Development of arc directed energy deposition process to achieve consistent bead geometry and microstructure with optimized feedstock chemistry in C-Mn steel

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BACKGROUND

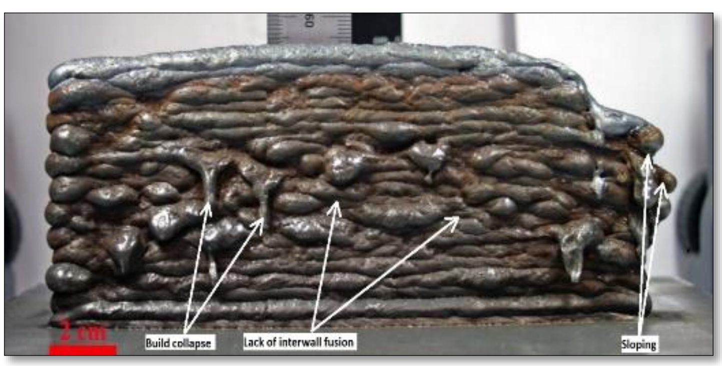
- Arc directed energy deposition (DED) process is getting immense attention for producing metallic parts in layer-by-layer fashion
- The process has demonstrated high deposition rates to produce near net shapes
- Surface roughness, inhomogeneous microstructure and heat accumulation are the prime challenges
- These pressing issues need to be addressed to improve process stability and structural integrity
- Limited research has been carried out in the field of widely used C-Mn steel

AIM & OBJECTIVES

Development of arc directed energy deposition process to achieve consistent bead geometry and microstructure with optimized feedstock chemistry in C-Mn steel

- Identify key process parameters and control methods
- Achieve consistent bead geometry with the use of efficient deposition paths
- Calculate thermal field and its use for process advancement
- Generate weld samples and measurement of process data
- Weld trials with optimum parameters and improved feedstock chemistry
- Preparation and characterization of the deposited samples

PROCESS CHALLENGES



Example of sloping & Build collapse in a maraging steel[4]

- High heat input due to layer-by-layer deposition
- Low heat dissipation through energy transfer modes
- Melting of initial layers can cause build collapse
- Heat accumulation affects layer formation
- Results in build collapse, sloping and surface roughness

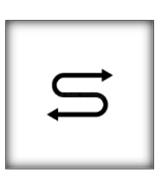
Building direction	Weld layers	Microstructure of low carbon steel
	Top layers	Acicular ferrite, allotriomorphic ferrite and bainite
	Intermediate layers	Transformation from acicular ferrite to polygonal
	Bottom layers	Polygonal ferrite & acicular ferrite/bainite

Anisotropic Microstructure[2]

- Inhomogeneous microstructure is function of repeated thermal cycles
- Bottom layers undergoes more thermal cycles compared to other layers whereas top layers experiences less cycles
- Thermal gradient is directly related to solidification and microstructure
- Mechanical properties compared to conventional welding
  Yield & Tensile strengths are ***lower*** and notch toughness ***increases***[1]

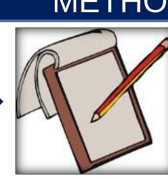
METHODOLOGY

Selection of critical process parameters

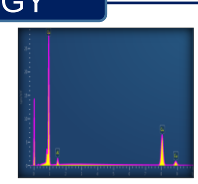


Selection of process path

Deposition trials

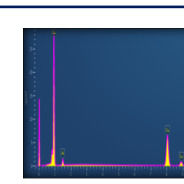


Recording data linked to thermal gradient



SEM analysis of welded samples

Deposition trials with optimized feedstock, ideal parameters & path



SEM analysis of welded samples with advanced data

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