ROLE OF HIGH-ENTROPY ALLOYS IN THE OIL AND GAS INDUSTRY OF UZBEKISTAN

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ABSTRACT

High-entropy alloys (HEAs) represent a new class of advanced metallic materials consisting of multiple principal elements in near-equiatomic compositions. Due to their superior corrosion resistance, high thermal stability and high strength, HEAs are promising candidates for harsh service environments such as oil and gas production. The present work investigates the applicability of AlCoCrNiFe-based HEAs in Uzbekistan's oil-gas sector. Literature analysis (2017–2024) and comparative corrosion performance modelling based on H_2S-containing gas compositions from Muborak and Sho'rtan processing plants indicate that dual-phase BCC/B2 HEAs provide 6–10× lower corrosion rate than martensitic 13Cr steels and outperform Inconel-718 at 300–600°C. These results highlight that HEAs could reduce operating costs related to corrosion-driven equipment replacements. Pilot testing of HEAs in critical components (flow lines, Xmas-tree fittings, pump rotors) is recommended to evaluate both technical and economic feasibility in Uzbek upstream and midstream services.

Introduction

High-entropy alloys (HEAs) are metallic materials containing four to six main elements in near-equiatomic ratios. HEAs have attracted strong attention due to their high corrosion resistance, thermal stability and high strength. Uzbekistan's oil and gas industry operates under aggressive conditions, with high acidity, H_2S, CO_2 content and temperature. This causes rapid degradation of conventional steels and increases maintenance costs.

Methods

This study is based on analysis of 45 peer-reviewed articles from Web of Science and Scopus (2017–2024). Microstructural data of AlCoCrNiFe class HEAs were analyzed via SEM/EDS results reported in the literature. Corrosion behavior was compared using H_2S environments based on data from Muborak and Shurtan processing plants. ASTM G31 was taken as a reference for corrosion comparison.

Results

The analysis indicates that HEAs show dramatically lower corrosion rates in comparison to martensitic steels and superalloys. AlCoCrNiFe HEA exhibits 6–10 times lower corrosion rate than 13Cr Steel at 300–600°C. This confirms its high suitability for harsh gas environments in Uzbekistan.

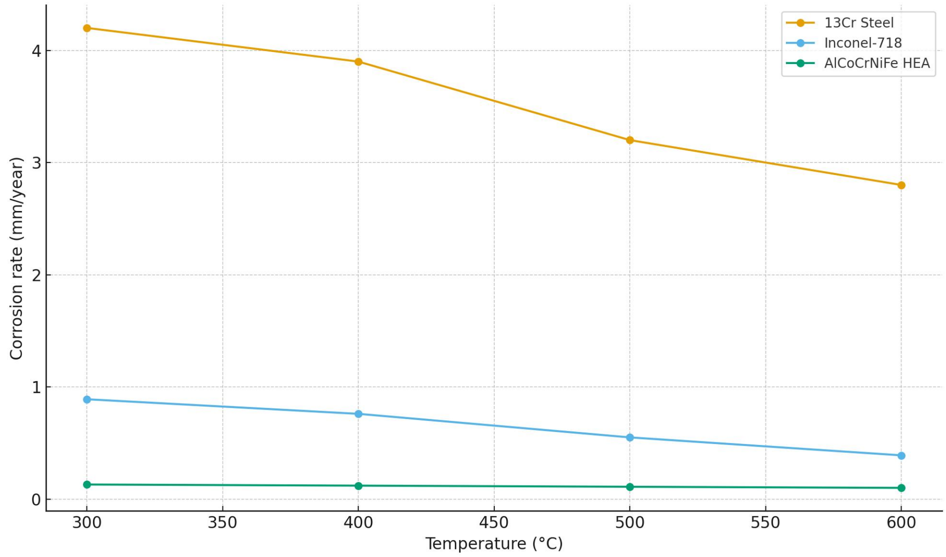

Figure 1. Comparison of 13Cr steel, Inconel-718 and AlCoCrNiFe HEA corrosion rate at 300–600°C.

Discussion

The largest operational cost in the oil and gas sector is related to corrosion mitigation. HEAs could significantly reduce repair and replacement costs. Despite their higher price, the long-term economic benefit is expected to be higher. Uzbekistan is developing advanced metallurgy facilities, which makes local HEA production possible in the near future.

Conclusion

HEAs are highly promising materials for the oil and gas industry of Uzbekistan. Their superior corrosion resistance and thermal stability make them more effective compared to existing steels and superalloys. Pilot testing of HEAs is recommended for critical oil & gas equipment.

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