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Additively Manufactured Nickel-Aluminium Bronze: Exploring Techniques and Corrosion Performance

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Extended Abstract

Additive Manufacturing (AM) has emerged as a transformative metal production technology that enables the direct fabrication of complex components. Unlike traditional metal processing methods, AM utilizes laser or electron beams to melt metal powders and build parts layer by layer. Additionally, the wire arc additive manufacturing (WAAM) method employs a wire as the input material, undergoing fusion and placement onto a substrate. This design flexibility and the ability to produce intricate geometries have made AM a promising manufacturing approach across various industries [1].

The production of copper-based alloys, particularly Nickel-Aluminium Bronze (NAB), using WAAM and Laser Powder Bed Fusion (LPBF) techniques, has been extensively investigated in our research group as well as in the literature [2], [3], [4]. It is well established that variations in AM processes significantly influence defect formation and the microstructural features of metallic components. Factors such as preheating of the substrate/platform, along with the geometry of the fabricated components, affect thermal conditions during the AM process. Consequently, these variations lead to different microstructural evolutions, which are closely correlated with the functional performance of the components, especially their corrosion resistance.

The objective of this study is to investigate the correlation between the microstructural features of NAB components fabricated using WAAM and LPBF techniques and their corresponding corrosion resistance.

NAB samples were manufactured using gas metal arc welding (GMAW) within the WAAM process, resulting in components referred to as WAAM-NAB. These components were produced in both cuboidal and cylindrical shapes. Similarly, the LPBF method was employed to fabricate NAB components using gas-atomized powder with a nominal chemical composition of Al: 8.5-9.5 wt.%, Ni: 4-5 wt.%, Fe: 3.4-4.5 wt.%, Mn: 0.8-1.5 wt.%, with copper as the balance element. Both cuboidal and cylindrical samples were fabricated using the LPBF process.

Electrochemical measurements were conducted on the AM samples in a 3.5 wt.% NaCl solution to evaluate their corrosion performance. Potentiodynamic polarization tests and electrochemical impedance spectroscopy (EIS) were employed to assess the corrosion behaviour. Microstructural analyses were performed using various characterization techniques, including scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD), to gain insights into the effects of microstructural features on corrosion performance.

The results revealed that the formation of martensitic phases and the precipitation of kappa phases, coupled with finer grain sizes in LPBF components compared to WAAM components, led to a reduction in their corrosion resistance. WAAM-fabricated NAB components predominantly consisted of the α-phase and kappa phases, which provided superior corrosion resistance compared to their LPBF counterparts. Furthermore, changing the geometry of LPBF components from cuboidal to cylindrical shapes did not significantly affect their microstructure or corrosion characteristics. However, this phenomenon exhibited an inverse trend in the WAAM-fabricated components, where shape variations between cuboidal and cylindrical samples resulted in noticeable differences in corrosion resistance.

These findings highlight the significant influence of AM processing parameters and component geometry on the microstructural features and corrosion resistance of NAB components, providing valuable insights for optimizing AM techniques for enhanced performance in marine and other corrosive environments.

References

[1] J. Kranz, D. Herzog, and C. Emmelmann, “Design guidelines for laser additive manufacturing of lightweight structures in TiAl6V4,” *J Laser Appl*, vol. 27, no. S1, p. 14001, Feb. 2015, doi: 10.2351/1.4885235/221702.

[2] A. Shahriari, D. Chalasani, B. S. Amirkhiz, and M. Mohammadi, “Corrosion performance of wire arc additively manufactured NAB alloy,” *npj Materials Degradation 2023 7:1*, vol. 7, no. 1, pp. 1–15, Oct. 2023, doi: 10.1038/s41529-023-00405-x.

[3] F. Moghabeli, S. Sadeghpour Boroujeni, F. Khodabakhshi, S. Taheriniya, D. Chalasani, A. Arumugham Akilan, S. Atre, G. Wilde, M. Mohammadi, “Electrochemical behavior of laser powder bed fused nickel aluminum bronze: As-built and tempered alloys,” *Corros Sci*, vol. 244, p. 112627, Mar. 2025, doi: 10.1016/J.CORSCI.2024.112627.

[4] G. Zhang, C. Chen, X. Wang, P. Wang, X. Zhang, X. Gan, K. Zhou, “Additive manufacturing of fine-structured copper alloy by selective laser melting of pre-alloyed Cu-15Ni-8Sn powder,” *The International Journal of Advanced Manufacturing Technology 2018 96:9*, vol. 96, no. 9, pp. 4223–4230, Mar. 2018, doi: 10.1007/S00170-018-1891-3.