especially well-suited for temperature-sensitive materials and critical applications.

The main advantages of Cold Spray include high deposition efficiency, preservation of the feedstock's intrinsic properties, negligible oxidation, and reduced residual stress.

On the other hand, its drawbacks relate to the need for ductile feedstock powders, higher equipment costs, sensitivity to substrate preparation, and difficulties in coating brittle materials. Even so, the adaptability of CS coatings has led to their application across a broad range of industries, such as aerospace, automotive, marine, energy, civil engineering and biomedicine.

From the experimental perspective, this study demonstrates that Ni/CrC coatings deposited by Cold Spray can significantly improve the corrosion resistance of 4340 high-strength steel. Microscopic and compositional analyses confirmed that the coating exhibits a highly compact and uniform structure, with no detectable oxides or voids, typical of Cold Spray coatings. Following exposure to an acidic corrosive environment, the Ni/CrC layer retained its integrity, showing only minimal surface compounds and no evidence of Fe-based corrosion products. This finding suggests that the coating effectively shields the steel substrate from oxidation, due to its dense and continuous microstructure.

In conclusion, Cold Spray coatings represent a valuable technological solution for protecting high-performance steels against corrosion, combining superior microstructural characteristics with minimal thermal damage to the substrate. Continued research into their behaviour in aggressive environments will help broaden their applicability and further improve the durability of critical components.

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REFERENCES

Abubakar A.A., Ankah N., Arif A.F.M., Goriya R.A., *Optimization and characterization of Cu-Zn-Al_2O_3 cold spray coating on PEEK*, Surface and Coatings Technology, 498, 131851 (2025), ISSN 0257-8972, https://doi.org/10.1016/j.surfcoat.2025.131851.

Assadi H., Kreye H., Gärtner F., Klassen T., *Cold Spraying – a materials perspective*, Acta Materialia, 116, 382-407 (2016).

Astaraee A.H., Raddi K.T., Bagherifard S., Colombo C., *Exploiting small punch test for mechanical characterization of cold sprayed deposits*, Theoretical and Applied Fracture Mechanics, 133, 104561 (2024).

Chicet D.L., Juhasz J., Cotrut C.M., Istrate B., Munteanu C., *Assessment of the Corrosion Resistance of Thermal Barrier Coatings on Internal Combustion Engine Components, Materials*, 18, 6, 1227 (2025), DOI: 10.3390/ma18061227.

Cortes R., Garrido-Maneiro M.A., Poza P., *Erosion behaviour of cold sprayed stainless-steel coatings for civil infrastructures: An energetic approach*, Results in Engineering, 22, 102166 (2024).

Cristisor D., Chicet D.L., Istrate B., Stescu C., Munteanu C., *Influence of TiO2 alloying percentage on the morphology of APS-deposited coatings from Cr2O3 powders*, Archives of Metallurgy and Materials, 69, 3, 1231-1239 (2024), DOI: 10.24425/amm.2024.150946.

Han P., Wang Q., Niu W., Ge S., Wan M., Li N., Qian R., *Bonding mechanism and fracture behavior of cold-sprayed Fe-based amorphous alloy on 6061 Al alloy*, Surface and Coatings Technology, 491, 131194 (2024).

Haraga R., Chicet D.L., Toma S., Carlescu V., Bejinariu C., *Microhardness and elastic properties evaluation of WC-TiC coatings obtained by arc spraying process*, Archives of Metallurgy and Materials, 69, 2, 795-801 (2024).

Harfouche M.M., Liang J., Aghasibeig M., Chromik R.R., *Effect of WC powder morphology on dry sliding wear behavior of cold sprayed CrMnCoFeNi cantor HEA composite coatings at room temperature*, Wear, 205838 (2025), ISSN 0043-1648, https://doi.org/10.1016/j.wear.2025.205838.

Levărdă E., Cîrlan D.-C., Chicet D.L., Petcu M., Toma S.L., *Investigations on Cavitation Erosion and Wear Resistance of High-Alloy WC Coatings Manufactured by Electric Arc Spraying*, Materials, 18, 2259 (2025), https://doi.org/10.3390/ma18102259.

Lupu F.C., Munteanu C., Istrate B., Lupescu S.C., Ciubotaru R., Adrian S., *Structural analysis and mechanical properties of some coatings obtained by cold spray method. A review*, IOP Conference Series: Materials Science and Engineering, 1262, 012023 (2022), DOI: 10.1088/1757-899X/1262/1/012023.

Lupu F.C., Munteanu C., Sachelarie A.C., Arsenoaia V.N., Istrate B., *Improving the Usage Properties of Steel Using Cold Spray Deposition: A Review*, Crystals, 13, 2, 245 (2023), https://doi.org/10.3390/cryst13020245.

Lupu F.C., Munteanu C., Müftü S., Benchea M., Cimpoesu R., Ferguson G., Boese S., Schwartz P., Istrate B., Arsenoaia V.N., *Evaluation of the Wear Properties and Corrosion Resistance of 52100 Steel Coated with Ni/CrC by Cold Spraying*, *Coatings*, 14, 145 (2024), https://doi.org/10.3390/coatings14010145.

Maeng S., Axe L., Tyson T.A., Gladczuk L., Sosnowski M., *Corrosion behaviour of magnetron sputtered a- and b-Ta coatings on AISI 4340 steel as a function of coating thickness*, Corrosion Science, 48, 2154-2171 (2006).

Sabelkin V., Mall S., Misak H., *Corrosion fatigue of coated AISI 4340 high strength steel with dent damage*, Fatigue Fracture of Engineering Materials and Structures, 41, 653-662 (2018), https://doi.org/10.1111/ffe.12725662.

Singh H., Sidhu T.S., Kalsi S.B.S., *Cold spray technology: future of coating deposition processes*, Frattura ed Integrità Strutturale, 22, 69-84 (2012), DOI: 10.3221/IGF-ESIS.22.08.

Toma S.L., Chicet D.L., Cazac A.M., *Numerical Calculation of the Arc-Sprayed Particles' Temperature in Transient Thermal Field*, Coatings, 12, 7, 877 (2022).

Toma S., Chicet D.L., *Expanding the applications of copper-based alloys by thermal arc spraying*, Archives of Metallurgy and Materials, 69, 4, 1629-1635 (2024), DOI: 10.24425/amm.2024.151434.

Voorwald H.J.C., Souza R.C., Pigatin W.L., Cioffi M.O.H., *Evaluation of WC–17Co and WC–10Co–4Cr thermal spray coatings by HVOF on the fatigue and corrosion strength of AISI 4340 steel*, Surface & Coatings Technology, 190, 155-164 (2005).

Voorwald H.J.C., Vieira L.F.S., Cioffi M.O.H., *Evaluation of WC-10Ni thermal spraying coating by HVOF on the fatigue and corrosion AISI 4340 steel*, Procedia Engineering, 2, 331-340 (2010).

Wang C., Li W., Xu Y., Luo X., Li Z., Li W., Song C., Wang M., Zhang Z., Huang C., *Effect of WC-17Co content on microstructure, mechanical properties and wear resistance of WC-17Co/Ni composites produced with cold spraying*, Surface & Coatings Technology, 493, 131252 (2024).

Wei J., Aghasibeig M., Lyu T., Liu Z., Chen H., Irissou E., Zou Y., *Cold spray deposition and microstructure characterization of CuNi, CuSn, and CuNiSiCr coatings*, Surface and Coatings Technology, 480, 130621 (2024).

Weng L., Zhang J., Kalnaus S., Feng M., Jiang Y., *Corrosion fatigue crack growth of AISI 4340 steel*, International Journal of Fatigue, 48, 156-164 (2013), ISSN 0142-1123, https://doi.org/10.1016/j.ijfatigue.2012.10.015.

Yang K., Jiang Z., Zhang S., Li W., *Quantitative analysis of microstructural evolution in cold-sprayed CuCrZr: Understanding heat transfer mechanisms from room temperature to 600°C*, Additive Manufacturing, 92, 104405 (2024).

Young B., Heelan J., Langan S., Siopis M., Walde C., Birt A., Novel Characterization Techniques for Additive Manufacturing Powder Feedstock, Metals, 11, 720 (2021), https://doi.org/10.3390/met11050720.

EVALUAREA REZISTENȚEI LA COROZIUNE A ACOPERIRILOR PE BAZĂ DE Ni-Cr FABRICATE PRIN TEHNICA PULVERIZĂRII LA RECE

(Rezumat)

Metoda de depunere prin pulverizare la rece se deosebește de tehnicile convenționale de pulverizare termică prin faptul că utilizează temperaturi mai scăzute, ceea ce permite depunerea particulelor fără topirea materialului. Astfel, proprietățile inițiale ale particulelor pulverizate sunt păstrate, iar degradarea termică este redusă la minimum. În schimb, metodele de pulverizare termică presupun topirea particulelor, proces care poate favoriza oxidarea, apariția tensiunilor reziduale și modificări ale structurii materialului în timpul solidificării.

În cadrul acestui studiu, a fost investigată rezistența la coroziune a oțelului 4340 acoperit cu un amestec de particule de nichel și carbură de crom (Ni/CrC). Testele de electrocoroziune au confirmat faptul că stratul depus se menține într-o stare aproape intactă, fiind identificate doar urme reduse de compuși în soluția electrolitică. Acest rezultat indică un grad de oxidare considerabil mai scăzut al acoperirii comparativ cu materialul de bază.