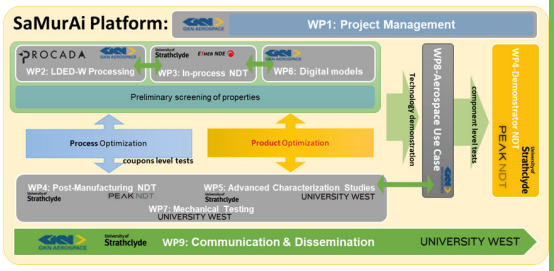
Sustainable Manufacturing of High-Integrity Aeroengine Components with Excellent Mechanical Properties (SaMurAi)

Abstract:

Laser Directed Energy Deposition is an industrially attractive manufacturing route to add intricate, near-net shaped deposits on large aeroengine components. Haynes 282 is a Nickel-based superalloy used in hotter sections of an aeroengine. The 1st challenge is that the LDED-w processed H282 is prone to occasional hot cracking, which compromises performance requirement. The second challenge relates to lack of mature non-destructive technique for detecting fine (~200µm) flaws. The overall goal of SaMurAi is to identify an LDED-w processing window for H282 deposition that yields minimal defects, and mature NDT methods. An inter-disciplinary approach (Experiments-Machine Learning) will be used.



Countries involved

Application sectors
Aerospace

Research and innovation domains
Advanced manufacturing processes

Total cost in M€ (millions)
1.68 M€

Starting date
01/06/2025

Duration (in months)
36 months

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RATIONALE OF THE PROJECT

The recent trend for aero-engine component manufacturing is driven towards deploying sustainable manufacturing routes when compared to castings and forgings. Laser Directed Energy Deposition (LDED) with wire (w) is a sustainable manufacturing technology due to its capability to deposit near-net shaped components that need minimal machining, which significantly lowers the buy-to-fly ratio for aero-engine components compared to billet forgings that undergo extensive machining. Haynes 282 (H282) is often used in hotter section of an aeroengine (turbine casings) due to its capability to withstand high (800° C) service temperatures. So far, no published studies are available on LDED-w processing of H-282. Deploying LDED-w processed H282 deposits for large hot turbine casings can improve the buy-to-fly ratio (9:1 in current forgings to 4:1 in LDED-w H282) significantly and save >800 Kg. of material from post-deposit machining on each engine casing manufactured due to the near-net shape builds achieved when compared to forgings. However, one of the major challenges for industrial adaptation of LDED-w H282 relates to the occasional hot cracking (observed in metallographic specimens) in certain regions of the LDED-w processed H282, which deteriorates the mechanical performance. The compliance to defect tolerance limit for an aeroengine application is very stringent when compared to other industrial sectors such as automotives, which necessitates the need for high integrity build.

TECHNOLOGICAL INNOVATION, ACHIEVEMENTS AND RESULTS

SaMurAi explores advanced manufacturing technologies that involve LDED-wire for nickel-based superalloys to fabricate high-performance aero-engine components. The project's value chain includes technical aspects such as component and process design, production, material, machine learning. It also includes in-situ and ex-situ quality assurance, component verification, and certification. The project aims to create high-integrity aero-engine components. This will be achieved using innovative and efficient manufacturing processes that produce superior components with improved performance and longevity.

MARKET POTENTIAL

The global Aircraft Engine Market is expected to grow at a 2.78% CAGR from 2023 to 2029. It is expected to reach above USD 80.5 billion by 2029 from USD 62.4 billion in 2022. The share of superalloy-based hot cases is roughly 6% of the total engine market, reaching USD 5 billion globally. GKN Aerospace's primary market is aeroengines as it provides a range of products and services to this industry, including engine systems. Detailed market research was conducted to estimate the growth of civil aircraft up to 2050. This study reveals that approximately 53000 new fleets will be in the market by 2050 with future generation and upgraded versions of current generation engine technology. By 2030 and 2040, there will be 16k and 33k new civil aircraft, respectively, with new and upgraded engines. This will create significant opportunities for our proposed component, primarily driven by increased engine efficiency (ability to operate at higher temperatures), reduced weight the same thrust, and subsequent fuel and emission savings over the lifecycle.

IMPACT POTENTIAL

The project has a clear economic and societal impact on the Swedish and UK's aerospace industry. It is heavily export-driven, with an estimated turnover of £22 billion in 2022. According to the UK's Aerospace Technology Institute (ATI) strategy document, the main strategical ambition and investment priorities are the development and adoption of sustainable aircraft technologies, with a focus on high-rate and advanced manufacturing of aerostructures, to bring aviation closer to Net Zero emissions by 2050 with potential growth in its market to 18% of the global market share worth £4.3 trillion in 2050.