White Paper

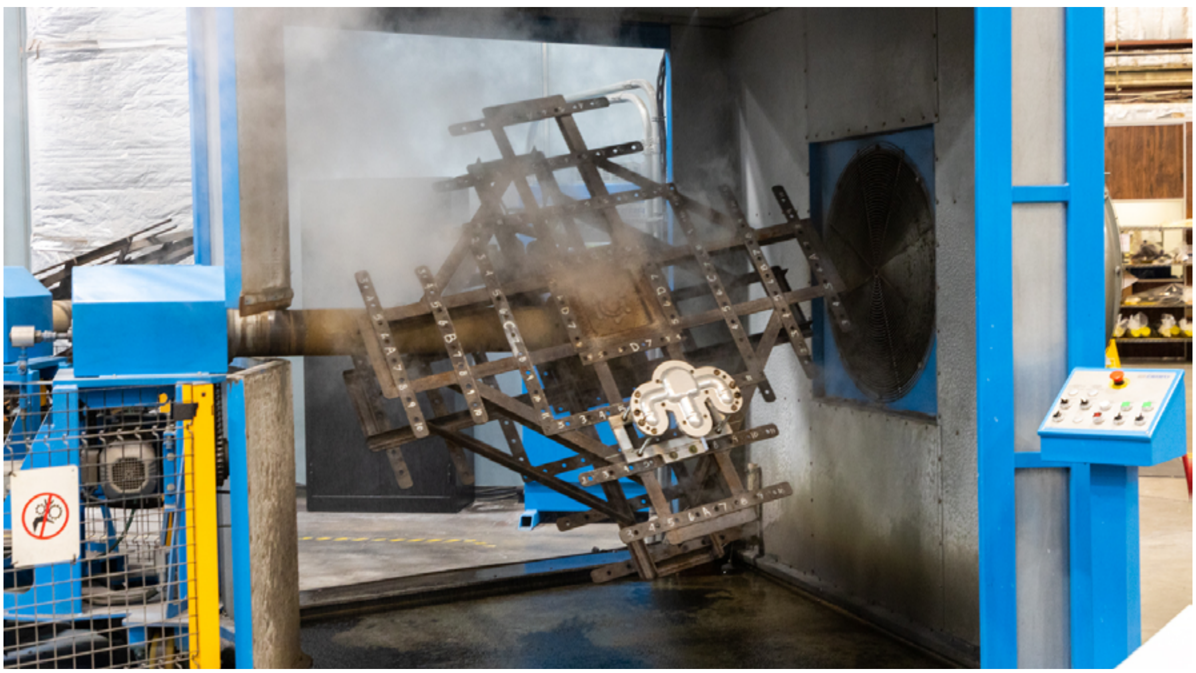
Innovative Technologies Serving the Aerospace Industry

Advantages of Rotomolding and 3D Printing

The aerospace industry's relentless pursuit of enhanced performance and efficiency is enabled by advanced, innovative, and nimble manufacturing techniques. However, part weight and complexity can challenge this pursuit. The weight of each individual part has significance due to the fact that every ounce of weight shaved off an aircraft contributes to sustainability goals by helping airlines to save fuel. Part complexity posed a puzzle without an answer until thermoplastics entered the manufacturing arena, freeing up aeronautical engineers' design capabilities.

Above all, safety remains a critical factor while still keeping efficiency, performance, and cost effectiveness in mind. Which methodology offers this ideal combination of reliability, precision, and cost efficiency when constructing aerospace components? Almost every manufacturing technique and material finds a place within an aircraft. However, polymer-based materials can replace traditional manufactured parts to achieve design goals and create more advanced aircraft.

Two processes that leverage the capabilities supplied by thermoplastic resins are rotational molding and additive manufacturing (laser sintering). These technologies can provide the ideal combination of factors for effective component design and fabrication. A closer examination reveals the strengths and potential applications for each of these processes within the aerospace industry.



An overview of rotational molding

Rotational molding, commonly referred to as rotomolding, is a unique plastic molding process ideally suited for creating hollow parts with complex shapes and features.

The process starts with the placement of a polymer powder within a mold. The mold is then heated while simultaneously being rotated biaxially within an oven. As the temperature rises, the polymer resin melts to uniformly coat the interior surface of the mold.

Next, during the cooling phase, the melted polymer solidifies, maintaining the shape of the mold. The resulting piece is seamless, devoid of any weld lines or joints. This method offers several advantages, including part flexibility, to deliver a durable, lighter-weight solution compared to a similar metal part. In addition, this process minimizes waste to help companies meet sustainability goals.

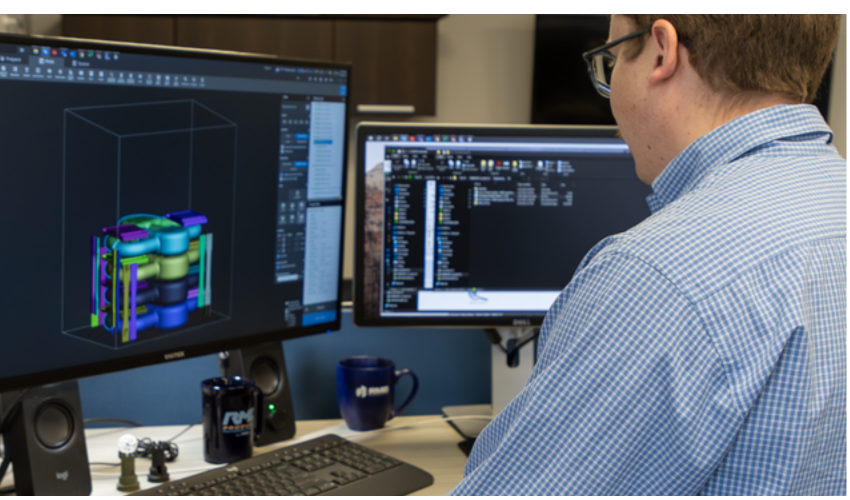
An overview of additive manufacturing

Additive manufacturing, also known as 3D printing or laser sintering, represents the forefront of innovation for component design and production. This process diverges in many ways from traditional manufacturing.

Traditional processes are often subtractive. When machining a piece of aluminum, as much as 90% of the original material may be discarded before obtaining a finished product. In contrast, 3D printing fabricates objects by adding material layer by layer, following a predefined computer-aided design (CAD) model. The part grows or is formed 0.005 inches at a time.

Offering a similar benefit as a rotationally molded part, a 3D-printed component has no weld lines or seams. It offers several advantages above and beyond that, bringing transformative benefits to the aerospace sector. These include:

- **Weight reduction.** The potential for weight reduction is significant. By utilizing high-performance thermoplastics or polymers, parts can often be fabricated at a fraction of the weight of their metallic counterparts without compromising on strength.



- **Intricate details.** This method allows for the printing of intricate geometries within a single component. The overall reduction or the reduction in overall part count results in a component with fewer points of potential failure, contributing to enhanced safety and reliability.

- **Easy iteration.** Additive manufacturing promotes rapid prototyping, enabling easy, quick, and efficient iteration. This swift turnaround can supply competitive advantages to bring products to market more quickly.

- **No tooling required.** Another unique aspect of additive manufacturing is the elimination of the molds or specialized tooling required for metal parts. This results in decreased upfront costs and shortened production timeframes. It also facilitates the creation of custom parts that are tailored to the customer's specific needs.

- **Less paperwork.** Because 3D printing processes create a single, contiguous build, the finished parts do not require welding or riveting, for example, to hold the structure together. This means a part might require a single certification or possibly two, if the part needs to be painted.

  Contrast that with a similar part made using traditional manufacturing methods. An environmental control system (ECS) duct fashioned in this manner at a minimum would require twice the number of certifications, such as for the weld and the welder, the gas, and material alloy, just to name a few.

- **Shelf-life concerns.** In the case of paint and adhesives, inventory management includes tracking shelf life. The shelf life for typical adhesives can be as little as six weeks and often not more than one year. Additive manufactured parts, with their reduced part count, may not eliminate shelf-life management issues but will definitely reduce them.

- **Expedited delivery.** Every part that is eliminated by a single-piece process removes potential supply chain impacts to an on-time delivery, bringing final product completion within the right time frame and within budget.

Types of resins specified for aerospace applications

Among manufacturing methods, 3D printing offers engineers a range of materials to choose from for projects, ranging from "neat" polymers to glass- and fiber-filled polymers, depending on the end application.

Ductwork and other aerospace components often rely on certain classes of polymers that exhibit the characteristics desired for the environments encountered and chemical exposure, for example. These often include polyamide 11 (nylon 11 and 12).

Each has various characteristics that offer functionality or processing capabilities. These preferred characteristics can include the ability to:

- Withstand temperature extremes
- Offer flame retardance
- Provide chemical resistance
- Enhance ductility
- Resist corrosion

Suitability of thermoplastic resins for aerospace applications

Thermoplastic resins have emerged as a material of choice in the rigorous aerospace environment — and for good reason. These materials exhibit a combination of properties that address the unique challenges encountered or posed by this industry.

Their lightweight nature directly contributes to fuel efficiencies, enabling extended flight ranges and reducing the overall carbon footprint for the industry.

Beyond weight benefits, thermoplastic resins exhibit high strength-to-weight ratios, displaying durability even under extreme conditions. Many of these materials exhibit resistance to UV radiation, chemicals, and temperature fluctuations, which makes them ideal for aerospace and other challenging applications

Moreover, the inherent flexibility of these resins when used for a rotomolded component, for example, allows for components to withstand stress and vibrations during take-offs, flights, and landings. This property also supplies value for parts during the installation process. Rotomolded components can flex and withstand an accidental drop, for example, in an instance that might shatter a composite component.

The ability to tailor the properties of thermoplastics through additives or blending further extends their versatility, ensuring they can meet specific performance requirements.

These characteristics enable the production of ductwork that is lightweight, durable, and capable of withstanding specific environmental, temperature, chemical, and pressure requirements.

Plastic polymers compatible with sustainability

RMB has the most extensive experience working with nylon 11 and nylon 12, although usually the customers will specify the resin selected for a project. In the commercial aviation sector, the preference leans toward fire-retardant polymers to comply with stringent safety regulations. In the defense sector, material selection can be a bit broader.

Within the realm of laser sintering, one particular polymer stands out for its combination of performance and sustainability — nylon 11. Sourced from the castor bean, this polymer not only provides robust performance characteristics but also offers green credentials to aid with aviation's sustainability efforts or pledges.

The castor bean, a plant that thrives in arid regions, is transformed into a versatile polymer, merging the worlds of agriculture and high-tech manufacturing. This sustainable origin makes nylon 11 a particularly attractive choice for aerospace manufacturers eager to strike a balance between rigorous part specifications and ambitious net-zero sustainability objectives.

RMB's commitment to quality is evident in its meticulous manufacturing processes. Each build includes a series of tensile bars, strategically positioned across the entirety of the build layout. The tensile bars validate whether the laser-sintered part can meet customer specifications or quality parameters by gauging the tensile strength and elongation.

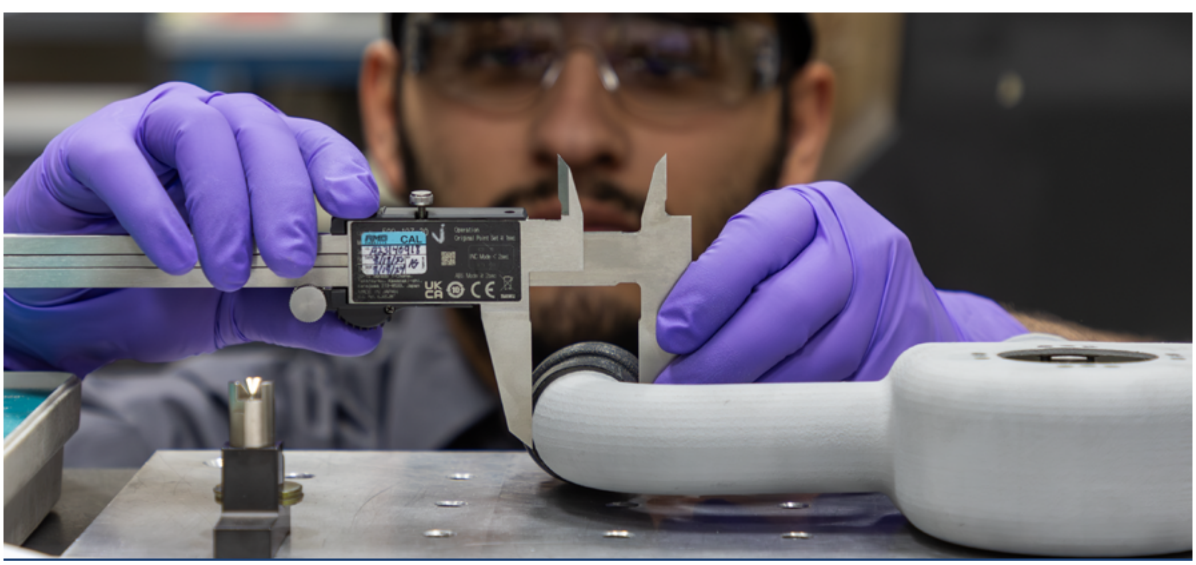
Importance of elongation in aerospace applications

Elongation refers to the ability of a material to stretch without breaking. In aerospace, where materials are subjected to varying stresses, elongation is a necessary criterion for many materials. A material that can elongate under stress without fracturing can absorb more energy and is less likely to fail under extreme conditions. Ensuring that materials have the right elongation properties is a vital part of the quality control process in additive manufacturing for aerospace components.

Comparing rotomolding with additive manufacturing

Consider the following advantages and disadvantages of rotomolding and additive manufacturing for aerospace solutions:

TECHNOLOGY	ADVANTAGES	DISADVANTAGES
Rotomolding	Offers seamless construction, which is ideal for hollow parts and part flexibility	A slower process compared to some other manufacturing methods
	Reduces material waste	
	Results in lighter components when compared to some metal alternatives	
	Is ideal for small-lot production runs	
Additive Manufacturing	Delivers rapid prototyping	May be costlier for large-scale production runs
	Enables design iteration	Part size limited by the print bed size
	Offers a high degree of flexibility	
	Can integrate complex internal features into a single build	
	Reduces lead times	
	Is ideal for creating custom parts	

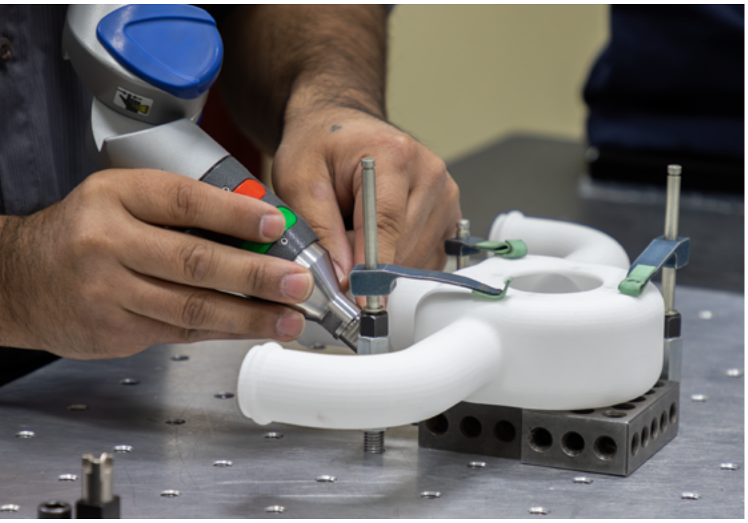


Forefront of aerospace innovation

The aerospace sector continues to be at the forefront of manufacturing innovation. As it strives for efficiency, safety, and sustainability, a company that offers expertise in both alternative processes, rotomolding and additive manufacturing can streamline production times while supplying components and parts that meet stringent aerospace requirements.

RMB is a leading production house for components used in the world's most advanced aircraft. As a company, it implements thorough quality control measures for any manufacturing process used, whether for rotationally molded or laser-sintered parts. These quality control measures include traditional inspection methods as well as coordinate measuring machine (CMM) inspection against the model.

We are committed to ensuring the utmost quality throughout the project lifecycle — from offering engineering design assistance during the developmental stages to actively overseeing every aspect of the production cycle.



RMB executes a comprehensive AS9102 first article inspection report for all parts that we manufacture. RMB's commitment to excellence is further underscored by its adherence to stringent quality benchmarks, such as:

- Meticulous and rigorous auditing
- AS and ISO certifications
- Cybersecurity Maturity Model Certification 2.0 (from the Department of Defense)

Holding AS and ISO certifications for more than two decades, along with its proactive approach to obtaining new certifications when required, demonstrates the company's dedication to quality and innovation.

Request a quote for your aerospace project to fully leverage cost efficiencies and create complex yet durable aerospace parts through RMB's additive manufacturing or rotomolding processes. Whether you have a CAD file ready to go or need an insightful consultation with an RMB engineer during the design phase, we are here to help your project reach the pinnacle of success.

ABOUT THE AUTHOR

Chris Glock

Chris Glock is vice president of program management at RMB Products. He began his career with RMB in 1991 and has held a variety of manufacturing and commercial roles within the company. His current responsibilities are program and project management. Glock has deep expertise in engineering product applications, quality requirements, and program management.

ABOUT RMB PRODUCTS

RMB provides highly engineered polymers and corrosion protection technology for demanding, mission-critical applications in aerospace, chemical processing, semiconductor, and biopharmaceutical industries. The company offers a variety of superior rotational molding and additive manufacturing technologies that have proven reliable and indispensable to customers around the world. RMB's unique rotational lining capability provides seamless, bonded linings that offer superior corrosion protection for pipes, fittings, tanks, and vessels — compared with competitive lining materials and methods.

Looking for more information or a quote? Call us at 719.382.9300.