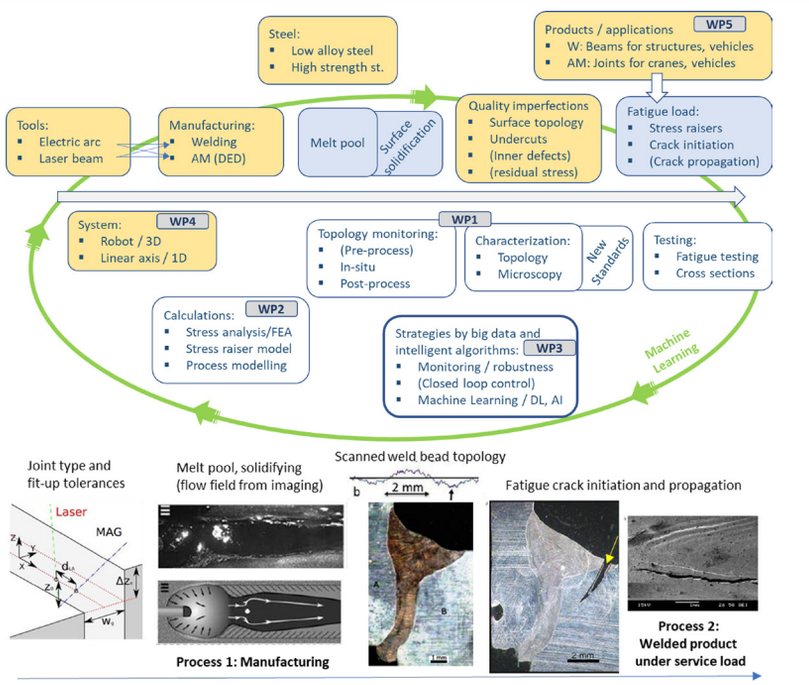
SIMS: Sustainable Surfaces by Intelligent Solidification in Manufacturing Systems

Abstract:

Fatigue life is an essential property for many metal products, determining their safety and life cycle. During welding or Additive Manufacturing, the solidification of the melt pool determines essential aspects of fatigue life, particularly by the surface topology. The project aims at the development of a smart manufacturing system based on Machine Learning using optical sensors and model-based algorithms to identify and optimize critical aspects during manufacturing, particularly stress raisers. A concept for an adaptable commercial manufacturing systems will result, integrating sensors and artificial intelligence for welding and additive manufacturing, using electric arcs or laser beams.



Countries involved

Application sectors
Industrial components

Research and innovation domains
Advanced manufacturing processes, Smart & adaptative manufacturing systems

Total cost in M€ (millions)
1.358 M€

Starting date
01/09/2023

Duration (in months)
36 months

Project website
https://www.ltu.se/research/subjects/Produktionsutveckling?l=en

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RATIONALE OF THE PROJECT

Fatigue life of a product requires careful optimization of manufactured surfaces, obtained during welding or additive manufacturing. This addresses also structural optimization and improved lifecycle service.

The goal of the project is enhancing the fatigue life of metal products like cranes, civil and offshore constructions. Three manufacturing techniques will be studied: Gas Metal Arc Welding (GMAW), Laser Arc Hybrid Welding (LAHW) and Wire Arc Additive Manufacturing (WAAM). The three processes have the solidification of a melt pool in common. It defines the topology and thus the fatigue life of a product.

Although a complete understanding of the complex processes is difficult to achieve, a sensor- and data-based method with suitable algorithms is required based on Machine Learning methods (artificial intelligence) for optimization of the targeted manufacturing processes, thereby increasing their robustness and providing the possibility to react on risky conditions.

TECHNOLOGICAL INNOVATION, ACHIEVEMENTS AND RESULTS

Based on advanced fatigue testing, correlated with surface topology of welds, a model for combined criteria will enable to predict critical crack initiation areas in the manufactured product and its fatigue life. Suitable models will enable specification of improved acceptance criteria, and hence propose better fatigue life standards for welding and additive manufacturing. High speed imaging and thermal (IR) imaging of the melt pool details together with finite element analysis, knowledge will be generated, as a base to develop an intelligent machine self-learning algorithm. The complex phenomena of the solidifying weld pool and during fatigue crack initiation will be analysed as a necessary fundament for the above-specified goals.

The project will study, develop and optimize the above approaches for manufacturing systems for fatigue loaded steel products in a generalizing manner for the following three manufacturing techniques: arc welding, laser-arc hybrid welding, WAAM (all resulting from similar melt pools). Other projects have made certain progress on this important challenge, but the underlying mechanisms have been too complex to be systematically solved yet. Here, Machine Learning based on a different approach is proposed to solve the challenge in a radically different manner. The approach does not need to immediately resolve and map the whole solution but instead proposes a system that can continuously and gradually improve itself, solve and widen the solutions.

MARKET POTENTIAL

The project addresses different markets. The OEMs sell loader cranes (HIAB) and construction equipment (Volvo CE). Winteria develops and sells software for analysis of scanned data. LMI installs metal manufacturing systems. JHS and Smulders carry out manufacturing for several customers. JHS serves energy, construction, transport, air-treatment markets etc. Guaranteed offers metal additive manufacturing services. Smulders, part of an international steel construction company, is active in civil construction, offshore oil and gas, and offshore wind market. The market potential through the project is of importance for all the participating companies (and similar companies in Europe). The highest holistic growth is expected in construction equipment (VCE) and loader cranes (HIAB), followed by welding supplier business (Jonckheere, Smulders), while systems integration (LMI), WAAM service (Guaranteed), and software (Winteria) industries can instead expect large relative growth rates.

IMPACT POTENTIAL

The SIMS project addresses three manufacturing processes: GMAW, LAHW and WAAM. While GMAW is well established in Europe, enhanced implementation of LAHW and WAAM as high-performance techniques will be promoted. LAHW requires further development support to release its potential and WAAM needs to develop technology readiness. The results from the project will enable powerful use of LAHW and WAAM and contribute to their enhanced implementation. The participation and involvement of different stakeholders from product development and preparation operations to manufacturing and resulting use, accompanied by system manufacturers and integrators strengthens the impact of the project.