



20

RTM

From prototype to series production: scaling resin transfer molding for mainstream applications

23

Optimisation

Improving wind blade productivity with glass kits and preforms

MANUFACTURING RTM

From prototype to series production: scaling resin transfer molding for mainstream applications



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French company C-INERTIA patented an RTM process that makes carbon wheels viable for mass production. With cycle times aligned to New Energy Vehicle (NEV) demands, the technology could drive wider adoption of lightweight composites in mainstream automotive.

Electric vehicle adoption and stringent emissions regulations are driving unprecedented demand for automotive lightweighting solutions. While carbon fibre wheels deliver compelling advantages up to 50% weight reduction compared to aluminium – their adoption has been constrained by manufacturing limitations and prohibitive costs. French technology company C-INERTIA developed a proprietary RTM process that addresses these fundamental barriers, making carbon fibre wheels viable for mainstream automotive production. The process has now reached industrial maturity, with production lines delivering finished wheels that are tested, painted, and installation-ready.

Breaking the manufacturing barrier

Traditional carbon fibre wheel production relies heavily on prepreg processes that require cold storage, meticulous hand layup,

and lengthy autoclave cure cycles. This approach delivers high-quality components but presents significant limitations for automotive-scale production. Cycle times are up to 12-24 hours per wheel, with substantial labour content and capital-intensive autoclave infrastructure, resulting in cost structures that are unsuitable for series automotive applications.

RTM represents a significant evolution in the way carbon wheels can be manufactured. At the beginning of the process, dry carbon fibre is positioned in the mould as cut plies shaped to anticipate complex wheel geometries. The tooling is then closed and liquid resin is injected under precisely controlled conditions, with real-time monitoring of flow progression

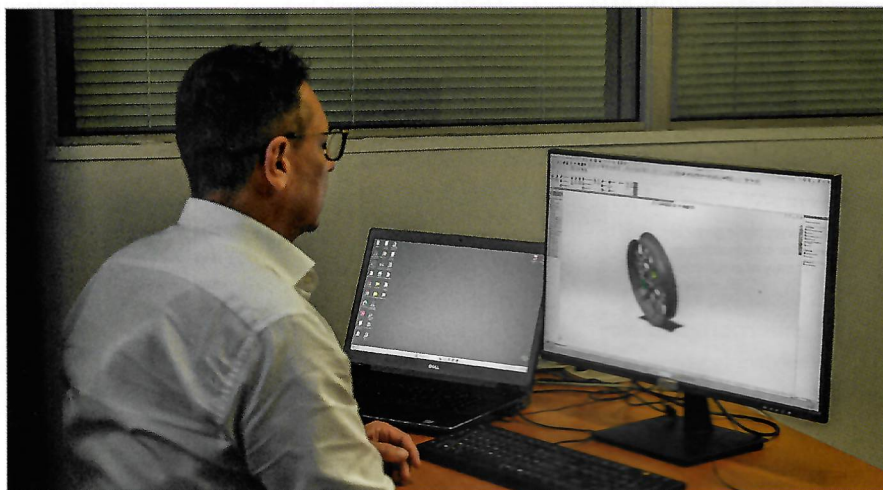


Fig. 1: CAD design and structural calculation of a carbon wheel

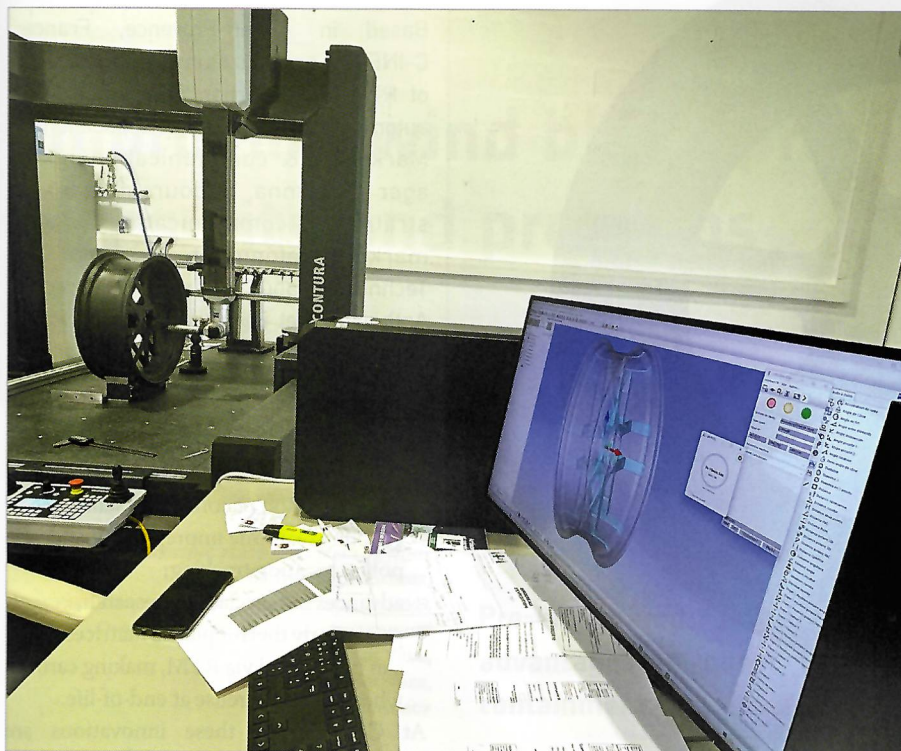


Fig. 2: Quality control workflow with coordinate measuring machine and CAD comparison

and cavity pressure. The polymerization stage is then temperature-controlled with adapted post-curing that eliminates the need for an autoclave.

This process dramatically improves production efficiency. Manufacturing cycles are reduced to less than two hours per wheel – approximately five to 10 times faster than traditional prepreg methods. This time reduction enables production volumes that are compatible with automotive market expectations while maintaining the surface quality and dimensional consistency required for series applications.

Process control and industrial integration

The success of RTM manufacturing depends on the precise control of key process variables. Each variable – resin temperature and viscosity, carbon fibre type, injection pressure and speed, polymerization cycles directly influences final part quality. Process deviations can result in porosities, dry zones, or dimensional defects.

C-INERTIA's carbon wheel development process relies on several integrated approaches: rigorous design through structural calculations and numerical models to take into account service loads; optimized layup

with a fibre architecture designed from the initial stages, enabling rapid, repeatable placement of dry carbon; real-time control with production parameter monitoring throughout all injection cycle phases; and calibrated post-treatments with post-cure cycles designed to stabilize the matrix and guarantee robust mechanical performance.

The whole manufacturing chain is handled in-house, from initial CAD design through final painted finishing. Each production step is integrated to ensure consistent quality and compatibility with series production. The company positions itself among the few European manufacturers that combine tooling, industrialization, layup, injection, quality control, and painting in a complete series production approach – a tested, functional industrial model.

Addressing the electric vehicle challenge

Electric vehicles present a fundamental engineering challenge that makes carbon fibre wheels particularly valuable. Increasingly heavy vehicles require a strategic mass reduction, while larger wheel sizes compound the unsprung mass problem. Reducing the unsprung mass through lighter wheels delivers benefits that extend far beyond simple weight reduction.

Carbon fibre wheels can improve EV driving range by 8-10% by reducing energy consumption, while improving acceleration response. However, the solution has historically been economically constrained. While carbon fibre wheels offer the required 50% weight reduction, traditional prepreg manufacturing costs have confined their adoption to luxury



Fig. 3: CNC machining operations for precision tooling and component manufacturing



Fig. 4: Finished carbon fibre wheel showing RTM surface quality and precision

applications. RTM technology breaks this economic barrier, enabling industrial-scale production for mainstream automotive and motorcycle markets.

Market applications and industrial readiness

Over the past 18 months, C-INERTIA has developed a proprietary RTM-based process purpose-built for carbon fibre wheels that integrates all the industrial building blocks: from fibre layup to certified, repeatable, series-ready parts. This is not standard RTM but a dedicated, production-grade technology that is unique in the industry.

As C-INERTIA's technical & industrial director Anthony Adnet says: *"We are at a pivotal moment. Market expectations, the need to reduce the weight of increasingly heavy vehicles along with the trend toward larger wheel sizes, and the maturity of the technology are converging."*

The company's CEO Loïc Bernard adds: *"RTM isn't just a process, it's a game-changer for lightweight, high-performance mobility for OEMs."*

Production economics and scaling challenges

RTM manufacturing offers compelling advantages through reduced cycle times

that decrease unit costs while eliminating the need for an autoclave. However, the initial investment in tooling, instrumentation, and development remains significant. Only series production allows for the amortization of investment.

The key scaling challenges include reproducibility, requiring precise process monitoring and integrated mould sensors; tooling robustness as RTM moulds have to withstand thousands of cycles without deformation; industrial flow management, requiring a different organization with optimal dimensioning of injection and polymerization lines; and automotive qualification, that demands validation according to strict mechanical resistance, fatigue, and safety protocols. Recent advances in simulation software, embedded sensors, and controlled-kinetics resins now enable reliable, repeatable RTM production for complex wheel geometries.

Future development

Several innovation areas are under active exploration:

- process automation to ensure superior consistency and efficiency;
- new resin formulations using faster, less energy-intensive bio-sourced systems that address environmental requirements;

Focus

Based in Aix-en-Provence, France, C-INERTIA specializes in the manufacture of RTM-based carbon fibre wheels for automotive and motorcycle applications. Marketing & communication manager Giovanna Saboureault leads strategic communications and market development. Technical and industrial director Anthony Adnet is in charge of the R&D, Industrialisation, Quality and Production Departments.

- intelligent mould monitoring through the integration of connected sensors enabling real-time impregnation and polymerization tracking;
- advances in recyclability research, particularly thermoplastic matrices that can be injected via RTM, making carbon wheels easier to reuse at end-of-life.

At C-INERTIA, these innovations are not merely future perspectives, they are integrated into the product roadmap with initial trials already underway on production lines.

Industrial impact

RTM technology addresses the cost and scalability barriers that have historically limited the adoption of carbon wheels to niche applications. By enabling industrial-scale production while maintaining superior composite performance characteristics, this approach unlocks broader market penetration across automotive applications where lightweighting delivers a strategic advantage.

The deployment of carbon RTM wheels across mid-to-high-end vehicles and EVs appears imminent. With the ability to combine production speed, mechanical robustness, and economic viability, this drives the industrialization of carbon in automotive applications – a discrete revolution already operating at full speed. □

More information:
www.c-inertia.com