WHITE PAPER

Maximize Manufacturing Options with **Magnesium Thixomolding**

Conventional part and product manufacturing has proven its value over centuries. But that doesn't make it perfect for everything.

Whenever design parameters and types of use get complex, metal die casting and plastic injection molding can hit a wall. Depending on the technology, they can have high carbon footprints in their use of expensive energy, be environmentally unfriendly, poor for recycling and require significant additional processing to meet design requirements. Electronics components might require additional shielding to avoid electromagnetic or radio frequency interference.

In such applications as medical devices, automotive and consumer electronics, common manufacturing processes may not provide the capabilities that engineers need to create products that will work under demanding conditions and that can be formed and built-in ways that fulfill business requirements.

Magnesium thixomolding is a manufacturing process that has been around for many years but engineers often overlook it because of their lack of familiarity. The process has a set of strengths that make it a powerful technique to address design, manufacturing and business.

Challenges of Production Technologies

Products and parts that address requirements in these demanding industries involve critical design. Applications are frequently heavily regulated, economics are challenging, and in some cases the uses can involve levels of safety concerns that can reach matters of life and death.

Design parameters are often complex and involve trade-offs. Weight, size and strength may be important. A product might need EMI and RFI shielding for key assemblies but need thin walls and size to fit within device design parameters. With a wall thickness of 0.039", greater than 85 dB shielding is possible. A mobile device could require a ruggedized shell that is still light enough to appeal to consumers as magnesium has a density 40% to 75% less than that of aluminum or steel, respectively.

A given manufacturing process could swap manufacturing speed—and, so, greater production volume—for the ability to enable finer and more defined details in the end part. For example, die casting might allow the formation of the basic product but be incapable of minimizing material thickness without additional machining of each part at higher expense.

One manufacturing process might on the surface seem capable of delivering final goods but allow too much variation in results and create an unacceptably high percentage of flawed items. Another process could excel in enabling design nuance but be too slow to create the needed volume of product or lack an ease of recycling that increasingly commands interest from consumers, business

Advantages of **Thixotropic Molding**

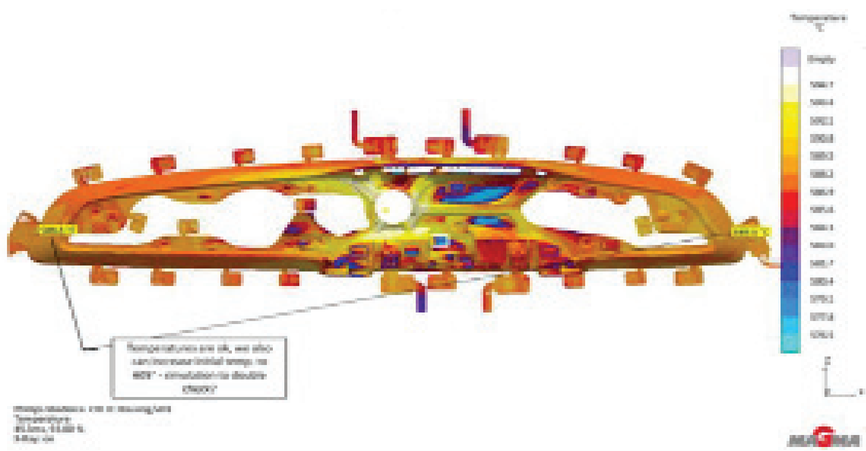
- Thermal Management
- Environmentally Friendly
- Thin Wall
- High Vibration Absorption
- High-Strength
- Light Weight
- EMI Shielding
- Cost-Effective

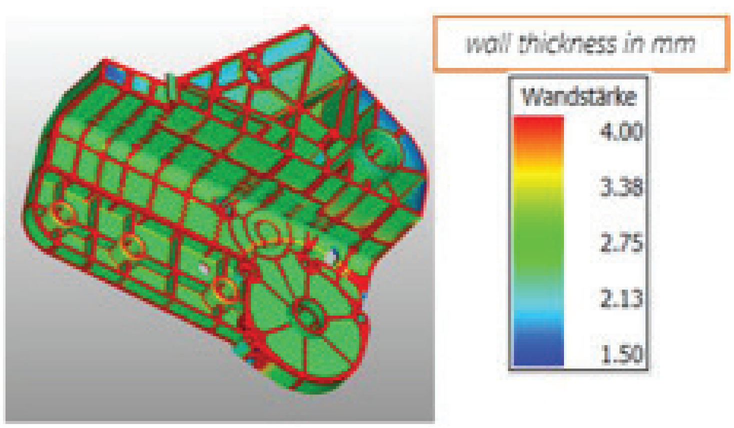
uses and even investors with an eye to so-called environmental, social and governance (ESG) issues. An approach could use materials that seem ideal initially but then don't mesh with the environments in which they must ultimately perform. Inclusion of electronics has become widespread in many types of products, which means electromagnetic and radio frequency interference become broadly important.

Common plastic injection molding and die casting are frequently problematic when it comes to more demanding design, manufacturing, and financial requirements.

Plastic injection molding can be expensive and time-consuming in set-up to avoid formation flaws. Minimizing such concerns can require time-consuming iterative refinement in both part and mold design. Wall thicknesses need to be uniform to keep defects from forming. As a result, the process typically makes financial sense only when parts runs are very high. Also, many plastics are not easily recyclable, even when labeled as such, thereby creating a waste problem.

Die casting has its own set of problems. Again, the set-up is costly and running a few prototypes and then modifying the results is challenging. Metals like aluminum or steel must be heated to melting—approximately 660°C and 1300°C to 1540°C, respectively—which is a significant use of energy. Die casting must overcome porosity, where air in the molten metal can cause gaps or surface defects. Further, if made of conducting materials, electronics contents might well need additional space, weight and cost for shielding.





The Magnesium Thixomolding Solution

Magnesium thixomolding is a manufacturing process with a unique set of strengths and the ability to deliver results from which many design projects could benefit. It all depends on the thixotropic characteristic of the metal which becomes a non-Newtonian fluid when sufficiently heated.

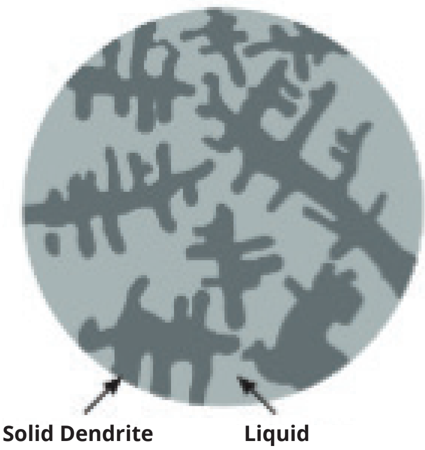
A non-Newtonian fluid is one in which viscosity is a function of stress rather than a uniform and unaltering characteristic. Change the stress and the viscosity alters. There are common examples, like ketchup, toothpaste and quicksand. If the change in viscosity is time-dependent—that is, the material takes a fixed amount of time for viscosity to regain equilibrium—it is thixotropic.

Magnesium already has a number of desirable characteristics for manufacturing products. With a density of 1.74 g per cubic centimeter, compared to 2.70 for aluminum and between 7.75 and 8.05 for steel, it has a high strength-to-weight ratio. Magnesium also offers excellent impact resistance and has exceptional stiffness and damping capacity to help isolate sensitive components from vibrations. It can also withstand exposure to far more heat than plastics.

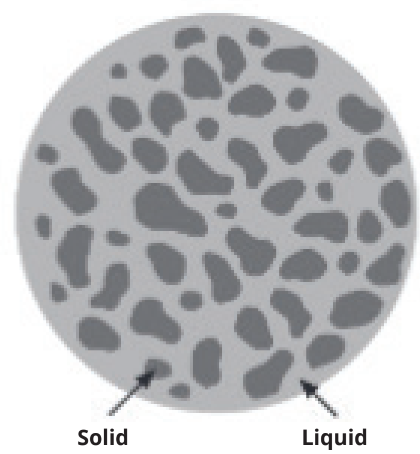
The metal, being non-magnetic, also can provide electromagnetic and radio frequency interference shielding because it doesn't readily conduct such wavelengths. Magnesium is thermally conductive, allowing housings to transfer heat to the surrounding environment. Those characteristics make it a good choice for structures that must protect electronics from interference while dissipating out generated heat. If additional machining is necessary, magnesium is outstanding at high speeds and feeds in either dry or wet systems.

Like some other metals, when heated to between approximately 560°C and 630°C, magnesium exhibits thixotropy. The thixomolding process feeds magnesium chips into a heated barrel, which contains argon to prevent oxidation.

Thixotropic **Structure**

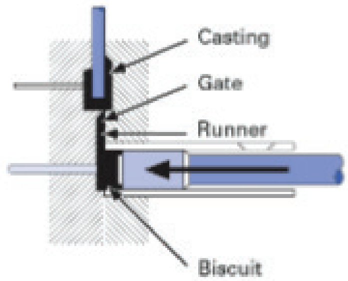


Thixotropic structure of semi-solid alloy resulting from stirring

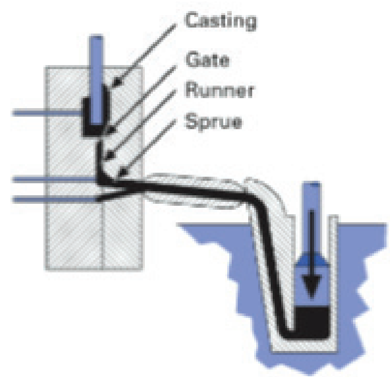


Conventional dendrite formation in semi-solid alloy

Conventional **Die-Casting**

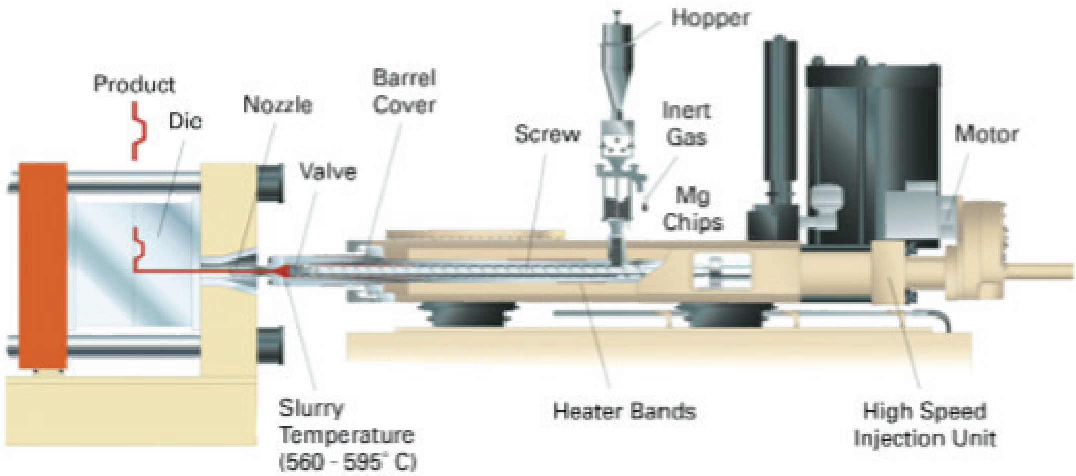


Cold Chamber



Hot Chamber

Magnesium **Injection Molding**



Sufficient heating creates a slurry that a rotating screw then forces into a pre-heated metal mold to accurately create the desired part. The resulting net-shaped parts also have better straightness and flatness and tighter tolerances than die casting.

Thixomolding, combined with the natural properties of magnesium, can also create thin walls. Thinner walls with the greater strength and stiffness of the metal reduce the amount of material needed, which can lower weight, size and materials cost.

Perhaps most importantly, thixomolding can improve product yields to 90%—**versus typical die-cast yields of 50%** while eliminating waste and loss of product to melting. The process is more worker- and environment-friendly and can easily integrate into automated manufacturing processes. It lends itself to shorter cycle times as well as longer tool life than die casting.

Pieces made from this process can also lend themselves to a variety of finishes, including prime, liquid paint, e-coat, powder coat, clear coat, pad print, laser etch or plating.

Overcoming the Final Barrier: Familiarity

Perhaps the biggest shortfall of the magnesium thixotropic manufacturing process is that many engineers are unfamiliar with it, leading to some mistaken presumptions. For example, on hearing about it for the first time, some engineers will express concern over magnesium's reputation for combustibility. It is true that magnesium is combustible—but only when in a granular or thin ribbon state. Even in this state, combustion requires a temperature of about 650°C and the application of a sufficient heat source.

Corrosion is another common concern. Magnesium is high on the galvanic scale, so in some conditions such as an acidic environment, corrosion could occur—potentially affecting surface or structural integrity. However, parts can be conversion coated to prevent oxidation and corrosion, ameliorating this concern.

A typical design approach involves these steps:

- Estimate budgetary needs and constraints
- Get design for manufacturability consultation
- Conduct flammability tests if needed
- Make design refinements and finalization
- Order tooling
- Develop gating and vacuum designs
- Perform moldflow analysis
- Design and build tooling
- Conduct sample runs
- Obtain customer approval
- Initiate production

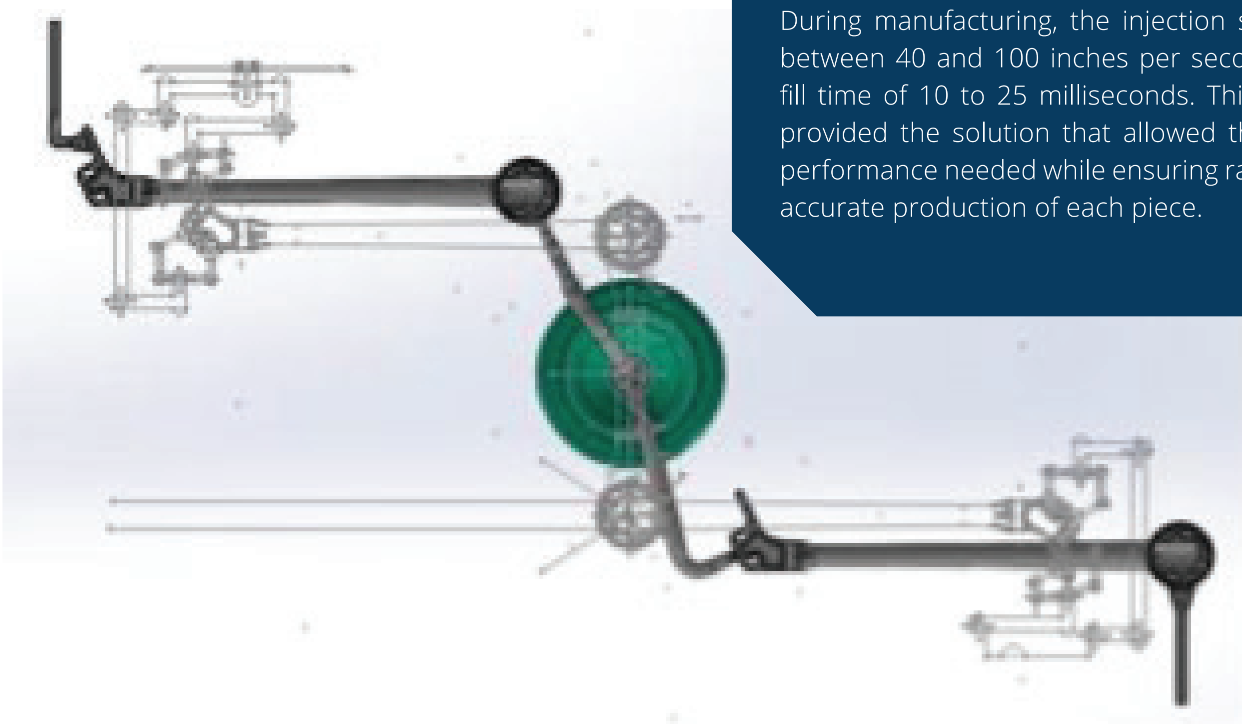
Putting Thixomolding **Into Practice**

Thixomolding has applications in a variety of sectors, including automotive, industrial and healthcare. Examples of medical applications include:

- Bio-monitor housings
- Heart pump controllers
- Wound therapy housings
- Medical wearable enclosures
- Surgical robot components

One real-world example is the tonearm for U-Turn Audio's Orbit Theory Turntable. The company needed a precise and lightweight arm for a record turntable. A new version of an existing product, the entire tonearm assembly received scrutiny from audiophile reviewers.

For better sound reproduction, U-Turn had to reduce resonance in the tonearm. That required a more rigid tonearm that would be less effected by vibration, which meant being able to cast a continuous piece to preserve a low center of gravity without costly additional machining. The magnesium thixomolding process allowed a nominal wall thickness of 0.080 inches with a hydraulic core pull to create the hole through the stem.



During manufacturing, the injection speed was between 40 and 100 inches per second, with a fill time of 10 to 25 milliseconds. This uniquely provided the solution that allowed the level of performance needed while ensuring rapid, highly accurate production of each piece.

Work With the Experts

The back-and-forth collaboration needed to solve the varying and often sophisticated issues during product design is common, especially in cases where a manufacturer is contracted to produce a product. With relatively few manufacturers using this technique, it's critical to engage one with deep experience and knowledge to ensure success right from the start of design and into full production.

The approach may fit the given needs of a project or net result. Then again, there might be a potential fit that will need testing and adjustments for the best outcome.

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With 7,000 employees, 36 locations in 11 countries, including six R&D centers in the U.S., Europe, and Asia, more than 2.5 million square feet of manufacturing space, and Class 7 and 8 cleanrooms and tool building sites, Phillips-Medisize has the knowledge and resources to advise you on the best approach for the results you need. Backed by the combined resources of Molex, and its parent company Koch, Industries, Phillips-Medisize offers greater access to even broader capabilities, expertise and best-in-class manufacturing solutions across the globe.