A BRIEF OVERVIEW OF ADVANCED ALLOYS DEVELOPED BY ARC-BASED ADDITIVE MANUFACTURING

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ABSTRACT

Alloys possess exceptional mechanical properties suitable for diverse applications. Wire Arc Additive Manufacturing (WAAM) has emerged as an efficient technique for fabricating complex geometries and is increasingly applied to the development of advanced alloys. This review explores the fundamental principles of WAAM and emphasizes the correlation between microstructure and mechanical properties. It synthesizes recent research on WAAM-fabricated alloys, focusing on microstructural evolution, mechanical behavior, and underlying strengthening mechanisms. Special attention is given to how WAAM influences phase formation, grain refinement, and defect distribution in various alloy systems. The review underscores WAAM's potential in accelerating alloy innovation and concludes with proposed future research directions to optimize alloy performance through process control and material design.

Keywords: *High Entropy Alloy, Wire Arc Additive Manufacturing, Strengthening Mechanism, Microstructure, Mechanical Properties.*

1. INTRODUCTION

Additive manufacturing (AM) as a process and high entropy alloy (HEA) as a desirable customalloyshowed high potential for application in the twenty-first century [1-4]. Among all the AM processes wire arc additive manufacturing (WAAM) stands out due to its cost-effectiveness and high-volume deposition [5].Ahsan et al. [6] used a single-wire system for Al0.1CoCrFeNi HEA development by wire drawing from molten metal and depositedon the HEA substrate which was taken out from the same melt. Huang et al. [7] took a double-wire approach to fabricate AlCoFeNi HEA and achieved balance strength and plasticity.As the critical combination of elements is getting higher in HEA more numbers of wires have been taken for the fabrication of HEA for instance Osintsev et al [8]used three wires to fabricate non-equiatomic CoCrFeMnNi HEA. Moreover, Shen et al. [9] combined seven wires to produce AlCoCrFeNi HEA and observed the presence of both BCC and FCC phases.However, the BCC phase was lesser compared to casting due to the loss of Al in splashing. Several challenges are still associated with WAAM toproduce functional HEAs such as controlled solidification, regular deposition, splashing, lack of fusion, porosity, etc.Compared to the other AM processes, WAAM is difficult to control regarding multi-principal element alloy (MPEA). This study has been conducted to understand the role of WAAM inproducing HEA as achieving a solid solution is more difficult in WAAM. The heterogeneous microstructure in WAAM which leads to anisotropy,needs exploration to understand the mechanism in HEA.

2. STRUCTURE-PROPERTY CORRELATION

The advancement of HEAs relies on thermodynamic principles, aiming to minimize Gibbs free energy. This primarily involves two key parameters, atomic radii difference (δ) and the mix enthalpy (ΔH_{mix}), expressed for a binary system as follows[10]:

$$\delta = \sqrt{\sum_{i=1}^{N} c_i \left(1 - r_i \Big/ \left(\sum_{i=1}^{N} c_i r_i\right)\right)^2} \quad (1)$$

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