AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE
The University Of Sheffield.

Automated Construction Demonstrator

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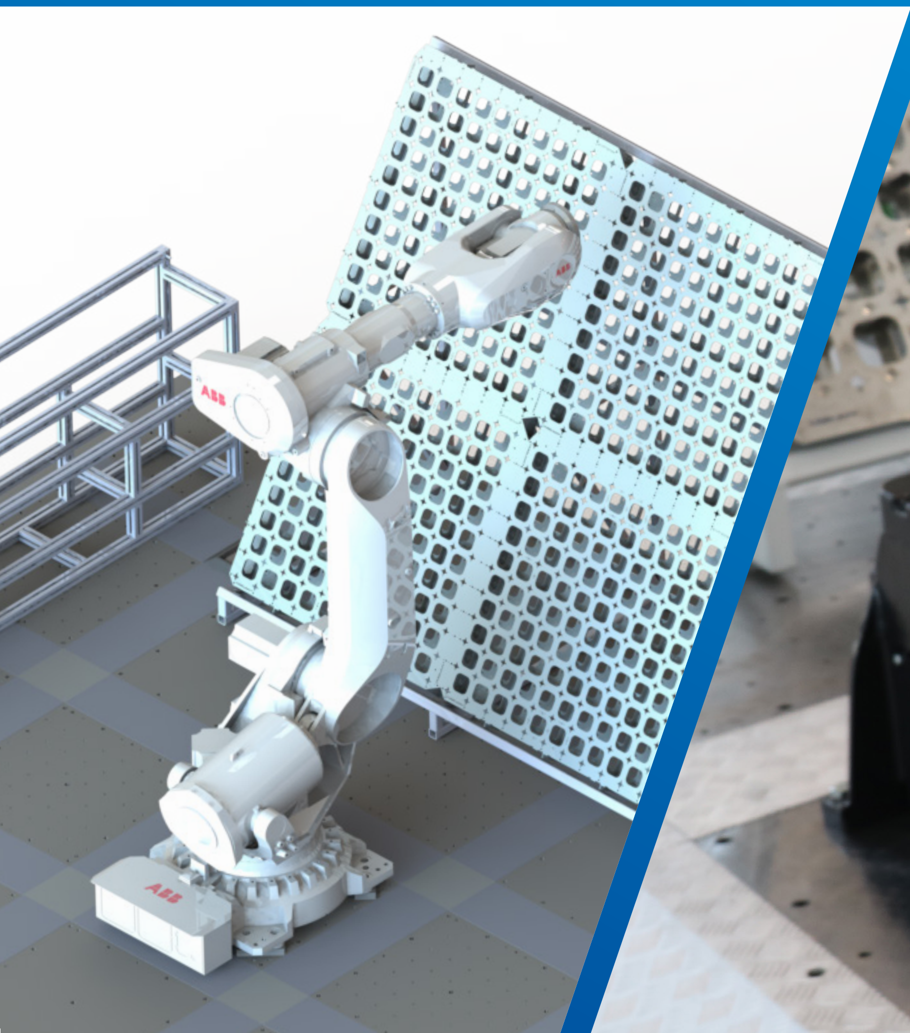

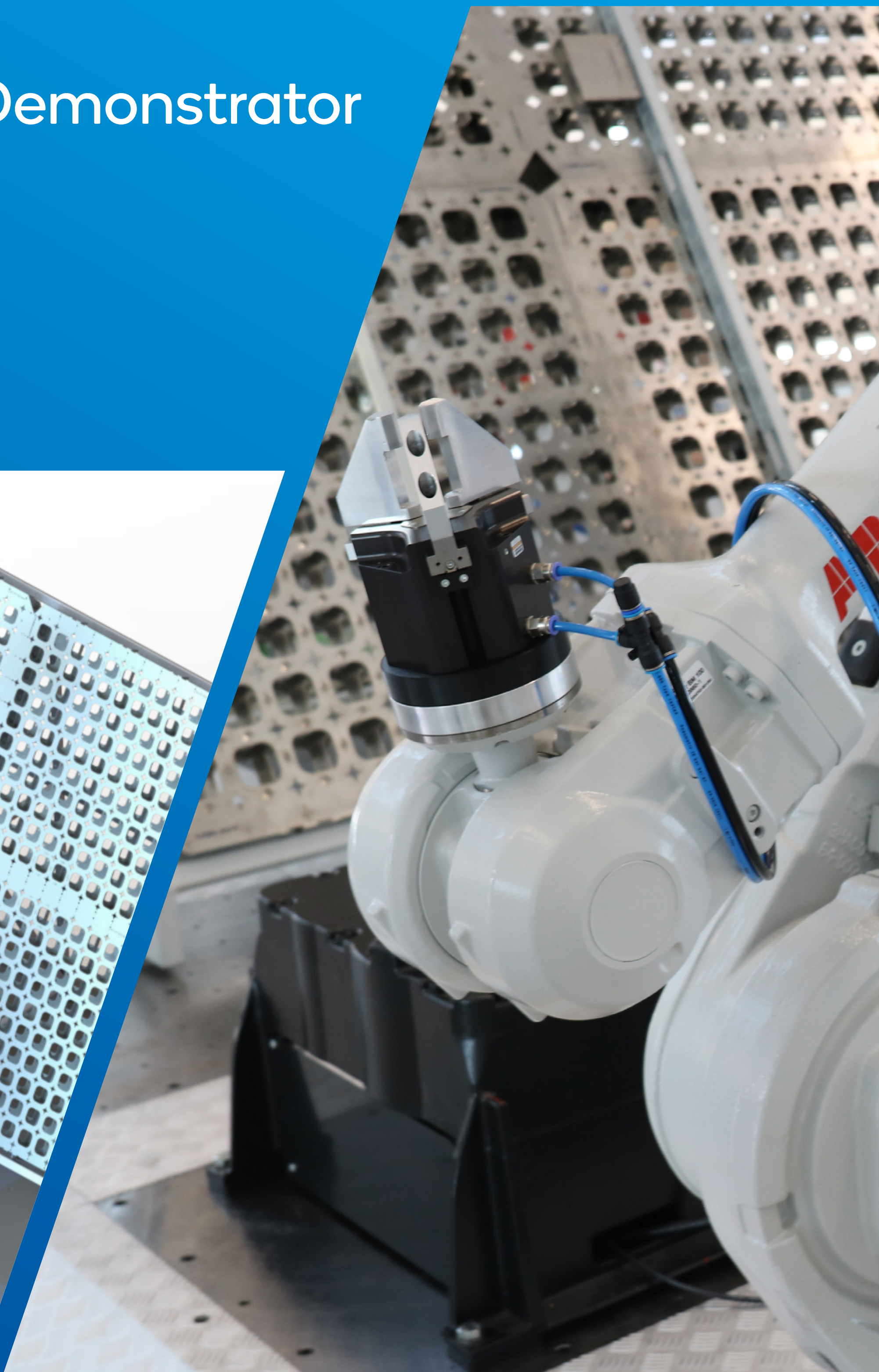

CATAPULT High Value Manufacturing
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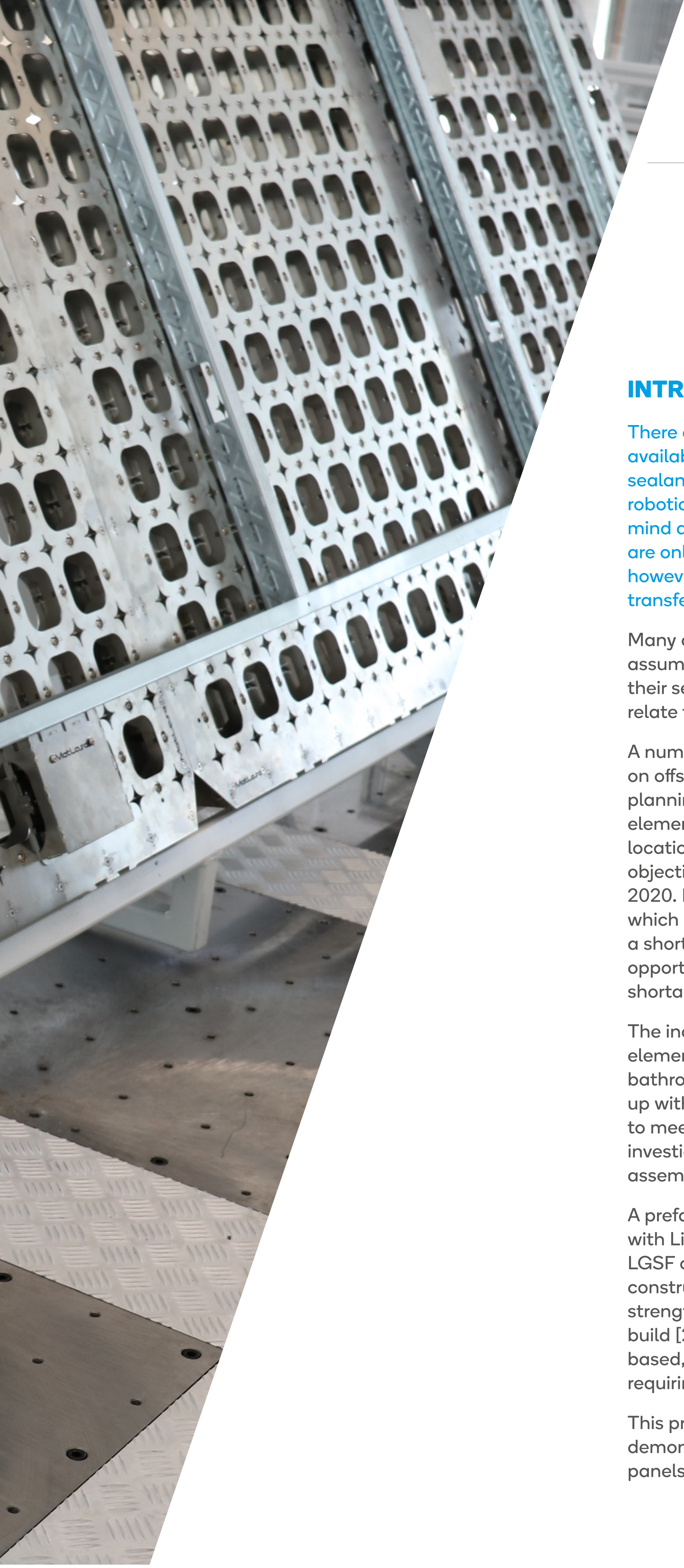
Abstract

The Advanced Manufacturing Research Centre (AMRC) already has a global reputation for the way it has revolutionised productivity in the aerospace sector working with major aircraft manufacturers and their supply chain. The AMRC is seeing increased interest from the construction sector in advanced manufacturing but often companies from this sector struggle to see the benefits of technologies being used in other sectors for use in their environment.

The purpose of this project is to build and showcase an automated demonstrator for construction processes and tasks to demonstrate the art of the possible.



INTRODUCTION

There are a wide range of automation applications available in Factory 2050, ranging from automated sealant application to robotic machining. These robotics cells are built with aerospace applications in mind and therefore it is thought by visitors that they are only applicable to aerospace companies. This however is not the case, as these technologies are transferable across different sectors.

Many construction companies visit the AMRC and assume the technologies displayed do not apply to their sector as the products being assembled do not relate to construction.

A number of construction companies are working on offsite manufacturing projects which involves planning, design, fabrication and assembly of building elements offsite away from their final installed location. The UK government has set a housing objective to deliver one million homes by the end of 2020. In 2015, around 143,000 homes were built, of which around 15,000 were modular homes. [1] There is a shortage of 100,000 homes per year and there is an opportunity for the offsite manufacturers to reduce this shortage by 2020.

The industry is focusing on manufacturing building elements, such as prefabricated rooms and bathrooms, in a factory at a quicker rate to keep up with the housing demand in the UK. In order to meet this demand, construction companies are investigating automation of certain process during the assembly.

A prefabricated room or bathroom is usually made with Light Gauge Steel Framing (LGSF) C-sections. LGSF construction is an alternative to wood framed construction. LGSF is easier to build, has higher strength, lighter and is easy to change/modify the build [2]. The current assembly of LGSF is paper based, as dextrous process and labour extensive, requiring a minimum of two or more operators.

This project focuses on creating an automated robotic demonstrator for the assembly of 2-Dimensional wall panels using LGSF.

Robotic Demonstrator Cell

As stated in the introduction, the AMRC have automated the assembly of 2D stud wall panels of LGSF C-sections. This included creating a robotic cell that is capable of picking and placing LGSF in position to form a panel and to also to fix the LGSF together.

It was decided that the robot demonstrator should be able to assemble full sized panels, in this case 2m by 3m panels. To be able to assemble to this size, a robot with long reach is required. An ABB IRB 6700-235 was chosen as it has a 2.35m reach.

To be able to build multiple variations of a wall panel, a flexible fixture was required where interface parts can be moved to set datum positions for the LGSF. Furthermore, a storage system was required to deliver the material for the robot to pick and place in to the fixture. Figure 1 below shows a CAD design of the robot cell.

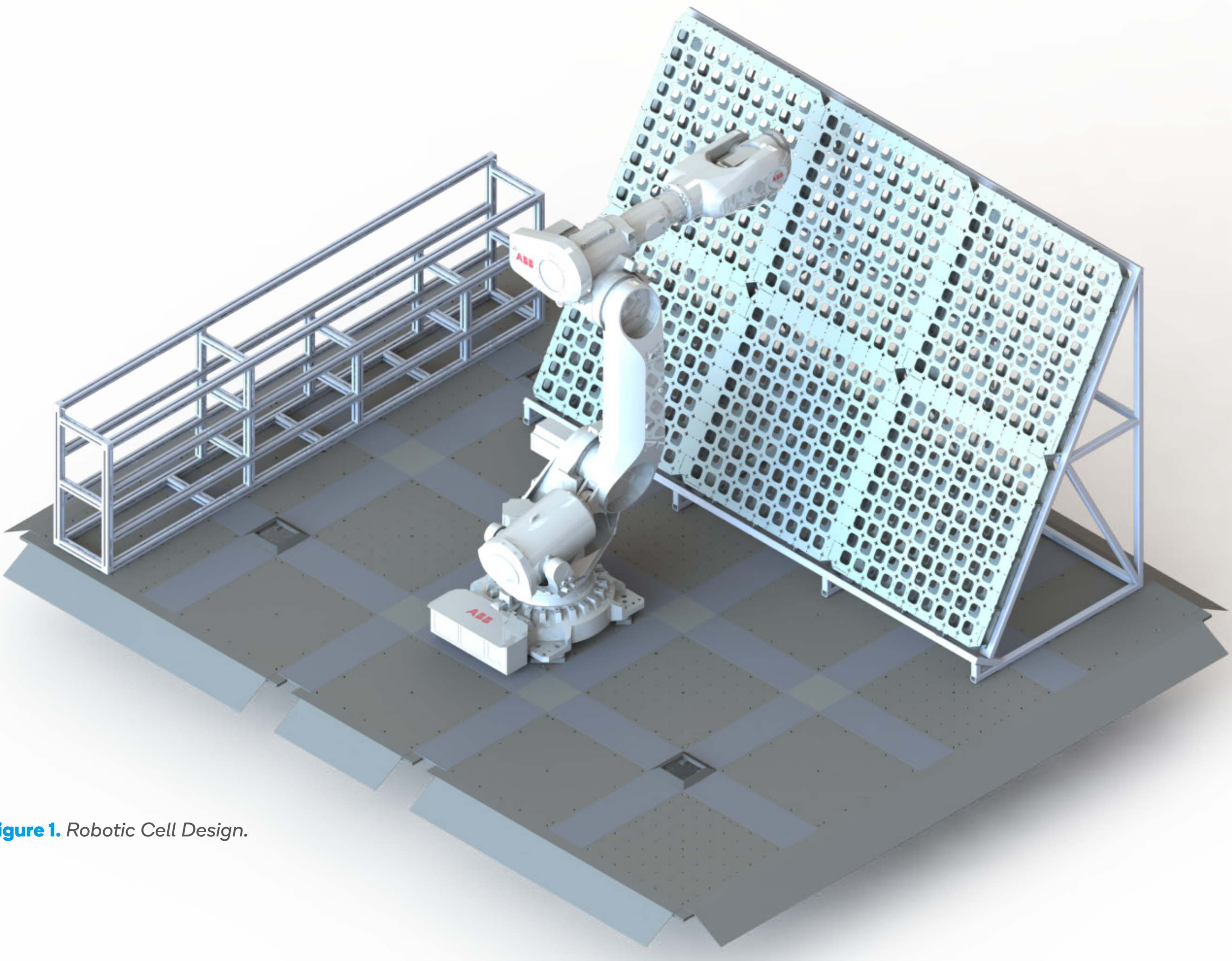


Figure 1. *Robotic Cell Design.*

Flexible fixturing

To suit different designs of stud walls, a flexible fixture was required to build many variations of LGSF wall panels.

The AMRC required a fixture which was modular, reconfigurable and flexible. With these qualities in mind, the AMRC designed the fixture with a ‘pegboard’ inspired features and worked closely with MetLase, a bespoke fixture manufacturer, to finalise the design and manufacture the fixture.

The concept for this pegboard is to have a modular square fixture with a series of holes in a pitch for movable part holders. The part holders can be placed anywhere within the fixture to make datum positions for the LGSF panel design.

Figure 2 above shows the pegboard flexible fixture, the pitch is fixed at 100mm and the part holders can be placed on the fixture at 90deg intervals. The part holders are used as a datum interface for the LGSF.

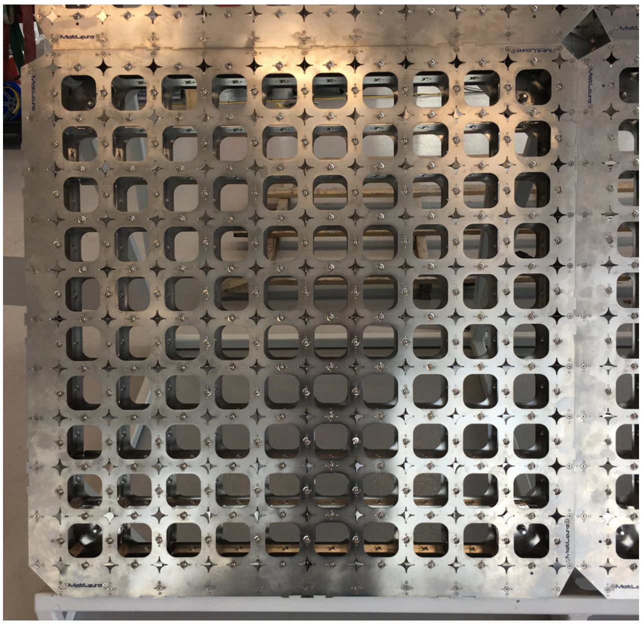


Figure 2. *MetLase Pegboard Flexible Fixture.*

Magazine Racking

To be able to build multiple walls, a storage system is required to feed material to the robot. There are two design requirements for the storage system, the first is that it is able to store various lengths of LGSF and the second is that the robot can pick the LGSF. With these requirements in mind, the storage system was designed with roller tracks so that it can hold multiple quantities of fixed lengths and allow the robot to pick up the LGSF. Once a piece of LGSF is removed, the remaining material will move to the front of the roller tracks under gravity.

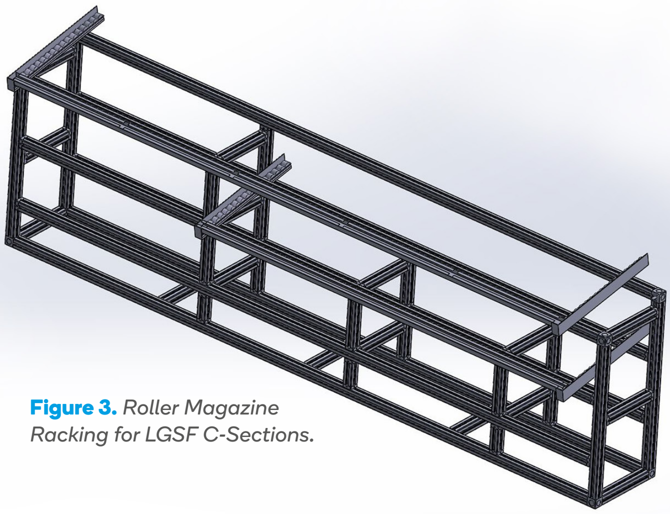


Figure 3. *Roller Magazine Racking for LGSF C-Sections.*

Automation Tools

Dual Gripper Robot End Effector

To have the ability to pick and place the pegboard interfaces and LGSF C-sections, automatic grippers are required. The AMRC designed and built a robot end effector (Figure 4) with dual grippers with adjustable jaws for flexibility.

The end effector consists of two Zimmer IO Link electric grippers to suit the control system of the robot cell. Electric grippers were chosen for this task over pneumatics grippers, as the gripper movement can be controlled through the programmable logic controller (PLC). This is in contrast to pneumatic grippers, which can only move to defined mechanical limits, and this can potentially damage the LGSF.

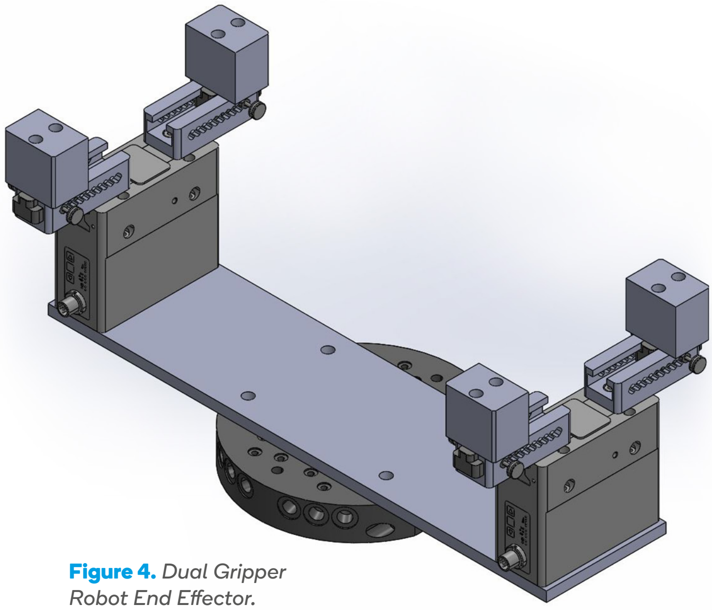


Figure 4. *Dual Gripper Robot End Effector.*

Rivet Tool

To complete the assembly of the stud wall, a tool, which fastens the LGSF together, was required. An automated rivet tool is the ideal solution for the robotic cell. The robot is using a pneumatically controlled Gesipa Taurus 2 Riveter. The robot moves to positions where a rivet is required. The tool is capable of inserting the rivet in position then drawing the mandrel through the tool fixing the rivet securely in position.

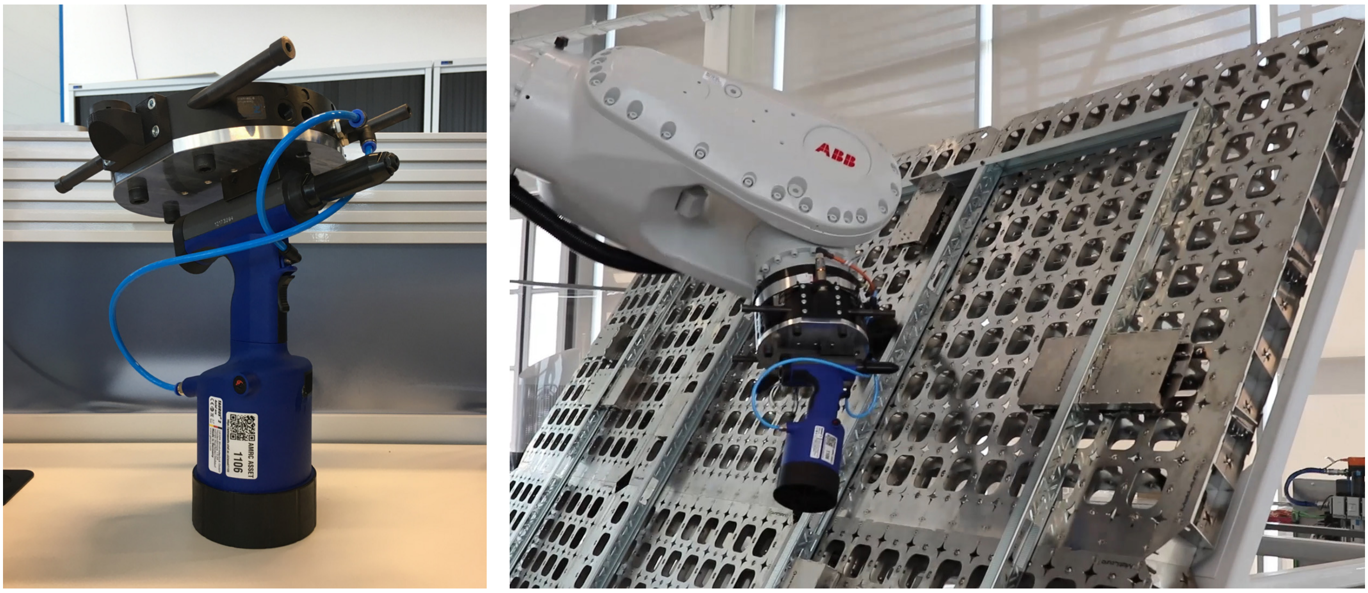


Figure 5. *Gesipa Rivet Tool.*

Conclusion

Manually manufacturing a stud wall panel requires multiple workers and is a time consuming process, which includes tasks that are repeated numerous times over the course of the build.

Automating this process has increased the repeatability of the build as the robot can place the LGSF in the same position repeatedly. Additionally, the robot is capable of assembling the panels continuously at production rate.

Currently the process of building the LGSF with the robot equals the time taken when built manually, this is due to the robot program not being optimised and not running at full production speeds.

In conclusion, this robotic demonstration has shown that it is possible to automate this process but requires further development to make the robotic process more robust.
The robotic process needs to be optimised to be able to build the stud wall panels more efficiently.

FURTHER WORK

Automated Inspection

Integrating an automated inspection system capable of checking if the panels are assembled correctly would make the system more robust. The inspection system can be used to track the assembly of panels and verify the panel before dispatch.

For example, a part presence inspection system is capable of comparing the current assembly to a gold standard, this can check if the current assembly has all the parts present at the end of the assembly.

Automated Riveting

The rivets used to attach the LGSF together are placed manually in position and then the robot uses the rivet tool to fasten them. This therefore slows down the automated process. To improve it would be ideal to remove this manual process and introduce a bowl feeder which can automatically transfer rivets directly to the rivet tool. This will reduce process time of the assembly and also remove the need for an operator to place rivets in manually.

An alternative solution to riveting the LGSF together, is to use an automated screwing system which uses self-tapping screws. This tool can be attached to the robot and be used fasten two separate LGSF C-sections together.

ACKNOWLEDGEMENTS

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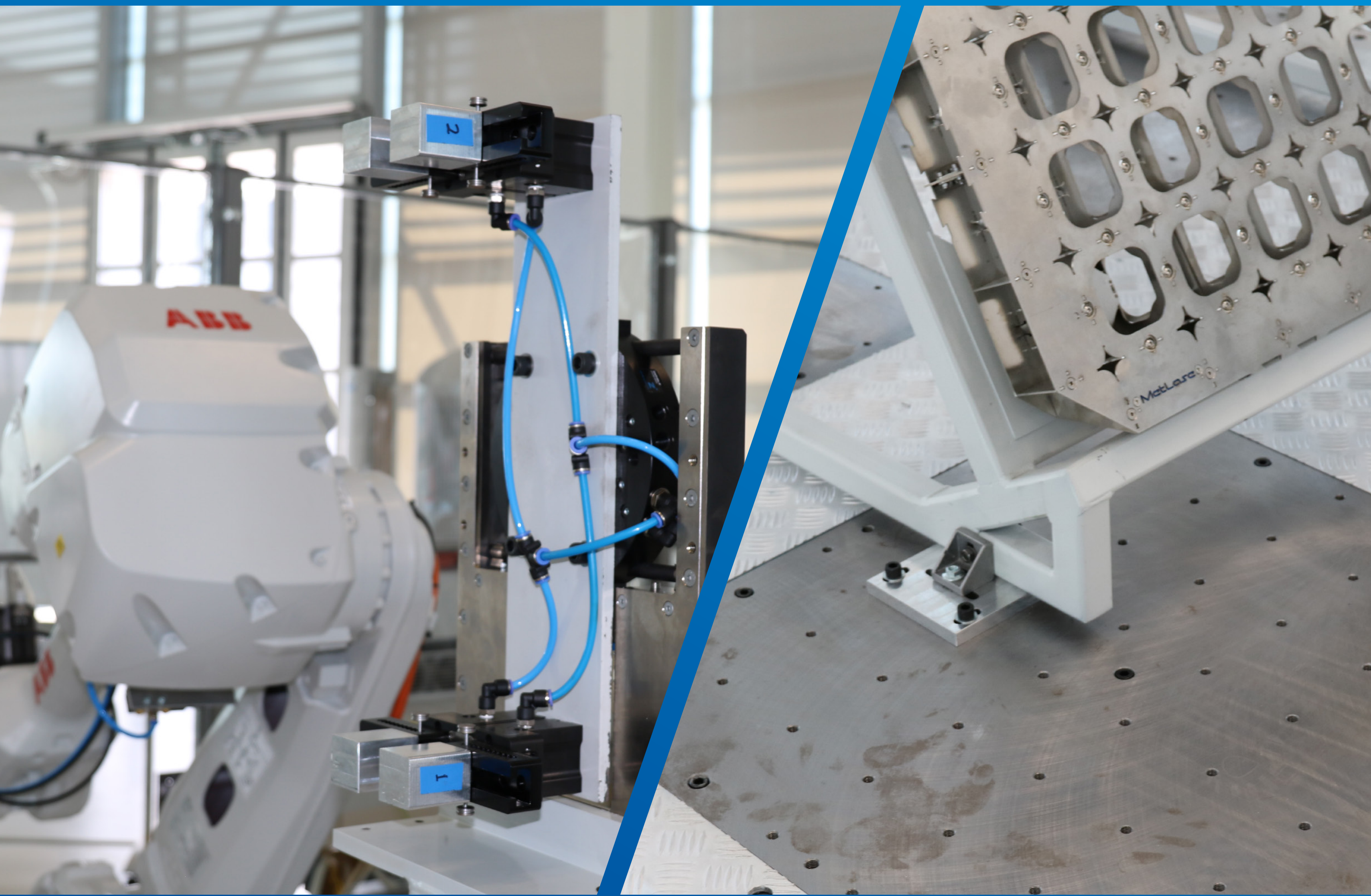

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