Master Thesis – (30 credits/ 20 weeks – 1 student)

"Mitigation of Surface Roughness Impact on Ultrasonic Testing in PBF-LB Additive Manufacturing."

About GKN Aerospace

GKN Aerospace is the world's leading multi-technology tier 1 aerospace supplier. With 55 manufacturing locations in 15 countries, we serve over 90% of the world's aircraft and engine manufacturers. We design and manufacture innovative smart aerospace systems and components. Our technologies are used in aircraft ranging from the most used civil aircraft to the world's advanced 5th generation fighter aircraft and the Ariane orbital rockets used by ESA.

Project Background

The rise of additive manufacturing (AM), particularly Powder Bed Fusion with Laser Beam (PBF-LB), has revolutionized the production of complex and customized components. The industries where metal AM is employed are often associated with critical safety applications. As such, the requirements for material quality and the size of present defects are stringent. As GKN Trollhättan is currently focused on additive manufacturing, there is a need to obtain fast feedback to determine the process capabilities in order to mature a technology with controlled and known material properties and process defects.

Non-Destructive Evaluation (NDE) methods are crucial for inspecting these components without causing damage. Ultrasonic Testing (UT) is a widely adopted NDE technique that uses sound waves to detect internal flaws. Inspecting parts at an early stage in the manufacturing process has its advantages.

Materials like In718 (a nickel superalloy) are extensively used for their strength and stability at elevated temperatures, making them ideal for components in jet engines and rocket motors, where temperatures can rise above 600°C. However, it has been revealed that inspecting In718 is more challenging than inspecting similar aerospace alloys. This difficulty may be attributed to the material's complex texture and anisotropic, coarse microstructure, which can affect the propagation of ultrasonic waves and the detection of defects.

Components obtained through PBF-LB are widely known to generate rough as-built surfaces. The inherent uneven surface has a negative impact on the UT inspection process, reducing inspection sensitivity.

Ultrasonic probes can rely on different beam propagation technologies. One example that differs from the conventional focused probe is the phased array probe, which consists of multiple small piezoelectric elements that can be pulsed independently, presenting considerable advantages in the investigation of complex materials.

Lastly, an highly interesting emerging technology to consider is Phase Coherence Imaging (PCI). Its operational mechanism is based on evaluating the coherence between the signals detected by all the elements of a phased array ultrasonic testing probe. Its major advantages consist of how it can be used on coarse-grained materials without sacrificing capability. This is particularly interesting since deposited nickel alloys such as Haynes 282 and Inconel 718 are very hard to inspect with conventional UT. PCI should be considered a relatively new technology, not yet investigated for AM components, and it has a limited number of suppliers.

GKN is currently making major invetsments in the industrial capability for manufacturing and fabrication of additively manufactured engine structures. Robust and capable post-processes and inspection solutions are essential in this industrial establishment. The outcome of this work is expected to provide guidance to the industrial road map by evaluating the industrial applicability of evaluated ultrasonic solutions.

Assignment Description

The objective of this study is to investigate several subtopics related to the inspection of Ultrasonic Testing (UT) on the surface roughness of PBF-LB components made from In-718.

1. Investigate the Effect of Surface Roughness and Methods to Reduce Impact on Ultrasonic Testing

- **Measurement of Attenuation**: Quantify how surface roughness in as-built In-718 PBF-LB samples affects ultrasonic signal apparent attenuation compared to post-processed surfaces.
- **Optimization of Inspection Parameters:** Explore methods to mitigate the impact of surface roughness by adjusting water column height and active aperture area during immersion UT inspections.
- **Signal Improvement Analysis:** Evaluate improvements in signal-to-noise ratio and defect detectability resulting from optimized inspection parameters.

2. Comparison of Sensitivity Between Conventional Focused Probe and Phased Array Annular Probe

- **Experimental Setup:** Conduct ultrasonic inspections using both conventional focused probes and phased array annular probes on identical test samples containing known defects.
- **Sensitivity and Resolution Analysis**: Compare the sensitivity, resolution, and depth penetration capabilities of each probe type in detecting and sizing defects.
- **Technique Evaluation:** Determine the advantages and limitations of each probe configuration for inspecting AM components with varying surface conditions.

3. Investigation of Phase Coherence Imaging (PCI) technology on challenging AM materials

- **Experimental analysis with PCI equipment:** Perform experimental analysis using the PCI method on AM samples that are challenging to inspect with conventional UT.
- **Sensitivity and Resolution Analysis**: Compare the sensitivity, resolution, and depth penetration capabilities of the PCI method.
- **Technique Evaluation:** Determine the advantages and limitations of the PCI technique and its applicability for AM components, potentially comparing it with casting materials.

4. Feasibility of Using Flexible Robotic Carrier Systems

- **UT Inspection integration:** Assess the use of articulated robotic arm specifically for ultrasonic inspections on flat geometry.
- **Defect sizing using the 6 dB-Drop Method**: Implement and validate defect sizing techniques using robotic manipulation to maintain consistent probe positioning and orientation.

Thesis Details

The presented thesis is a collaboration with University West and GKN Aerospace. Therefore the student will have a person of reference and present the obtained results in both organisations.

1. **Qualifications:**

The student shall have completed any relevant course in scientific writing and material science.

2. **Time Frame:**

6th January – 5th June 2025 (during the university thesis period).

3. **Number of students:**

One student.

4. **Working location:**

Inspection Laboratory at Innovatum, PTC (laboratory shared between GKN and University West), Trollhättan.

5. **Remuneration:**

The student is remunerated for its industrial work for 1.000 SKr per credit.

6. **Supervisors:**

- Mikael Sahl – University West
- Luigi Fadini – GKN Aerospace Trollhättan

7. **Examiner:**

Håkan Wirdelius

8. **Apply by:**

Last date for application: 2024-12-17.

Send your resume to Luigi.Fadini@gknaerospace.com.