Extreme Automation For Composite Material Cutting, Kitting And Sorting

Increasingly, IIoT solutions for composite parts manufacturers use a combination of automation hardware and AI software to deliver radical productivity improvements.

Authors:

Marcus Kremers | Chief Technology Officer at Airborne
Amir Ben-Assa | Chief Marketing Officer at Plataine

Contents

Executive summary

Composite parts manufacturers face increasing demands from customers to produce higher volumes at lower costs. This trend is particularly marked in high growth industries, such as aerospace, automotive and marine.

Working with composite materials is demanding, both because of the complexity of the production processes, and because the uncompromised demand for quality and tolerances.

The Industrial Internet of Things (IIoT) and Industry 4.0 (I4.0) are opening up new possibilities for composite parts manufacturers to cut costs and increase throughput by automating and optimizing processes such as material cutting, kitting and sorting.

Industry partnerships between IIoT hardware and software companies that are already experienced in the composites industry offer the most capable and cost-effective solutions.

Glossary of terms

Nesting

In the manufacturing industry, nesting refers to the process of laying out cutting patterns to minimize raw material waste.

Kitting

Kitting is the gathering of plies, components and parts needed for the manufacture of a particular part or product.

Plies

Plies are the individually cut pieces of composite material that are used to manufacture a composite part or structure.

Sorting

Sorting refers to the sorting of composite plies into kits.

The Industrial Internet of Things (IIoT)/ Industry 4.0 (I4.0)

The IIoT/I4.0 is a vision of fully connected factories where machines, employees, raw materials, processes and finished products use the cloud to share all data in real-time, allowing managers to constantly optimize and improve operations.

Introduction

All sectors of the composites manufacturing industry currently face a challenging global trend: lower prices are in high demand. In part, this trend is driven by global economic recovery landscape , and the increasing drive to use lightweight materials and save fuel consumption, which is especially strong in certain industries such as aerospace and automotive. And in part, the trend is driven by the latest IIoT/ I4.0 advances. This is because, when market leaders use connected technology to increase throughput and efficiency without increasing labor, it increases competition for all companies in the same market.

For composites parts manufacturers, keeping resilience while dealing with the igh cutting costs is particularly troublesome. That's because composite parts are some of the most highly engineered components in industry – they are used in a plethora of demanding sectors from aerospace to automotive to marine to high-speed trains – and so there can be no compromising on quality in the drive for high volume and low costs.

If you are a composite parts manufacturer for the aerospace industry, ask yourself: are you ready to the next 5 years?

"If you are a composite parts manufacturer for the aerospace industry, ask yourself: **are you ready to double your current production rate in the next five years?"**

[1] Airborne (2018), The commercial aircraft market. Available to download at: https://www.airborne.com/why-i-am-worried-about-the-commercial-aircraft-market-and-you-should-be-too/

As we are coming out of the pandemic, composite parts manufacturers who fail to increase volumes and cut costs will be at a serious competitive disadvantage in the next two years.

Figure 1: Boeing assembly line at South Carolina. Boeing & Airbus are radically ramping up production[3]

The challenge

Higher volume at lower cost

The composite parts manufacturing industry faces three main challenges in its production processes:

4.1 Raw material waste

Automated cutting is already widespread in the composite parts manufacturing industry, but ply picking and sorting are still usually done manually. And the need for manual sorting places heavy restraints on the mixing of work orders using the same material within cut plan or a "nest". In an ideal world, a cutting plan would be designed to mix nests in the most efficient possible way, to minimize material waste. In practice, this is not always possible (see Fig. 2).

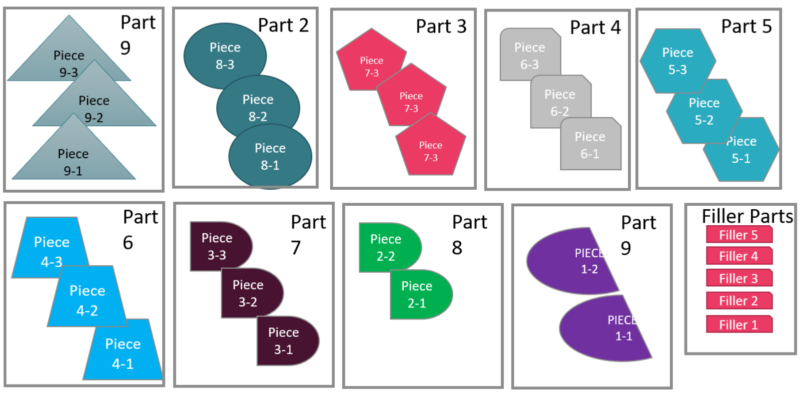

Figure 2: Simple nesting for composite part manufacturing. The unused white space in each index represents composite material that will be discarded. In some of the indexes, 50% of the material available is not being used.

[2] Johnsson, J. & Katz, B. (2018) 'Engine maker to Boeing-Airbus: not so fast on 737, A320 ramp' in Bloomberg Business: https://www.bloomberg.com/news/articles/2018-07-14/engine-maker-to-boeing-airbus-not-so-fast-on-737-320-rate-jump

[3] Image used under Creative Commons courtesy of airbus777: https://commons.wikimedia.org/wiki/File:Boeing_South_Carolina_assembly_line_(26135377557).jpg

Complicated mixing is much more efficient in terms of material savings, but it's much harder for the workers who have to pick the plies and sort them into kits. This is because complex nests contain plies from multiple parts. These can be very difficult for an operator to keep track of, and human error can result in mixed up plies or missing plies in a kit that may lead to recuts and waste. Consequently, many manufacturers are forced to produce simpler cut plans that result in excessive material waste. Yet composite materials are one of the largest costs for any composite parts manufacturer. Additionally, the production of composites is energy-intensive, so waste reduction is important for companies trying to meet sustainability goals.

4.2 Human error

Because the sorting and kitting process is still almost entirely manual across the composite parts industry, human error is widespread. Errors in sorting and kitting result in missing plies, production delays and recuts of plies. Manual processes are very difficult to trace, which compounds the problem. Ultimately, human error can lead to excessive costs and even more manual intervention.

4.3 Cost of manual labor

The composite parts industry is unusually reliant on manual labor compared to other manufacturing sectors. There are a variety of reasons for this, but they center around the difficulties associated with working with composite materials. For example, some composite materials must be freezer-stored and, once removed for use in a manufacturing process, have only a limited shelf life during which work can be performed on them before they must be either cured in an autoclave or returned to the freezer. Such complexities have inevitably led to a more manual manufacturing process where humans are readily on hand to respond to unexpected situations and problems. With such a high reliance on manual labor, it can be very difficult for composite parts manufacturers to meet their customers' demands for continual cost reductions.

The Automated Sorting Solution

Automation hardware must be fully integrated with AI-based software

The solution to the problems of today's composite parts manufacturers is to adopt an automated solution in full. An automated, AI-based solution can help parts manufacturers industrialize and optimize the entire cut and kit process. Automation makes it possible to go to a higher mix ratio, with plies from multiple parts or work orders in one cut plan. The system will keep track of every variable and will not make errors in kitting or sorting. It also increases flexibility in operations, which allows for further efficiency gains.

This set-up can automate and optimize the entire cut and kit process, while considering all relevant production elements in real-time. The AI software is able to absorb information from multiple data sources to get a complete view of production inputs across the manufacturing facility. For example, it connects with ERP software, so it has a view of all incoming customer orders, needs and preferences. The software is also tied into the Material Management System, meaning it has oversight of all inventory on hand. Integration with CAD and Product Lifecycle Management systems allows retrieving accurate Bill Of Material of parts and most recent geometry files.

The result is a system that delivers automatic cut to order based on the work orders that have been received from the ERP system. The AI software automatically creates optimal 'ready-to-cut' plans. A variety of production decisions are also fully automated, such as deciding what composite material to use or which cutting machine to use. The system generates automated reports including cut plan logs for complete traceability from raw material to the finished part.

Automated sorting and kitting solutions using industrial robots is fully integrated with the software, whereas the most advanced systems automatically pick plies from the conveyor belt or cutting table. To achieve this, the robots must make a different movement for every different ply – a dynamic automated programming system allows such movements to be generated on the fly, directly from the cutting plan or integrated vision system. Next, the robot places the plies in the sorting station. In the sorting station, the robot has the capability to move plies between a series of trays which are arranged in a patented, automated vertically stacked system to optimize floorspace (see Fig. 3).

Figure 3:
The sorting station has a robotic arm sorting composite plies on an automated vertically stacked tray system.
A different kit is assembled on each tray, and trays move up and down to allow the robot to sort the plies between them

This system allows the robot to sort the plies in the correct order to make a fully sorted kit. An AI -driven sorting algorithm determines on the fly what the best strategy is to complete the sorting in the shortest time.

For manual layup processes, only at that point does a human operator need to intervene – in order to take the sorted kit of plies for layup or the next production process. Alternatively, a robot system can take the plies from the sorting station and build up the laminate with pick & place. This sort of automated system can manage thermoset prepregs, thermoplastic prepregs and dry fiber materials. An advanced system can pick up to 300 plies per hour and the size and number of plies is easily scalable according to operational requirements.

Automated sorting and kitting systems require no human involvement and can be fully integrated with either an automated or manual cutting system depending on the preferences of the customer. It is also possible to implement a standalone sorting system which allows customers to use automated sorting without having to worry about integration with an existing manual cutting system. In this type of arrangement, instead of the robot picking the plies directly off the conveyor belt, a human operator places the cut plies into a dedicated bin. The robot system then uses a camera to recognize which ply is which and, takes them from the bin into the sorting cell where they are sorted into kits and then removed by another human operator for further processing.

The benefits

Reduced material waste and increased production efficiency

The benefits of an automated optimizing, cutting and kitting solution for composite parts manufacturers are significant. One major benefit is increased production rates allowing manufacturers to fulfil more customer orders by automating the cutting, kitting and sorting processes and better utilizing their existing cutting tables and manufacturing resources.

Another major benefit is material savings. The main source of material savings comes through the creation of optimal cutting plans which is enabled by a combination of automated nesting by AI software and the robotic automation of the previously manual sorting process. The picture at Fig. 4 shows a traditional approach to a cutting plan.

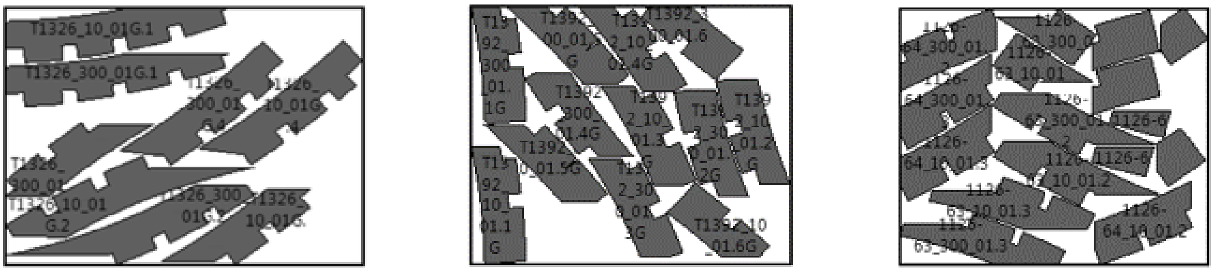

Figure 4: A traditional approach to a cutting plan. Material use from left to right is: 1.48m, 1.32m and 1.3m

Each job is laid out on a separate piece of material. Between them, the three jobs require 4.1m or yard of material. With a manual sorting process, it was necessary to split up the jobs in this manner to avoid the risk of human error mixing plies from different jobs.

But, when the cutting plan generation and manual sorting processes were automated, all three jobs could be combined into a single nest which used just 3.29m or yard of material, resulting in around 20% material savings (see Fig. 5).

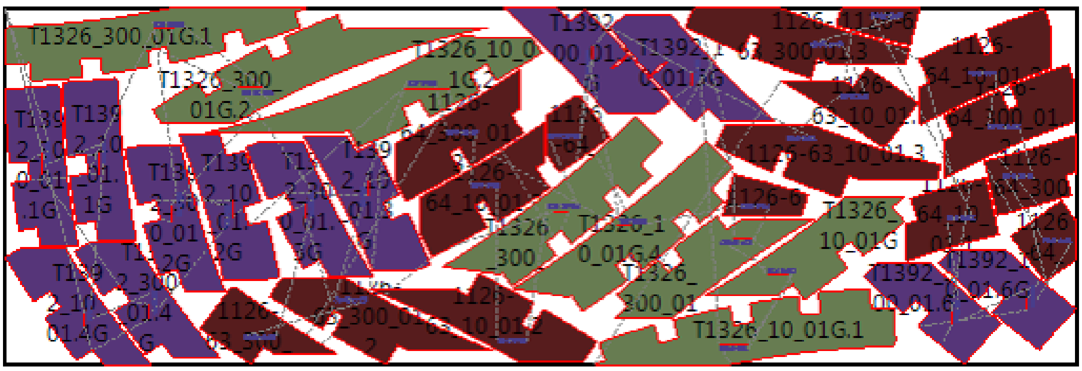

Figure 5: When all three jobs from Fig. 4 were combined into a single cut plan, 20% material savings were achieved

A key reason that the nests could be mixed in Fig. 5 was because the sorting process has been automated with industrial robots, meaning the system can keep track of all plies regardless of the number of products or the complexity of the nest – unlike a human worker who would be liable to lose track of which ply belonged in which kit. Full automation of the sorting process allows manufacturers to take part mixing to the extreme.

"Full automation of the sorting process allows manufacturers **to take part mixing to the extreme."**

Automation leads to increased production efficiency in other ways, further reducing costs. For example, reducing to a minimum recuts that are the result of missing plies.

Additionally, automation, particularly the automation of previously manual tasks, and the resulting reduction in the ever-present risk of human error, leads to reduced rework or re-cuts, and reduced scrap. Efficiency and quality are yet further enhanced via the full visibility and traceability at every stage of the manufacturing process that a true IIoT system can deliver.

There are multiple considerations to bear in mind when implementing changes to improve the outcomes of composite parts manufacturing processes. Fig. 6 shows several relationships between manufacturing costs and mixing nests. With material scrapping (the dark blue line), the costs go down the more you mix nests. Whereas with sorting (the green lines), costs go up as mixes get more complicated. If sorting is automated, though, the cost increase is less than with manual sorting. The orange lines show the combined cost of materials and sorting in different circumstances. The upper line represents the combined costs of material scrap and manual sorting. The lower line shows the combined costs of material scrap and automated sorting. The manufacturing 'sweet spots' are marked by the orange circles. They show the optimal mix between cost and mix complexity. The preferable of the two is on the lower line (with automated sorting), which allows a higher mix rate at a lower cost.

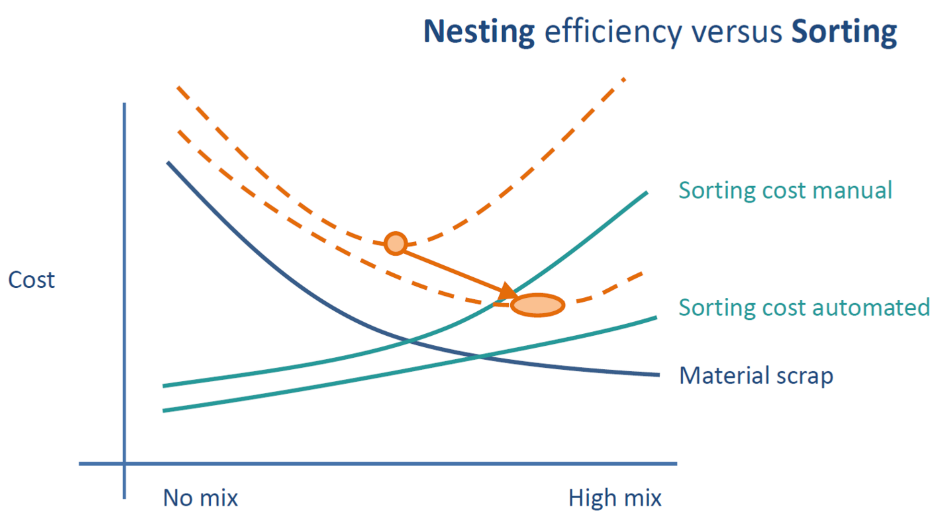

Figure 6: Seeing the whole picture when optimizing manufacturing processes

Conclusion

Keep it simple

Composite parts manufacturing is highly dependent on manual labor. This is expensive, and it is particularly problematic in advanced Western economies such as the US and Europe where the labor market is extremely tight, making it very difficult to recruit workers.

However, investments in automation do not always pay off – some automation systems are complex and expensive. The trick is to keep it simple. The best automation suppliers for composite parts manufacturing are already experts in the composites industry. By working with automation partners who already know the composites industry inside-out, manufacturers can rest assured that they will be buying software, hardware and machinery that can do a specific task very well, keeping the costs of automation down. When using industrial robots, it is best to use standard affordable products that can switch end-effector easily and quickly (ideally within 1 minute), meaning that systems can perform multiple tasks. Flexible automation systems should also adopt a modular, building-block approach, allowing scalability so that manufacturers can quickly react to today's constantly changing production environment.

"By working with automation partners who already know the composites industry inside-out, **manufacturers can rest assured** that they will be buying software and machinery that can do a specific task very well."

Finally, working with automation partners such as **Airborne** and **Plataine** who know the composites industry well will guarantee quality – probably the most important consideration of all for high-end parts manufacturers. Manual labor, for all its faults, does offer implicit quality control because humans are excellent at using direct feedback (such as vision and touch) to interpret what is needed to maintain product quality. Putting that level of quality control into industrial software and machinery is difficult and requires strong industry knowledge.

For truly effective automation in the composites industry, you need more than just a machine: you need a full composites automation solution. So, when picking automation partners for a composite parts manufacturing operation, ensure to find partners with strong composite manufacturing experience.

About Airborne:

Airborne is a technology leader in advanced composites, specialising in the industrialisation of engineering and manufacturing of durable fiber reinforced composites for the space, aeronautics and marine industries. With our 20 years' heritage in composites, we provide our clients with high-end composite solutions either directly through advanced manufacturing of components or by developing industrialisation packages which we implement at manufacturers of choice. Airborne's focus is on high-end composite components and at high production rates at radically low conversion costs.

About Plataine:

Plataine is the leading provider of Industrial IoT and AI-based optimization solutions for advanced manufacturing. Plataine's solutions provide intelligent, connected Digital Assistants for production floor management and staff, empowering manufacturers to make optimized decisions in real-time, every time. Plataine's patent-protected technologies are used by leading manufacturers worldwide, including Airbus, Boeing, GE, Renault F1® Team, IAI, Triumph, General Atomics, TPI Composites, PCC, Steelcase and Argosy International.