

The logo for Tech-Clarity, featuring the word "Tech-Clarity" in a bold, sans-serif font. "Tech-" is in white and "Clarity" is in yellow, both set against a dark blue rounded rectangular background.

Tech-Clarity

Composite Trends in the A&D Industry

***Identifying
Opportunities to Save
Cost and Time***



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Executive Overview

Composites have become increasingly important to the Aerospace and Defense (A&D) industry. In fact, Tech-Clarity's Composite State of the Market study, found that A&D companies overwhelmingly turn to composites to help with light weighting so that they can improve performance and realize better fuel economy. The study also found that while composites offer significant benefits, the expense of the material means companies should look at ways to get better insight. This way they can make better decisions during design to produce better composite parts. This is especially important to the A&D industry, which is under significant pressure to manage costs.

To further examine the use of composites in the A&D industry, Tech-Clarity surveyed 181 A&D manufacturers. The study examines two areas that can be a source for bottlenecks when working with composites: springback and manufacturing planning.

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Springback can cause significant issues for A&D companies. Springback is a manufacturing defect that can occur while the composite part is curing. Due to shrinkage, the material can deviate from the original molded shape. When this happens, the part is out of tolerance. Depending on how severe the distortion is, manufacturers have to spend extra time correcting the part to get it within tolerance so that they can assemble it. In a worst case scenario, they may even have to scrap the part. This results in a lot of wasted time and excess cost.

The good news is that companies who have adopted best practices for composites are much less likely to experience springback.

The good news is that companies who have adopted best practices for composites are much less likely to experience springback. One of those best practices includes using design guidelines. Another best practice involves communicating ply level design information by providing direct access to the composite data in the engineering model.

Manufacturing planning is another important part of producing quality composite parts.

Manufacturing planning is another important part of producing quality composite parts. With composites, it is especially crucial to produce parts exactly as designed. Even a slight deviation in fiber orientation significantly impacts part strength. By following manufacturing planning best practices you are more likely to produce composite parts as-



designed. Best practices involve leveraging an accurate engineering model. In addition, manufacturers should look at ways to automate changes to avoid wasted time manually reworking manufacturing plans.

This report examines design and manufacturing trends in the use of composites in the A&D industry. It also offers advice to overcome common problems to help A&D companies lower cost.

Understanding Springback

Springback is rather common and many A&D companies struggle with it. Considering how prevalent it is, one might even wonder, how does it impact the business? Survey respondents report it results in:

- Scrapped parts
- Wasted development time to address springback issues
- Longer assembly times to correct for springback or distortion during assembly

Manufacturers find that springback is usually severe enough that the distortion is outside of tolerance.

Manufacturers find that springback is usually severe enough that the distortion is outside of tolerance. When this happens, it takes extra time to properly adjust parts so that they fit together. In other cases, the distortion is so bad you cannot correct it so parts have to be scrapped. Given the expense of carbon fiber, this can significantly drive up cost. Companies who take the right steps to minimize springback will be much better positioned to have a competitive advantage. This is because they can produce high quality parts and avoid the excess cost associated with springback.

Companies who are taking the right steps to minimize springback are much better positioned to be at a competitive advantage because they can produce high quality parts, avoiding the excess cost associated with springback.

So what kinds of parts are most likely to experience springback issues? Figure 1 shows that the more complex the geometry, the more likely it is to have problems.

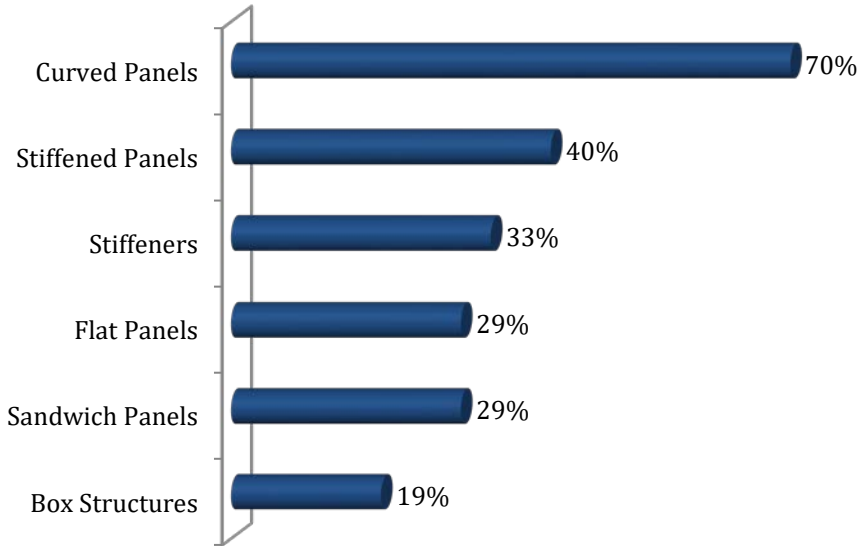


Figure 1: Types of Parts Likely to Have Springback Issues

A whopping 70% of respondents indicate that they have problems with springback in curved panels. This makes sense because the curvature is more likely to create internal stresses that will lead to the distortion. However, almost a third of respondents find they even have problems with flat panels.

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Springback can also be consistently repeatable or completely random. This is impacted by the type of part it is (Figure 2).

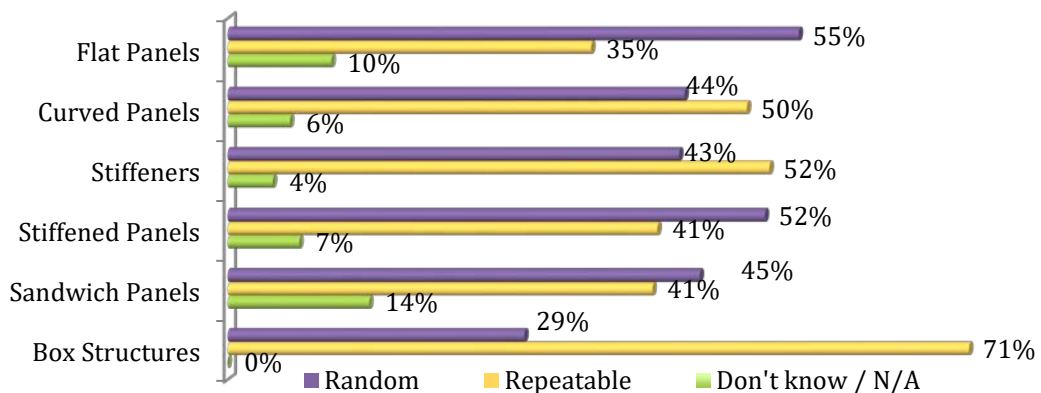


Figure 2: Is Springback Random or Repeatable?



Springback also comes from a variety of sources, but most commonly from resin shrinkage and fiber deviation.

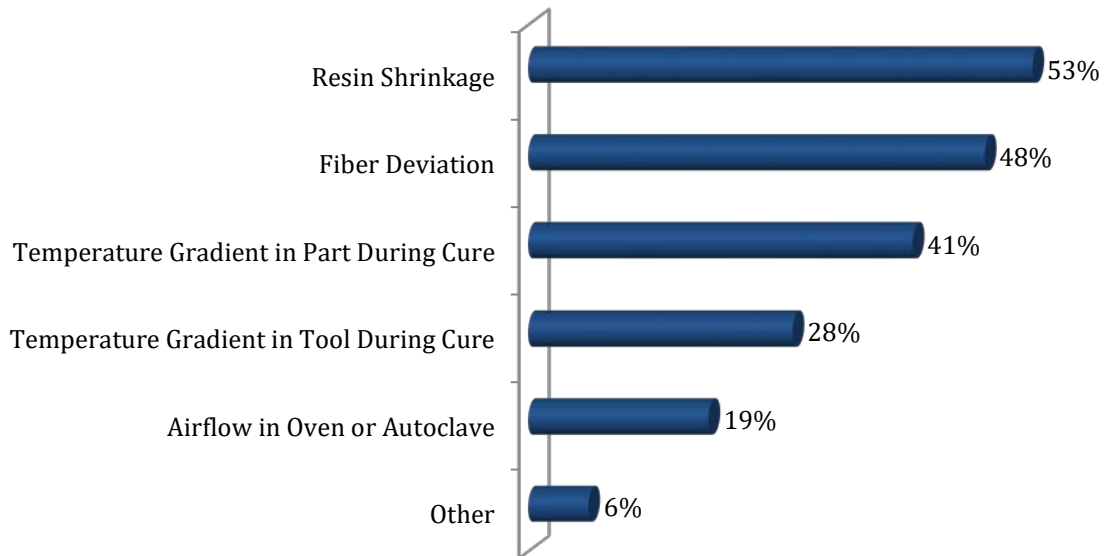


Figure 3: Source of Springback Issues

Corrective Actions for Springback

When springback occurs, A&D manufacturers take several approaches to correct the part (Figure 4).

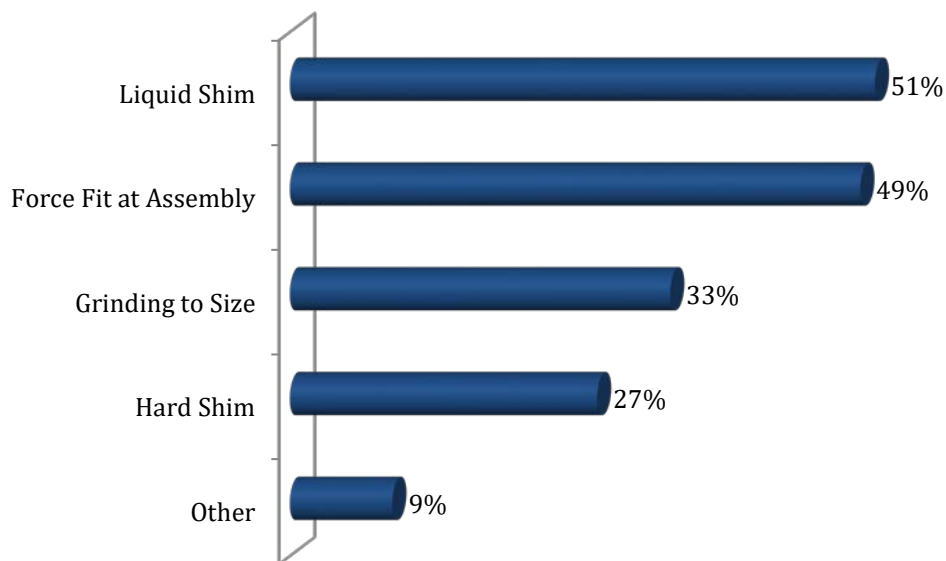


Figure 4: Part Corrective Actions



The most common methods involve using a liquid shim or force fitting the part into the assembly. Both involve extra steps during the assembly process that take extra time. Figure 5 shows the most common practices for avoiding springback.

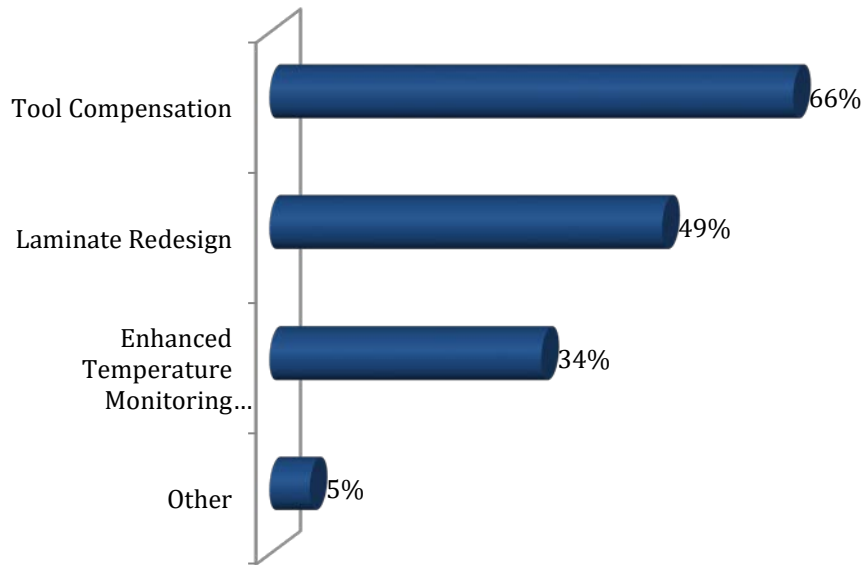


Figure 5: Corrective Measures to Avoid Springback

The results show that A&D manufacturers are more likely to take the easiest and fastest approach of updating the tool rather than making design adjustments or ongoing process monitoring. This reinforces that there isn't a lot of time to deal with springback issues and manufacturers need a quick fix.

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Identifying the Top Performers

Considering that springback is a source of excess time and cost, companies looking to save money should examine it more closely. Given how common it is, there is still work to do to reduce its occurrence. Even still, some companies have made a lot of progress in taking the right steps to address it.

To identify some of these best practices, Tech-Clarity researchers isolated Composite Top Performers. These companies were categorized according to how well they meet their targets for composite parts. The metrics used include the ability to meet:

- Design due dates
- Cost targets
- Product development budget
- Production cycle times

The top 20% who do the best job of meeting these targets were considered Composite Top Performers and everyone else was labeled Average. Based on the results, Composite Top Performers do a better job managing their processes. As a result, they avoid surprises that cause delays and drive up costs.

Avoiding Springback

Proving that Composite Top Performers avoid unexpected problems, they are less likely to experience springback (Figure 6 and 7).

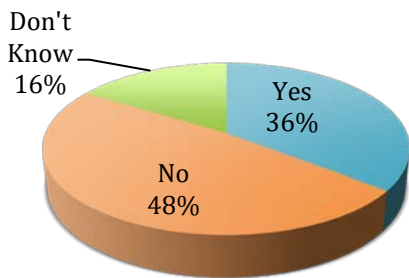


Figure 6: Composite Top Performer

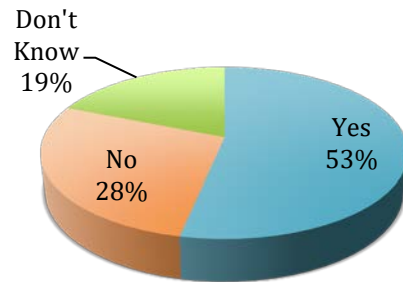


Figure 7: Composite Average Performer

Compared to Average Performers, Composite Top Performers are 32% less likely to experience springback. Clearly, they are doing something right to significantly cut down on the occurrence of springback.

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The area that made the biggest difference was the use of design guidelines. Composite Top Performers are 41% more likely to use design guidelines compared to their peers (Figures 8 and 9). This shows that better information up front during the design process can significantly reduce the occurrence of springback and distortions.

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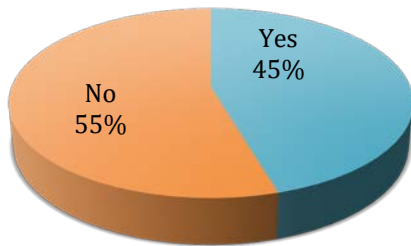


Figure 8: Composite Top Performer Use of Design Guidelines

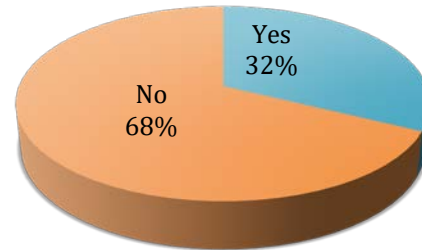


Figure 9: Composite Average Performer Use of Design Guidelines

Interestingly, beyond performance categories, companies who tend to specialize and stick with only one type of fiber, tooling, mold, and molding material are less likely to experience problems with springback. Because they are so focused, they can develop the expertise and the guidelines to avoid springback more easily.

On the other hand, those who take a variety of approaches and use different fibers, weave architectures, tooling, etc. can offer more options to support different applications. However, it becomes harder to develop the internal expertise and guidelines to avoid springback. As a result, they are much more likely to report problems with springback.

Many manufacturers who do not experience problems with springback offer advice to avoid it. The advice falls in four buckets:

- **Experimentation:** Make adjustments to the parts
- **Manufacturing adjustments:** Adjust production parameters and closely monitor the cooling and curing process
- **Experience:** Rely on expertise to make the right design decisions
- **Design and Analysis:** Use analysis and calculations to guide design decisions

These are all great suggestions to help avoid springback. They all have their benefits as well as some drawbacks.

The first two options occur during production. As an example of experimentation advice, one manufacturer suggested, “*Adjust the local orientation and the resin of the composite parts.*” While this will add to ramp up time, planning for this and applying lessons

learned during experimentation will lead to better parts. However, experimentation can create waste, which adds cost.

Manufacturing adjustments offers similar benefits. Another manufacturer recommended, *“By using proper tool methods, allowing for a proper curing cycle, and using proper jigs for after-release components, we avoid springback.”* Similar to experimentation, this will take care of the problem, but as you make adjustments to arrive at the right combination of variables, you may experience excess waste and additional cost.

The second two options happen during design. For these options, experience is extremely helpful. As one manufacturer commented, *“We have in-house experts and collaborate with external experts who know how to design tools to avoid springback issues.”* However, it can take time to develop that expertise, and as those experts approach retirement age, you can lose that knowledge. Outside resources can also be an invaluable asset, but waiting for their feedback can slow down the design process.

Many commented that they take care of springback during development and that calculations are key. One manufacturer said, *“We take care of springback problems during design. We also use analysis to avoid any problems.”* This approach may add a little time during design, but it takes less time to run simulations than it does to run those same experiments on the production floor. In addition, you avoid the costly waste.

It also shows that software solutions that have built-in intelligence to provide design guidance can be extremely helpful to save time and cut costs.

All of this advice points to the need to develop and follow guidelines. This reinforces why design guidelines are such a big differentiator for Top Performers. It also shows that software solutions that have built-in intelligence to provide design guidance can be extremely helpful to save time and cut costs.

Planning for Manufacturing

Once engineering work is complete, parts are ready for production. With composites, the link between the design model and produced part is especially critical. Even a slight adjustment in fiber orientation can have a significant impact on strength. As such, produced parts must match the as-designed model as closely as possible or they may not meet the engineering criteria they were designed for. Manufacturing planning is a critical step to ensure parts are produced correctly. Most companies producing composite parts have a manufacturing planning system they use for composite parts (Figures 10 and 11).

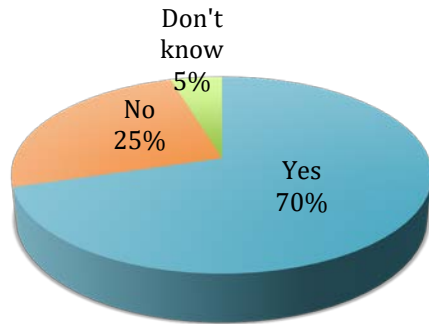


Figure 10: Do You Use a Manufacturing Planning System?

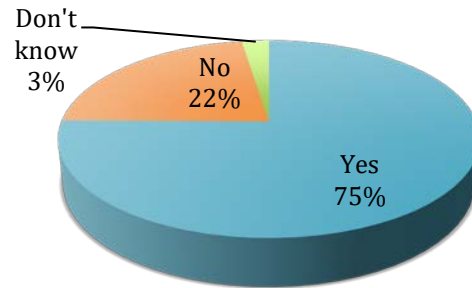


Figure 11: Of Those Using a Manufacturing Planning System, Is It Used for Composite Parts?

Compared to average companies, Composite Top Performers are 84% more likely to provide direct access to the composite data in the engineering model.

Most companies use a variety of methods to communicate ply level design data to manufacturing. Overall, 2D drawings are the most common method. However, compared to Average companies, Composite Top Performers are 84% more likely to provide direct access to the composite data in the engineering model (Figure 12).

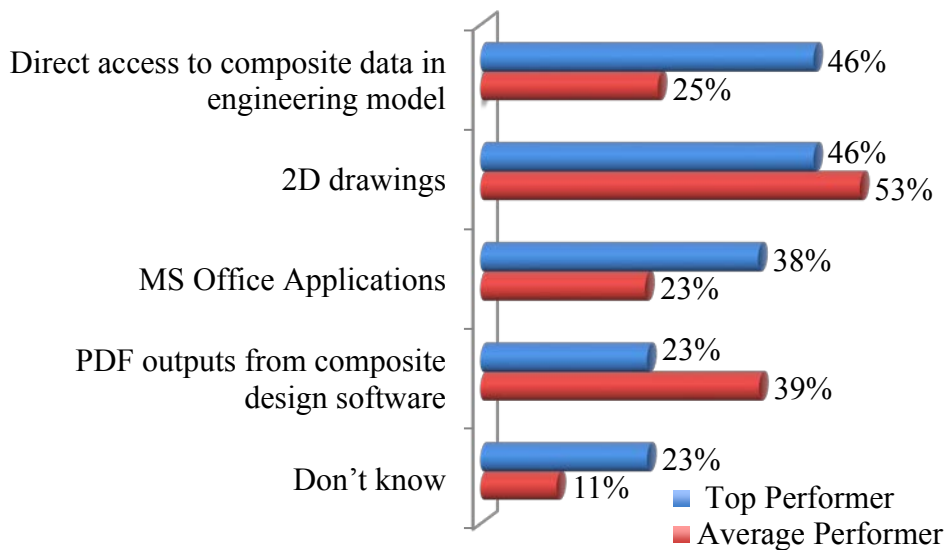


Figure 12: Methods for Manufacturing Planning

Using the engineering model directly saves time and leaves little room for misinterpretation or errors. However, the right technology must be in place to make it work. Furthering the use of engineering tools, the majority of A&D manufacturers use the design tool to create visual aids for composites parts, although many also use Office applications as well (Figure 13).

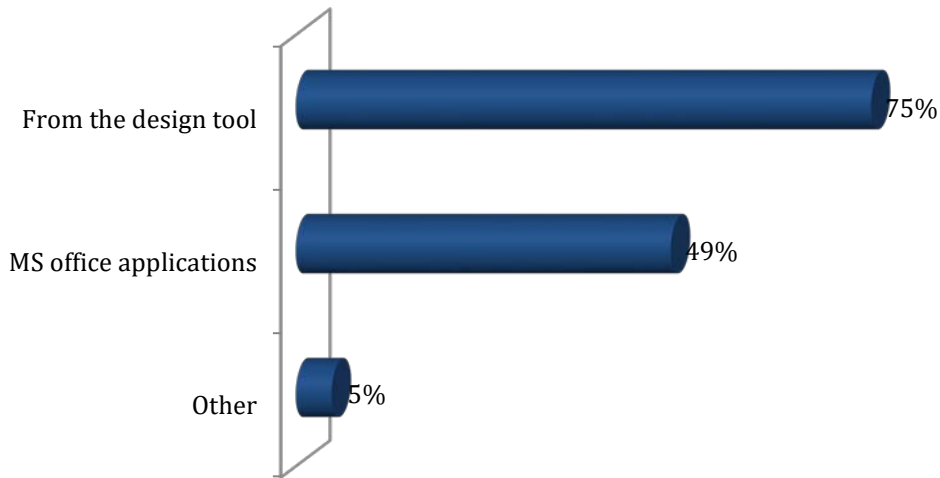


Figure 13: Manufacturing Processes to Produce Composite Parts

Using the engineering model directly saves time and leaves little room for misinterpretation or errors

By taking the information directly from the design tool, you can reuse more information rather than recreate it. This saves time and reduces the risk for errors.

Don't Overlook the Time Impact of Changes

Developing the manufacturing plan is a critical piece of producing quality parts. A significant amount of time goes into creating them, but an almost equal amount of time goes into making changes. Overall, it takes over a day to get the plan ready. To implement changes, for most companies, the process is currently very manual (Figure 14).

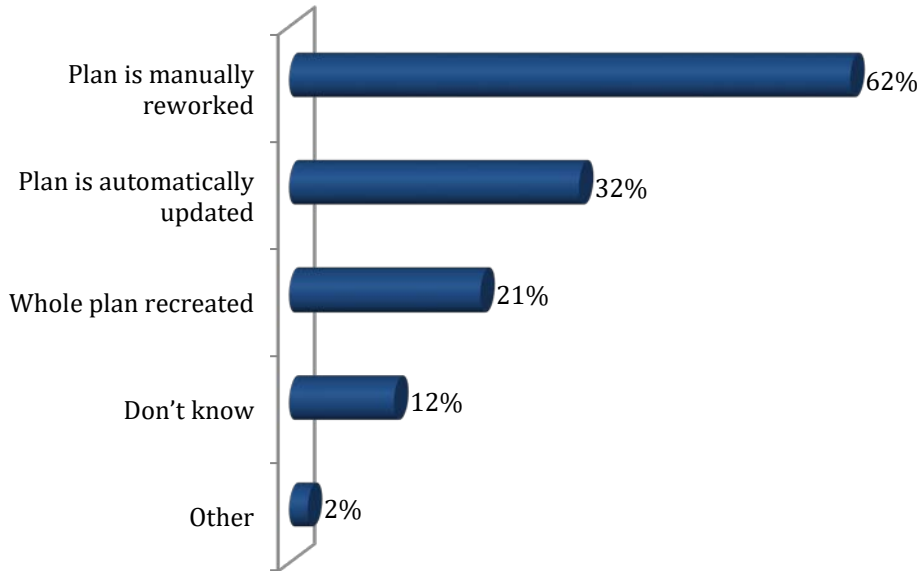


Figure 14: How Changes Are Implemented into Manufacturing Process Plans

Given how manual the process is for 83% of respondents, **there is an opportunity to reduce some of the time spent on manufacturing plans, especially changes.** With better automation, rather than waste time making manual updates you can spend it producing parts instead.

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Considering Programming Trends

There is a fairly even distribution among approaches for creating programs to run automated fiber placement (Figure 14).

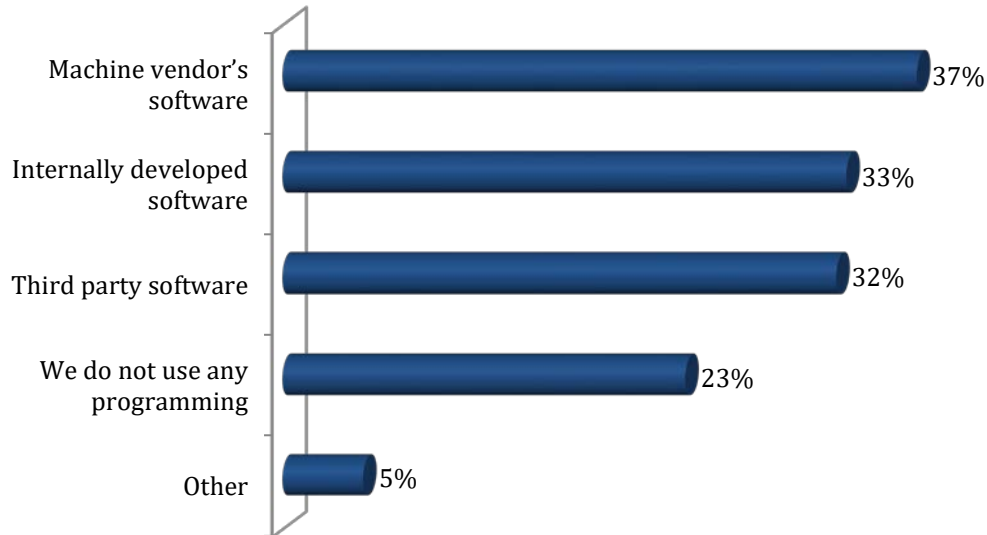


Figure 15: How Programs Are Created to Run Automated Fiber Placement

Using the machine vendor's software is the most common approach, but internally developed software and third party software are used with nearly equal frequency. A&D manufacturers tend to use automated layup machines from 2.2 different vendors. Changes are not easy here either as it takes 0.7 days to make a change to an automated layup program.

Conclusion

Many A&D companies have turned to composites to help them improve performance and realize better fuel economy. However, the A&D industry is also under significant pressure to lower costs. Addressing manufacturing defects such as springback as well as better manufacturing planning can help A&D companies take advantage of the benefits of composites while improving design and production efficiency and lowering costs.

Springback can be a considerable source of excess cost and waste. Typically, springback causes parts to be out of tolerance so manufactures have to waste time correcting parts, or worse, scrapping them. By adopting best practices, such as using design guidelines, A&D manufacturers can avoid springback.

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Adopting best practices for manufacturing planning is another area where A&D manufacturers can improve quality. It is crucial that composite parts are manufactured as designed to ensure performance. By adopting practices such as leveraging the

engineering composite model for manufacturing planning and automating changes, A&D manufacturers will be better positioned to produce parts as designed without quality issues.

Recommendations

Based on industry experience and research for this report, Tech-Clarity offers the following recommendations:

- To avoid springback, focus on identifying potential occurrences during design.
- Take advantage of design guidelines to help avoid springback.
- Consider solutions that offer embedded intelligence to provide guidance and support better decision to reduce the occurrence of springback.
- Communicate ply level design data to manufacturing via the engineering model.

About the Author

Michelle Boucher is the Vice President of Research for Engineering Software for research firm Tech-Clarity. Michelle has spent over 20 years in various roles in engineering, marketing, management, and as an analyst. She has broad experience with topics such as product design, simulation, systems engineering, mechatronics, embedded systems, PCB design, improving product performance, process improvement, and mass customization. She graduated magna cum laude with an MBA from Babson College and earned a BS in Mechanical Engineering, with distinction, from Worcester Polytechnic Institute.

Michelle began her career holding various roles as a mechanical engineer at Pratt & Whitney and KONA (now Synventive Molding Solutions). She then spent over 10 years at PTC, a leading MCAD and PLM solution provider. While at PTC, she developed a deep understanding of end user needs through roles in technical support, management, and product marketing. She worked in technical marketing at Moldflow Corporation (acquired by Autodesk), the market leader in injection molding simulation. Here she was instrumental in developing product positioning and go-to-market messages. Michelle then joined Aberdeen Group and covered product innovation, product development, and engineering processes, eventually running the Product Innovation and Engineering practice.

Michelle is an experienced researcher and author. She has benchmarked over 7000 product development professionals and published over 90 reports on product development best practices. She focuses on helping companies manage the complexity of

today's products, markets, design environments, and value chains to achieve higher profitability.

About the Research

Tech-Clarity gathered and analyzed 181 responses to a web-based survey on designing and producing composite parts. Survey responses were gathered by direct e-mail, social media, partners, and online postings by Tech-Clarity. Tech-Clarity also interviewed leaders from leading manufacturers in order to share their experience and knowledge.

The respondents were comprised of about one-third (35%) who were individual contributors. Nearly one-half (45%) were manager or director level, and the remaining (20%) were VP or executive levels.

The respondents represented a mix of company sizes, including 36% from smaller companies (less than \$100 million), 32% between \$100 million and \$1 billion, 32% greater than \$1 billion. All company sizes were reported in US dollar equivalent.

Of the responding companies all (100%) were from the Aerospace and Defense industry.

The respondents reported doing business globally, with over a third of companies doing business in North America (39%), a little less than one-half doing business in Western Europe (45%), a little less than two-third doing business in Asia (61%), Eastern Europe (15%), Middle East (9%), Latin America (8%), and Australia (6%).

Only responses from those determined to be directly involved in designing and/or producing composite parts were included in the analysis.

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