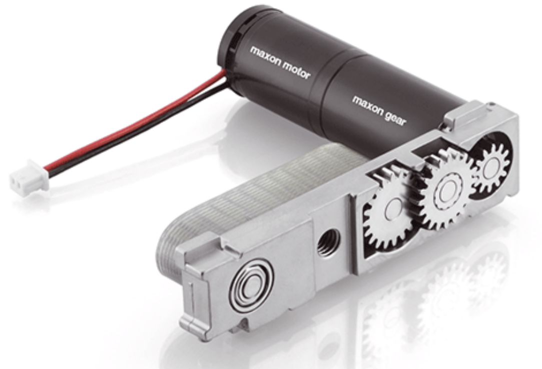
Metal Injection Moulding

Metal injection molding (MIM) offers a manufacturing capability for producing complex shapes in large quantities. The process utilizes fine metal powders (typically less than 20 micrometers) which are custom formulated with a binder (various thermoplastics, waxes, and other materials) into a feedstock which is granulated and then fed into a cavity (or multiple cavities) of a conventional injection molding machine. After the “green” component is removed, most of the binder is extracted by thermal or solvent processing and the rest is removed as the component is sintered (solid-state diffused) in a controlled-atmosphere furnace.

The Advantages of the metal injection molding process lie in its capability to produce mechanical properties nearly equivalent to wrought materials, while being a net-shape process technology with good dimensional tolerance control. Metal injection molded parts offer a nearly unlimited shape and geometric-feature capability, with high production rates possible through the use of multi-cavity tooling.



The MIM process is very similar to plastic injection molding and high-pressure die casting, and it can produce much the same shapes and configuration features. However, it is limited to relatively small, highly complex parts that otherwise would require extensive finish machining or assembly operations if made by any other metal-forming process.

Benefits of Metal Injection Molding MIM

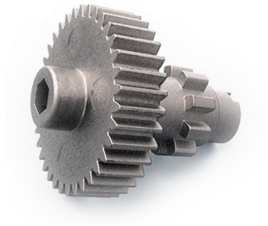
- Repeatability
- Less material waste
- Lower overall product cost
- Excellent mechanical properties
- High complexity shape capability
- Tailored solutions using unique materials
- More efficient use of material and processes
- Materials can be brazed/joined to a variety of components for complete assembly solutions

Metal Injection Moulding can produce relatively small, highly complex geometries with excellent surface finish, high strength, and superior corrosion resistance. Parts that are well suited for MIM are those that would require extensive machining set-up or assembly operations if made by any other metal forming process. If the designer begins work at the concept stage, overall part size and weight can be reduced and multiple components can be consolidated into a single design. By designing components for the MIM process, part count and assembly time are reduced resulting in overall cost savings.

MIM General Guidelines





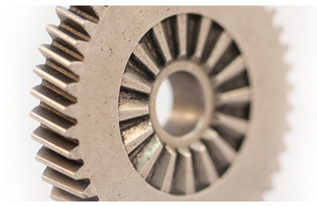
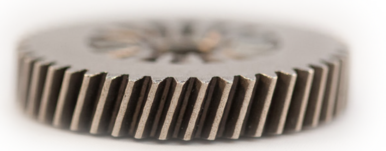


Complexity

MIM offers the same design freedom as plastic injection molding. The more geometrically complex a part is, the more solid the rationale for manufacturing it via the MIM process. Parts may include cross holes, angle holes, internal threads, irregular shapes, splines, undercuts, side holes or grooves, complex contours, or cantilevers.

Parts that would usually be made by assembling multiple components can be designed as a single MIM part. Some parts that could not be fabricated via any other process can be made through MIM. Complexity that would be cost prohibitive to do via multiple machining operations or by casting and then finishing can be achieved cost effectively through MIM processing.



Size

In general, the weight range MIM parts tend to fall within is 0.1 to 250 grams, although above 100 grams the high cost of the extremely fine powders used in the process begins to neutralize MIM's cost advantages, unless the complexity is extreme. Parts should have wall thicknesses not less than .13 mm (.005 in.) and not more than 12.7 mm (.5 in.). Due to material flow limitations, the distance from gate to the farthest point on the part should be around four inches. MIM part tolerances are nominally ±0.3%–0.5%, although tighter tolerances can be achieved in some cases if deemed essential.

Production Volume

Volumes will be based on individual component cost versus the ability to amortize costs associated with tooling and start-up engineering. The best economic advantages are achieved at higher quantities, due to the benefits of larger material purchases, multi-cavity tooling, and dedicated production units. Often the indivdual component cost savings will justify the MIM choice.

Final Properties

MIM fabrication is ideal where near-full density, high impact toughness, fracture toughness, and fatigue and corrosion resistance are required. And if non-standard material properties are required, these can be developed with new alloy systems.

MIM is appropriate for materials that are difficult to machine, materials with multi-phase microstructures, or high work-hardening materials. And it delivers a high-quality surface finish (32 rms or better) and cleaner feature detail than investment casting.



5225 Orbitor Drive Suite #2 Mississauga, Ontario Canada L4W 4Y8
Tel: 1.905.624.1800 1.877.902.2566 sales@baknor.com www.baknor.com

baknor

MIM Capability and Comparisons

Technology Comparisons - There is a place for each of the traditional metal-forming processes; each has its own strong suits as well as its limitations. But wherever a component fabrication choice exists between MIM and one or more of the other processes, it pays to see how they stack up in a head-to-head comparison.

MIM Material Properties		Density 103kg/cm3	Hardness	Tensile Strength M Pa	Bending Strength M Pa	Elongation %
Iron Based Ally	MIM-2200 (Sintered)	7.5	45-64HRB	310		40
	MIM-2700 (Sintered)	7.6	70-90HRB	410		25
Stainless Steels	MIM-316L (As-sintered)	7.75	110-160Hv1	498		40
	MIM-316 Duplex (As-sintered)	7.65	70-100HRB	732		24
	MIM-178-4PH (As-sintered)	7.5	20-25HRC	900		11
	MIM-178-4PH (Heat Treated)	7.5	35-40HRC	1160		7
	MIM-304 (As-sintered)	7.65	110-160Hv1	480		35
	MIM-440CL (Sintered)	7.5	25-35HRC	-		-
Tungsten Alloy	95%W-Ni-FE (Sintered)	18.1	30	960		25
	97%W-Ni-FE (Sintered)	18.5	33	940		15
	MIM-4605 (Sintered)	7.5	70-HRB	700		11
	MIM-4605 (Heat Treated)	7.5	45-50HRC	1610		3
Cemeted Carbide	YG8X	14.9	HRA90		2300	

MIM vs Traditional Processing

Item	Powder Injection Shaping	Powder Metallurgy	Precise Casting	Mechanical Processing	Punch
Density	98%	86%	98%	100%	100%
Tensile strength	High	Low	High	High	High
Smoothness of surface	High	Medium	Medium	High	High
Microminiaturization	High	Medium	Low	Medium	High
Thin wall	High	Medium	Medium	Low	High
Complexity	High	Low	Medium	High	Low
Products drawing tolerance	High	Medium	Medium	Medium	Low
Mass production	High	High	Medium	Medium To High	High
Material scope	High	High	Medium To High	High	Medium
Supply ability	High	High	Medium	Low	High

MIM vs Precision casting technology

Trait	Precision Casting	MIM
Diameter of the minimum hole	2mm	0.4mm
The largest depth of blind hole of 2mm diameter	2mm	20mm
Minimum thickness of side	2mm	<1mm
Maximum thickness of side	No limit	10mm
Tolerance of 4mm Diameter	±0.2mm	±0.06mm
roughness of surface (Ra)	5µm	1µm

MIM Comparisons & Design For Manufacturability

MIM vs. Conventional PM

- MIM can produce geometries that eliminate secondary operations
- MIM offers superior density, corrosion performance, strength, ductility
- MIM can combine two or more PM components into one, reducing part count
- MIM parts offer superior magnetic performance

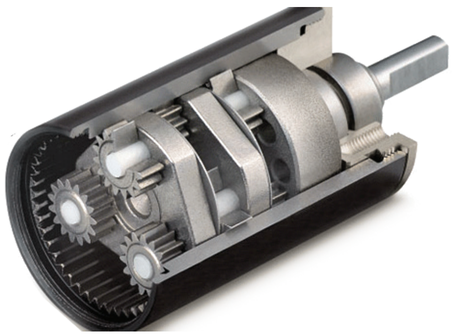
MIM vs. Machining

- MIM designs save material and weight
- Molding from a single tool eliminates multiple set-up operations
- Difficult-to-machine materials can be molded into a net shape
- MIM provides cost savings through better material utilization

- sprues and runners can be reground and reused as feedstock with no compromise to final properties

MIM vs. Investment Casting

- MIM can produce thinner wall sections, sharper cutting points
- MIM produces better surface finish
- MIM is better for small-diameter blind and through holes
- MIM greatly reduces requirements for finish machining
- MIM produces high volumes of small components at a lower cost, with faster lead times



Designing for Manufacturability The simplest MIM shape is produced in a mold made of two sections with plane surfaces that meet to seal off the cavity. One section consists of a core which fits into an impression in the other section with uniform clearances that produce shapes with uniform wall thicknesses. The core produces the internal features while the impression produces the external features. All features are designed to permit the cavity to release the solidified form, which is pushed off the core with ejector or knock-out pins.

Increased complexity in MIM components can be achieved with the addition of slides, cores, and other tools commonly used in plastic injection molding. While added features, along with their increased complexity, can have economic benefits by eliminating secondary processes or assembly operations, they typically entail additional costs associated with tooling and start-up engineering. These benefits and costs must be carefully weighed against each other at every stage of the design. A MIMA-member parts fabricator is best equipped to provide help with this assessment.

There are many critical aspects that must be considered when designing a MIM component in order to take full advantage of all the benefits of the process.

5225 Orbitor Drive Suite #2 Mississauga, Ontario Canada L4W 4Y8
Tel: 1.905.624.1800 1.877.902.2566 sales@baknor.com www.baknor.com