How AI and the IIoT can improve manufacturing sustainability

Across the world, consumers and governments are calling for companies to become environmentally sustainable and achieve net zero emissions. A combination of government regulations and public opinion is forcing the industry to sit up and take note.

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When it comes to composites, the situation is complex. On the one hand, the products of certain major composite end users such as aviation and automotive are perceived to be amongst the worst environmental offenders. On the other hand, these same end users are making enormous strides towards cleaning up their acts.

Composites already play a vital role in helping such end users reduce emissions. Firstly, they are extremely lightweight. Replacing steel, titanium, or aluminium parts in a jetliner or car with composite parts therefore significantly improves fuel economy and reduces emissions. Secondly, composites are highly durable and corrosion resistant. Often, manufacturing a product or part out of composite materials can increase its lifespan by literally decades, thereby removing all the emissions that would otherwise have been produced by having to manufacture replacement products more frequently.

Looking beyond the short-term fix of simply reducing emissions, many composite end users are also making real strides towards complete net zero through impressive R&D investments. Automotive is clearly a good way down the road to a wholesale switch to electric vehicles, while even aerospace is working towards the commercial deployment of short-range electric aircraft and hydrogen-powered aircraft. Composites will be equally vital in these instances, since keeping vehicle weight down in order to maximize range will be key.

Yet there is another consideration that companies in the composites supply chain need to be thinking about: the sustainability of their own manufacturing practices. That's because, for composite end users to achieve full net zero, all the companies in their supply chains have to do so as well. In the future, it will not be enough for an aircraft manufacturer to know that their own manufacturing processes and the resulting products are not causing emissions. They will also need to know that the composite parts used in their aircraft, and the composite raw materials themselves, also did not cause emissions to happen during their manufacture.

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Another major user of composite materials is the wind energy business. Speaking recently to Composites Manufacturing magazine, Mike Gromacki, the president of Dixie Chemical Company, made an important point: *"When there is a sustainability orientation of the market, and the growth is tied to sustainability issues, the participants in that market are generally held to a higher standard"*. His point was that such companies are likely to very soon start to demand that their suppliers are as green as they are. Composite part manufacturers need to get out one step ahead of this trend, and they should start thinking now about how to get their own manufacturing practices to net zero.

The three Rs

There are a number of relatively obvious and easy ways to make manufacturing operations sustainable. These include measures such as buying electricity from green providers, or staggering machine start-up times to save energy. Any composite part manufacturer can and should do these things. But a slightly less obvious way to significantly improve the sustainability of manufacturing processes is to employ emerging AI

and IIoT technologies to enable smart manufacturing techniques. Most factory managers may see AI and IIoT as a way to improve the bottom line, yet it will also be a crucial part of the path to net zero because it can improve outputs in the so-called 3Rs:

- Reduce: a reduction in material waste and scrap
- Reuse: ensuring to re-use short rolls, material offcuts, and remnants that are left over from previous jobs
- Recycle: reusing expired composite raw materials

Reducing waste and scrap

Intelligent, automated cut plan creation

Reducing composite waste during the composite part manufacturing process obviously saves large amounts of money for part manufacturers. However, it also equates to a major reduction in emissions, since it reduces the overall quantity of composites that needs to be manufactured. One important way to reduce material waste is to optimize cutting plans. Advanced AI technology can seamlessly integrate with existing systems, such as ERP, MES, and CAD/PLM, allowing the creation of automated, ready-to-cut dynamic plans. In addition to saving the time of the human workers who previously had to manually create the cut plans, this can result in significant material savings – often delivering over 10% higher material utilization. The very highest material utilization can be achieved if an IIoT solution has complete visibility over every element of the production line.

An AI production management system can automate record keeping and tracking for time-sensitive composite raw materials.

This enables the system to consider all customer orders and production requirements in real time, mixing different work orders into the same cut plans to achieve the most efficient possible material use. Figure 1 below shows a simple approach, where three jobs are each arranged into a separate cutting plan, requiring 160.99" (4.06 m) of material. Yet compare this to Figure 2, where all three jobs have been combined into a single cutting plan. This combined cutting plan uses only 129.65" (3.28 m) of material, resulting in a 19.47% material saving (as well as significant labour savings).

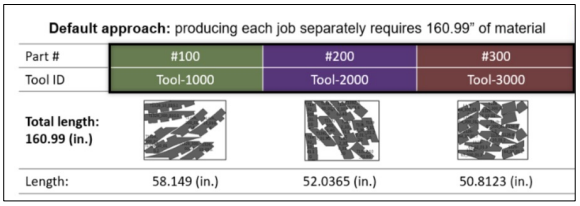

Fig. 1: A simple approach, where each job is arranged into a separate cutting plan

Fig. 2: A more complex approach, where all three jobs from Figure 1 above have been combined into a single cutting plan, resulting in significant material savings

However, one potential problem with very complex cut plans, especially if they mix different work orders, is that it can then become very difficult for human workers to pick and kit the plies. This is not always a problem – it depends how manual the picking and kitting process is at the composite part manufacturer in question. To avoid this problem, it is crucial that any advanced automated cut plan creation system is fully aware of the limitations on the kitting side, so that it can strike the optimal balance between material utilization and easy kitting.

Better management of time-sensitive composite materials

Managing time-sensitive, freezer-stored composite raw materials is one of the largest challenges that faces managers of composite part production lines. Once such a material has been removed from the freezer and defrosted, the exposure time left (ETL) immediately starts to count down. Tracking ETL manually requires complex and cumbersome paperwork records to be kept, taking up significant employee time and carrying a high potential for human error, which can lead to material waste. But an AI production management system can automate record keeping and tracking.

I. Context

Complete visibility over every element of the production line leads to improved material utilization

If there is an unexpected delay on the production line and a material roll's ETL gets dangerously low, intelligent digital assistants can proactively alert factory managers and present them with a range of options, such as to quickly use the material and get it into the autoclave for curing, or, if that is not possible, to return it to the freezer. As a side benefit, such a system can radically improve quality control by preventing the accidental usage of expired materials. Full traceability through the digital thread – a record of all production activities from raw material to end product – also ensures that composite part production lines are always audit-ready, with full production records available instantly for all components, stretching across multiple sites and organizations. Finally, the system also tries to always use up materials that have only a limited ETL (see below).

Reducing waste through tracking other assets

It is not just about tracking ETL. Material waste can also be significantly reduced by tracking other key elements on the production line. For example, tracking tool utilization and work cycles allows for maintenance to be planned in advance, allowing it to happen at the optimal moment. Intelligent tool tracking systems can also learn how and where tools are normally utilized, using this information to work out when there are misplacement and quality concerns. This avoids defect repetition that could otherwise see the waste of perfectly good raw materials. It also helps to spot upcoming production delays in advance – delays that could otherwise cause the risk of a time-sensitive material's ETL expiring – and prevent them from happening in the first place. Ideally, to get production delays down to a minimum and to increase efficiency as far as possible, an IIoT system should track every other element on the production line in real time too, including kits, resin buckets, resin kits, and core splices.

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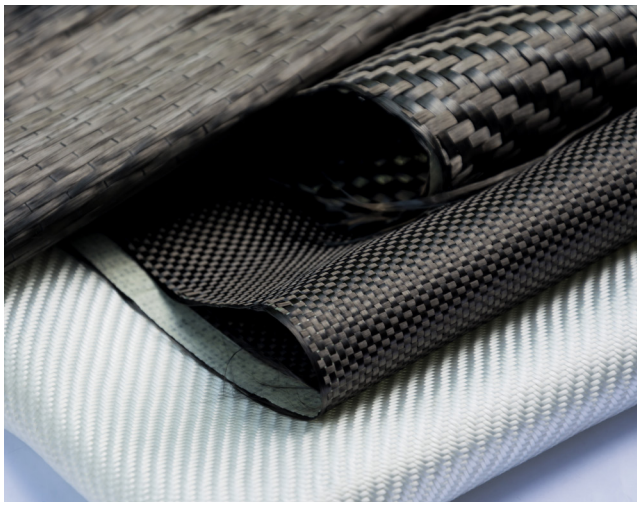
Inteligent automated production planning technology is the solution

Reusing composite materials that would otherwise go to waste

Material short rolls, material remnants, and materials with only a limited ETL often get needlessly wasted during composite part manufacturing processes. The reason is because it can be difficult and time consuming for human workers to calculate where to fit these less convenient composite materials into the production process. In fact, it can be so time consuming to work it out, that it is often just quicker to throw such raw materials away. Clearly, from both an economic and environmental sustainability standpoint, this is less than ideal.

Intelligent automation is the solution. A combination of AI technology and RFID tagging can ensure that every single piece of raw material in the inventory is tagged and monitored from the moment it arrives in the factory. Meanwhile, automated production planning technology has real-time visibility across all manufacturing workflows. It is aware of every production plan, and every cut plan, and it knows the instant that any work order changes. This enables it to immediately spot any opportunities in the production plan to cleverly use up material short rolls or remnants, or materials with only



Digital thread technology for composites reduces material waste and disposal costs

a limited ETL. A final important point is that expired composite materials must be appropriately disposed of, and this costs money. So, any reduction in material waste, as well as being a bonus for the environment, saves on disposal costs too.

Recycling expired materials

Finally, digital thread technology has one more sustainability application: recycling. For all their environmental benefits in terms of reducing the weight and fuel consumption of vehicles, as well as allowing the construction of more effective wind turbines, the vast majority of composites are actually manufactured in a carbon-intensive way. Additionally, it is currently difficult to recycle composites because recycling processes often degrade the performance of the materials. For example, of the 110,000 tons of composites that are produced annually in the UK, only 15% get recycled. Organizations such as Sustainable Composites are working to develop better recycling processes, as well as to develop new types of more environmentally-friendly and easily-recyclable materials that are created from sustainable sources.

In the meantime, digital thread technology can help improve the recycling rates of today's composites. The digital thread monitors all raw materials at all times, instantly identifying expired time-sensitive composite materials and prompting employees to recycle them. Even though current recycling processes do degrade the material, it is still possible to take expired high-end materials that were destined for use in applications such as aerospace, and repurpose them for less demanding products, according to QA department recommendations.

The digital thread technology can help improve the recycling rates of today's composites.

Smart manufacturing saves money and the environment

The drive for sustainability cannot be avoided by any companies in the manufacturing value chain. Pressure is coming from two sources: public opinion is increasingly demanding green solutions, and government environmental regulations are becoming ever more stringent. While OEMs using composites will always be the first movers in the sustainability drive, their push for net zero will inevitably cascade down the value chain and cannot be avoided by any raw material or component supplier. That's because it is impossible to manufacture a net zero product unless every single piece of raw material and every component in the product was also manufactured using net zero processes.

Although AI and the IIoT are primarily perceived as tools to improve factory efficiency, their value as a tool for sustainability is also clear. The most advanced AI-enabled smart manufacturing systems save both money and the environment by reducing raw material waste, helping to reuse raw material remnants and short rolls, and improving recycling rates.

AI and the IIoT are valuable sustainability tools

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