AUTOMATION OF CARBON FIBRE PREFORM SCANNING: A CASE STUDY

NATIONAL COMPOSITES CENTRE

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The National Composites Centre (NCC) is an independent, open-access technology centre delivering world-class research and development of composites. As part of the UK's Catapult Network, we offer our partners access to the latest technology, provide technical expertise and the business support they need to overcome barriers to innovation and accelerate their growth.

The CoSInC project is supported by the ATI Programme, a joint Government and industry investment to maintain and grow the UK's competitive position in civil aerospace design and manufacture. The programme, delivered through a partnership between the Aerospace Technology Institute (ATI), Department for Business and Trade (DBT) and Innovate UK, addresses technology, capability and supply chain challenges.

Introduction

Composite Smart Industrial Control (CoSInC) is a Research & Development (R&D) programme of work tackling bottlenecks in composites manufacturing. The programme's aim is to develop a robust and repeatable production system through digital capabilities and advanced manufacturing tools. Reliable inspection data is crucial for CoSInC's success.

This case study explores how Hexagon's AS-1 3D laser scanner, integrated with an industrial robot, addresses a key challenge in CoSInC's goals: ensuring consistent and repeatable inspections of carbon fibre preforms throughout the manufacturing process.

Challenge

Manual scanning of intricate carbon fibre preforms is a labour-intensive and highly challenging task due to their optical properties. This process can also lead to ergonomic issues for operators, as it often involves physically demanding movements.

Recognising the necessity for a more repeatable scanning process, there has been a drive to explore automated solutions. By using the developed automated system, we can efficiently gather data, ensuring trustworthy results are achieved. Automating the process minimises potential inconsistencies in manual scanning, leading to optimised efficiency in data acquisition overall.

Implementation

Collaboration with robotics experts facilitated the integration of the AS-1 3D laser scanner onto a robotic arm.

This integration was aimed at ensuring seamless operation and user familiarity within the CoSInC framework.

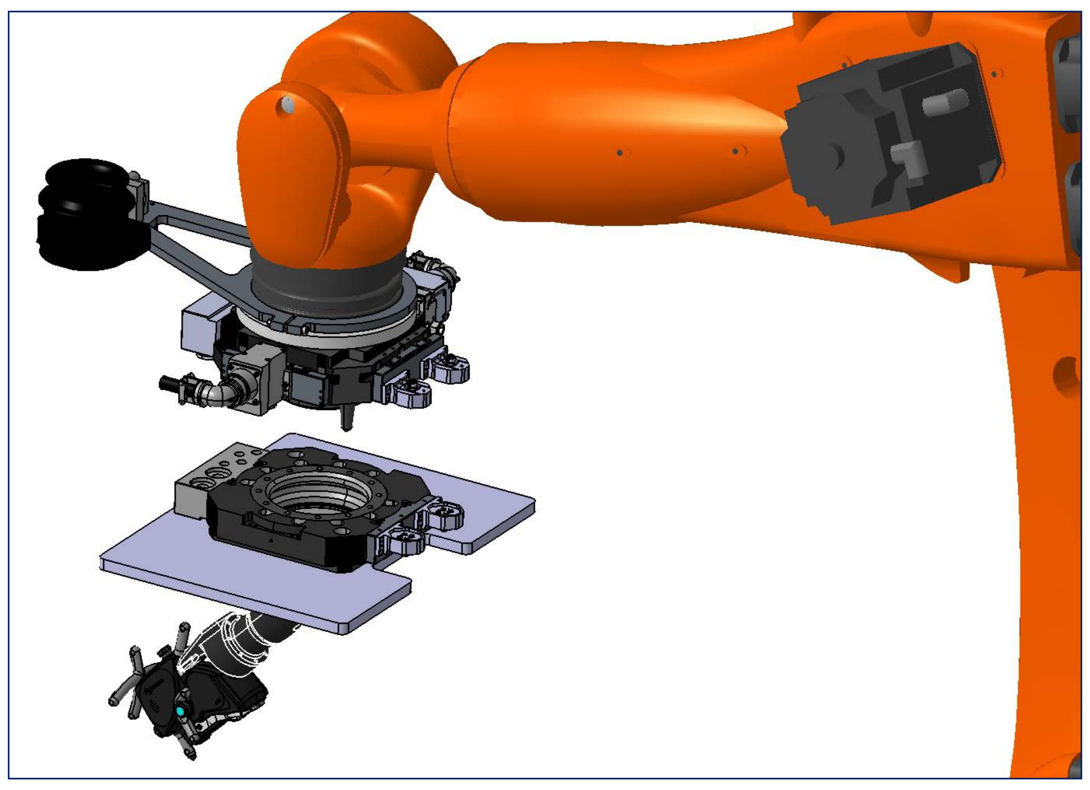

Figure 1: Quick-change end effector of the robot with the scanner assembly.

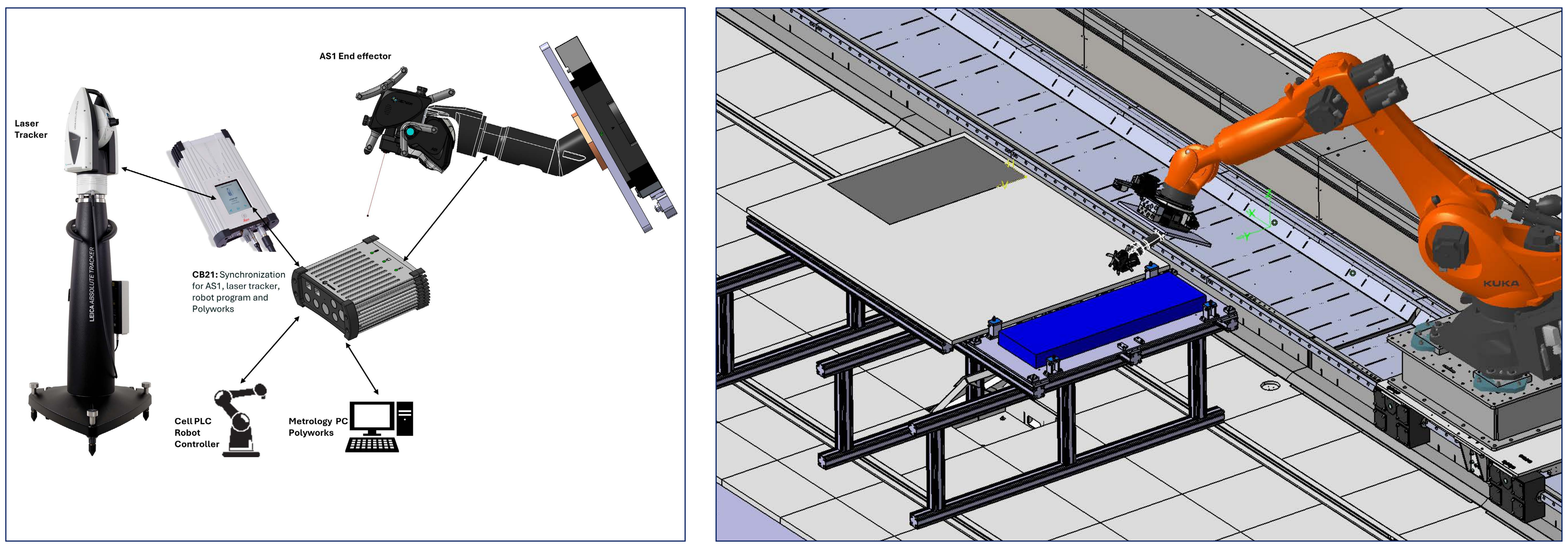

Figure 2: Schematic showing setup of automated scanning system at NCC

The AS1 was attached to the robot's quick-change end effector in the automation cell. It was connected to the tracker and then linked to the cell's computer. A cable from the cell's Programmable Logic Controller (PLC) was connected to the AS1 CB21 box, allowing the robot and tracker to work together automatically. The CB21 has two cables secured to AS1 end effector, a cable connecting to the cell PLC, a network cable to the cell computer, and connections to the tracker control box.

The system was managed by a PolyWorks (PW) script, which issued commands to the robot program. Signals and flags were sent between the PW script and the robot program through the PLC; this let the robot know when to move and told PW when the robot finished its tasks.

Results

We achieved reductions in scanning time while upholding consistent and repeatable results across various geometries.

The automated scanning process has led to a threefold decrease in scan time for simple flat geometries and a tenfold reduction for more complex shapes. This efficiency enhancement ensures swift data acquisition without compromising accuracy. Furthermore, our data collection process has demonstrated consistency, guaranteeing repeatability across scans.

The integration of the AS-1 scanner with automation systems has further optimised our workflow, contributing to our overall success in achieving faster, more reliable scanning processes.

Valuable Data for CoSInC

Repeatable scan data from the AS-1 system provides the foundation for CoSInC's development of validated simulations for carbon fibre preform inspection. Although this was focused on preform inspection for simulation validation, it would be equally capable for cured part inspection. This data will contribute to building a Digital Twin (DT) of the process, enabling virtual testing and optimisation within the CoSInC framework.

(a) (b)

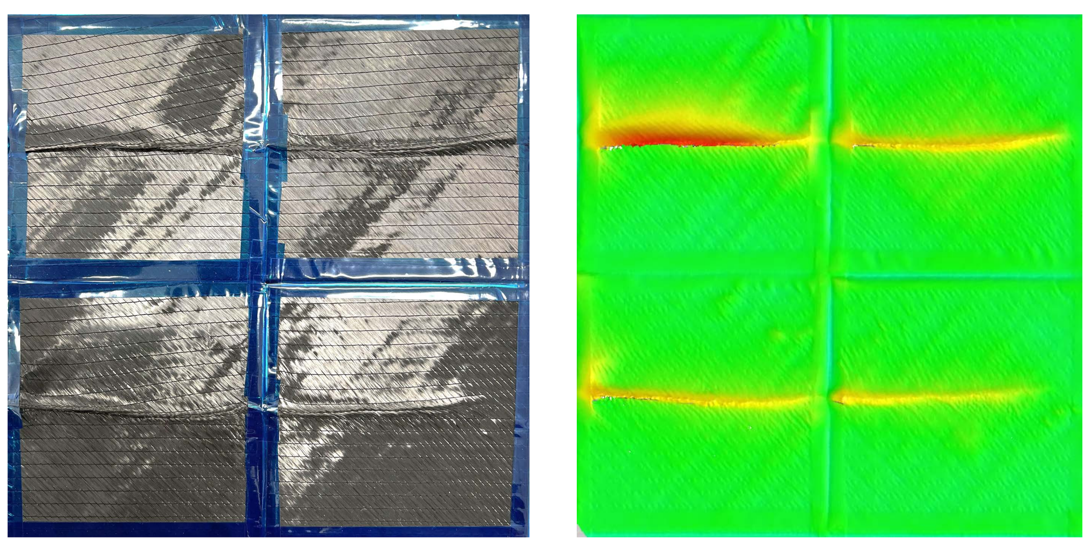

Figure 3: (a) Defect artefact in Non-crimp fabric (NCF) material with cone wrinkles of different sizes. (b) Defect artefact scan and heat map for defect detection.

(a) (b) (c) (d)

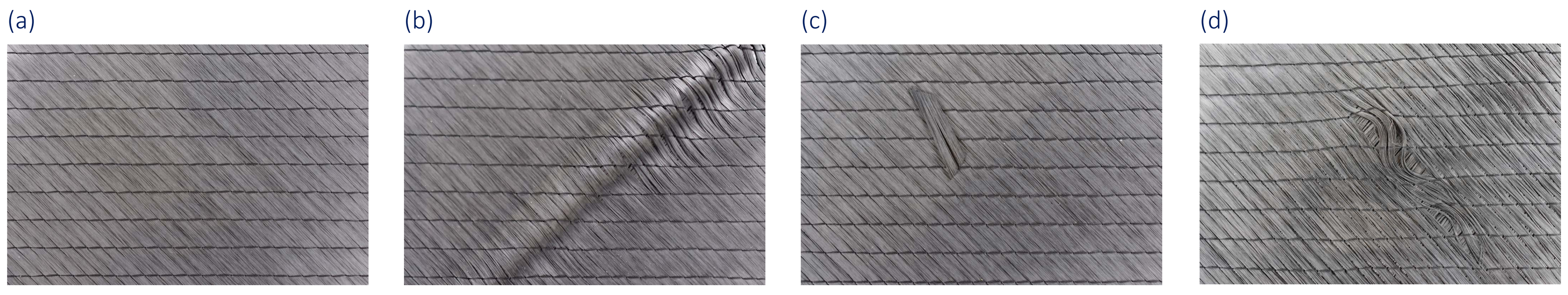

Figure 4: Examples of NCF showing (a) No Defect (b) Straight wrinkle (c) Foreign Object Debris (FOD) and (d) In plane waviness.
Defects such as these need to be identifiable from the collected data and processed to determine their type, severity, extent, and location.

Conclusion

By integrating the AS-1 scanner into the robotic system at the NCC, we have successfully established a robust system for collecting repeatable datasets on composite part defects. This capability is invaluable in a research environment where physical part production is costly and data acquisition can be challenging. Rapid robot setup and programming times enable us to efficiently collect data across various geometries, materials, and production stages. These datasets are instrumental in addressing critical research questions, such as:

- How can we objectively quantify composite defects like "wrinkles" to ensure consistent inspection results?
- What constitutes a "good" part? For instance, how many wrinkles are acceptable at a specific process stage, and what are the tolerable severity, extent, and location?
- How can we effectively compare real-world results with simulations to enhance the accuracy and reliability of our computational models?

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