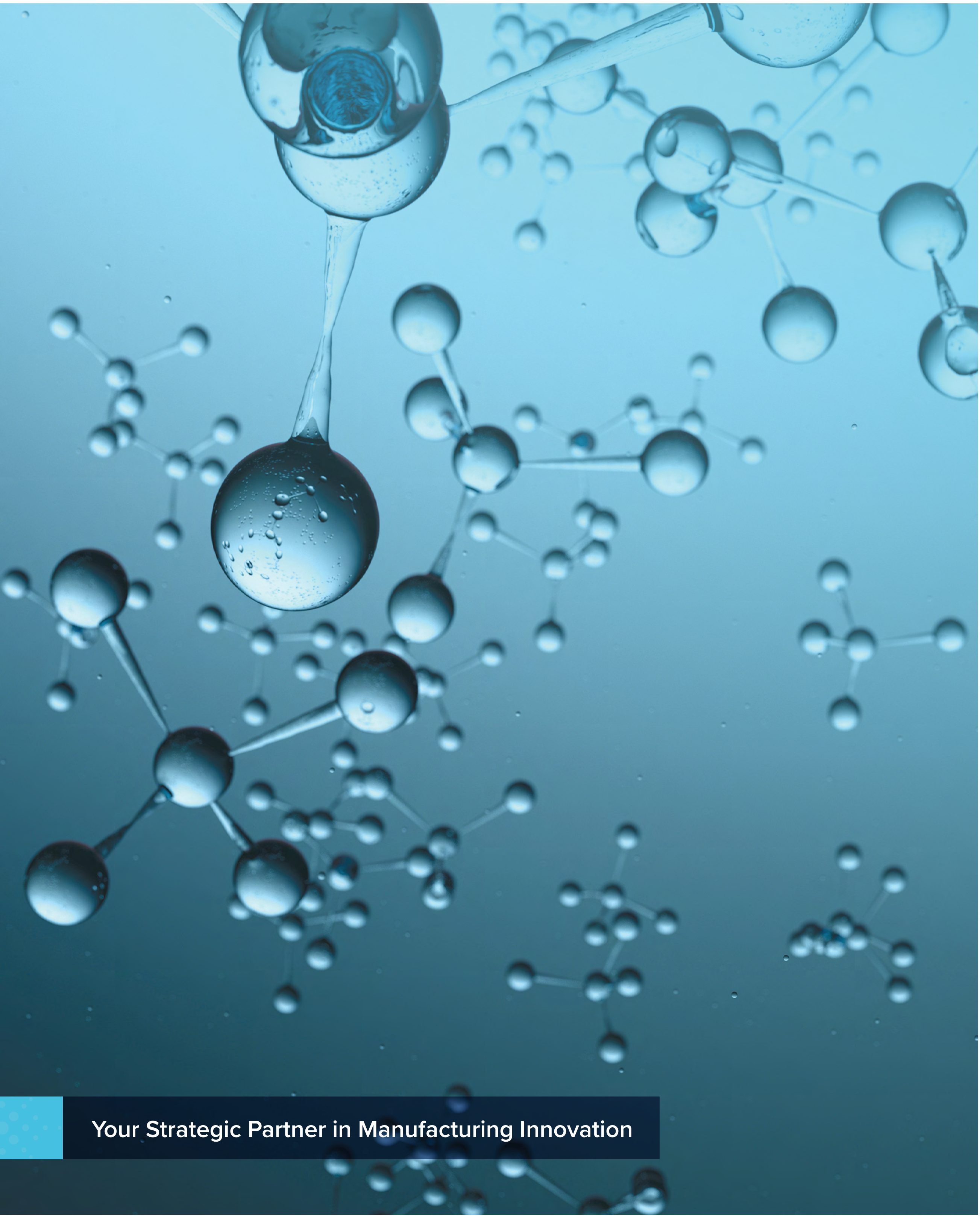
AMT Design Handbook



Your Strategic Partner in Manufacturing Innovation

Contents

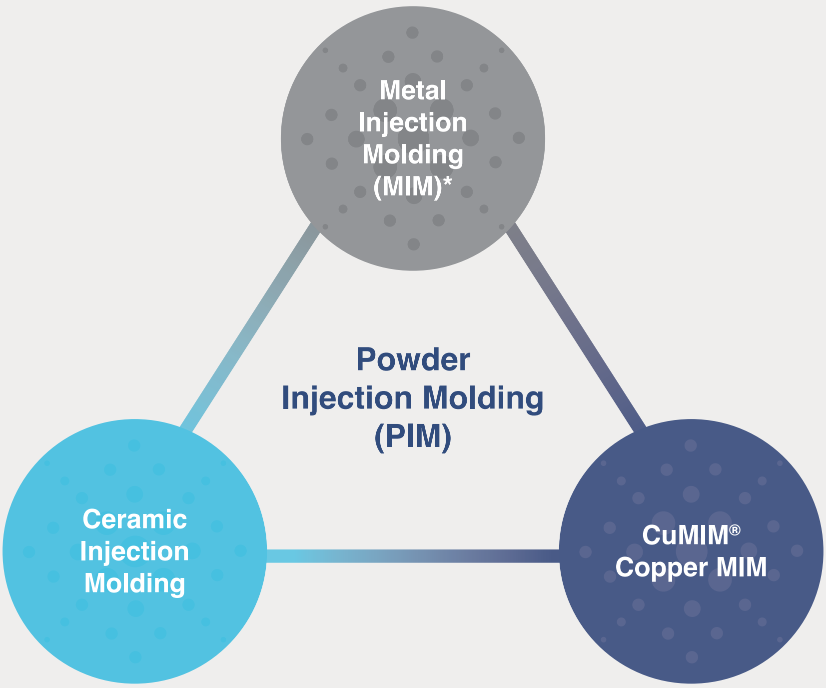
Overview of Powder Injection Molding (PIM)

Powder Injection Molding (PIM), encompasses Metal Injection Molding (MIM) and Ceramic Injection Molding (CIM), utilizes a plastic injection molding machine to form precision engineered geometries. This is accomplished using metal and/or ceramic powder in conjunction with a thermoplastic binder system.

The commercialization of PIM occured only a few decades ago. However, the process has rapidly grown into a cost-effective manufacturing solution for designs that are not viably produced via conventional forming technologies. At present, PIM is a reliable manufacturing process that offers a high degree of design flexibility in association with cost savings.

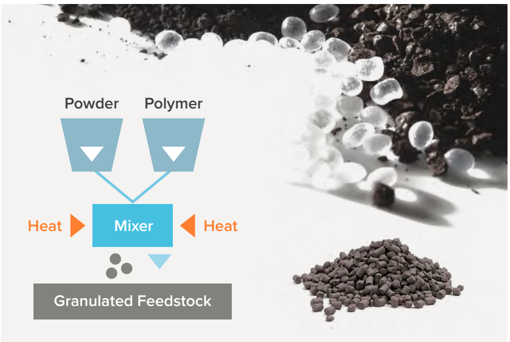
PIM excels in applications that require shape complexity and demanding final mechanical, magnetic, thermal, chemical, and electrical properties. Injection molded metals and ceramics offer finished properties not possible via plastics or light metal alloys.

Powder injection molding (PIM) uses thermoplastic binders in conjunction with metal or ceramic powders to form precision-engineered components.



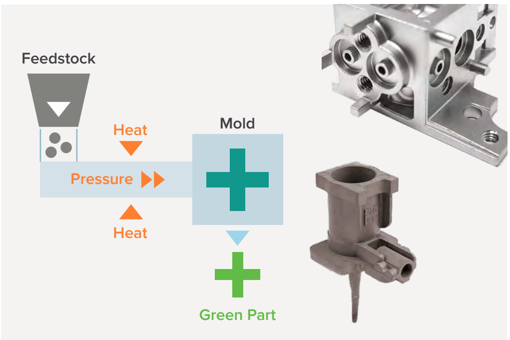
*MIM includes Tungsten Alloy and Super Alloy

The PIM Process



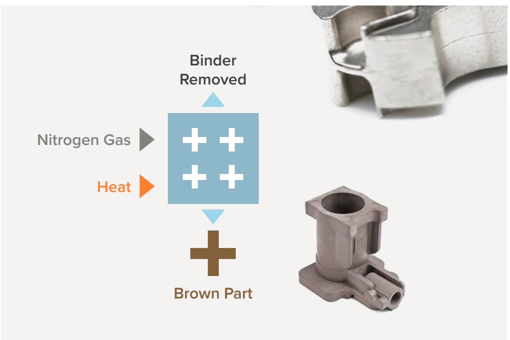
1 Mixing

Very fine metal or ceramic powder is mixed with a thermoplastic polymer (known as the binder) to form a homogeneous mixture of ingredients. The mixture or feedstock is made into granulated pellets and directly fed into the injection machine.



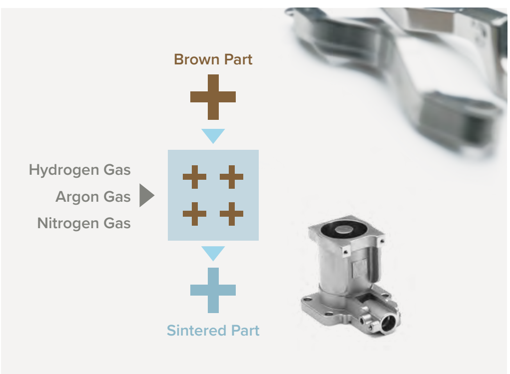
2 Injection

During molding, the feedstock is heated and injected into the cavity of the mold. This allows the desired shapes and geometries to be formed. The molded part is known as the green part.



3 Debinding

The polymeric binder is removed thermally via the debinding process. The green part is subjected to the debinding process at a temperature of about 500°C (932°F). While maintaining its relative size and shape, the debound or brown part consists of a powder skeleton that is brittle and porous.



4 Sintering

The final stage of the PIM process is sintering. During sintering, the brown part is heated to about 85% of the material's melting temperature. As sintering progresses, density increases, pores are eliminated and the part shrinks. A final sintered density that is about 98% of theoretical allows the near-net shape component to deliver handbook material properties.

The Advantages

Improved performance at compelling cost

- Attractive cost savings
- Wide latitude of part shapes and sizes (0.1g to 250g; 0.0035oz to 9oz)
- Thin wall capability of 0.3mm (0 .012in)
- Ability to combine functions and eliminate sub-assemblies
- Good dimensional control with general tolerances of ± 0.3%
- Net shape production minimizes or eliminates machining
- Wide range of materials and properties
- Cost efficient for annual production volume of >10k
- Suitable for intricate and complex geometries
- Design flexible
- Minimal or zero material wastage
- Good surface finish (Ra 0.8µm or 32µin)

Material Table

		Stainless Steels										Low Expansion Alloy
Common Designation		304L	316L	420L	430L	440C	440C-HT	17-4PH	17-4PH-HT	HK 30	Nitronic 50	Kovar
Standard		AISI 304L	AISI 316L	AISI 420L	AISI 430L	AISI 440C	AISI 440C-HT	AISI 630	AISI 630-HT	equivalent to AISI 310	XM-19	ASTM F-15
MPIF Standard / ASTM (B883)			MIM-316L	MIM-420-HT	MIM-430L		MIM-440-HT	MIM-17-4PH	MIM-17-4PH-HT			
DIN Standard		1.4301	1.4404	1.42021	1.4016	1.4125	1.4125-HT	1.4542	1.4542-HT		1.3964	1.3981
Typical Applications		Corrosion Resistance										
Nominal Composition	%C	0.03 Max	0.03 max	0.15 - 0.4	0.05 max	0.95 - 1.20	0.95 - 1.20	0.07 max	0.07 max	0.4 - 0.5	0.06 Max	0.05 max
	%Mo		2.0 - 3.0							0.10 max	1.5 - 3.0	
	%Si	1.0 max	1.0 max	1.0 Max	1.0 max	1.0 max	1.0 max	1.0 max	1.0 max	1.25 - 1.75		0.3 max
	%Cr	18.0 - 20.0	12.0 - 14.0	12.0 - 14.0	16.0 - 18.0	16.0 - 18.0	16.0 - 18.0	15.5 - 17.5	15.5 - 17 .5	23.0 - 27.0	20.5 - 23.5	0.5 max
	%Ni	9.0 - 13.0	10.0 - 14.0	0.6 Max		0.75	0.75	3.0 - 5.0	3.0 - 5.0	19.0 - 22.0	11.5 - 13.5	29.0 - 30.0
	%Cu							3 0 - 5 0	3.0 - 5.0			
	%Others		Mn 2.0 max		Mn 1.5 max			Nb+ Ta 0.15 - 0.45, Mn 1.0 max		Nb 1.2 - 1.5		Co 16.0 - 17.0
	%Fe	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal
Mechanical Properties (Typical)												
Ultimate Strength, 1000 psi (MPa)		65 (450)	75 (520)	180 (1240)	60 (415)	90 (620)	190 (1310)	130 (900)	172 (1185)	94 (650)	83 (570)	65 (450)
Yield Strength (0.2%). 1000 psi (MPa)		23 (160)	25 (175)	174 (1200)	35 (240)	59 (410)	170 (1170)	106 (730)	158 (1090)	36 (250)	55 (380)	44 (300)
Elongation, % [in 1 in (25 mm)]		25	50	<1	25	10	1	8	6	30	16	25
Hardness		<100 HRB	67 HRB	44 HRC	65 HRB	90 HRB	56 HRC	27 HRC	33 HRC	90 HRB	200 HRB	65HRB
Density, g/cm³		7.55	7.6	7.4	7.5	7.5	7.5	7.5	7.5	7.5	7.8	7.8
Thermal Properties (Typical)												
CTE µm/m, 20°C - 300°C												5.4 - 5.8

Material Table

		BASF Catamold						Ceramic		
Common Designation		316L	17-4PH	17-4PH-HT	SD2507	42CrMo4	8620-CH	Alumina	Zirconia	ZTA-25
Standard		AISI 316L	AISI 630	AISI 630	AISI F53	AISI 4140	AISI 8620-CH			
MPIF Standard / ASTM (B883)										
DIN Standard		1.4404	1.4542	1.4542	1.441	1.7225	1.6523			
Typical Applications		Corrosion Resistance				Structural Strength		Wear Resistance / Heat Insulation		
Nominal Composition	%C	0.03 max	0.07 max	0.07 max	0.03 Max	0.35 - 0.45	0.12 - 0.23			
	%Mo	2.0 - 3.0			3.0 - 5.0	0.15 - 0.30	0.15 - 0.25			
	%Si	1.0 max	1.0 max	1.0 max	0.2 - 0.6					
	%Cr	16.0 - 18.0	15.0 - 17.5	15.0 - 17.5	24.0 - 26.0	0.9 - 1.20	0.40 - 0.60			
	%Ni	10.0 - 14.0	3.0 - 5.0	3.0 - 5.0	6.0 - 8.0		0.40 - 0.70			
	%Cu		3.0 - 5.0	3.0 - 5.0	0.1 Max					
	%Others	Mn 2.0 max	Nb+ Ta 0.15 - 0.45, Mn 1.0 max					Al_2O_3	ZrO_2	Al_2O_3 - ZrO_2
	%Fe	Bal	Bal	Bal	Bal	Bal	Bal			
Mechanical Properties (Typical)										
Ultimate Strength, 1000 psi (MPa)		74 (510)	138 (950)	160 (1100)	109 (750)	94 (650)	160 (1100)			
Yield Strength (0.2%). 1000 psi (MPa)		26 (180)	104 (720)	138 (950)	73 (500)	51 (350)	145 (1000)			
Elongation, % [in 1 in (25 mm)]		50	6	5	20	11	1			
Hardness		67 HRB	32 HRC	38 HRC	200 HV	180 HV	580 HV	2000 (HV0.3)	1200 (HV0.3)	1800 (HV0.3)
4-Point Flexural Strength (MPa)								235	580	395
Density, g/cm^3		7.9	7.6	7.6	7.68	7.48	7.5	3.9	5.6	4.3

Material Table

		Low Alloy Steels							Soft Magnetic Alloy			
Common Designation		Fe-2Ni	Fe-2Ni-0.5C	Fe-2Ni-0.5C-HT	Fe-8Ni	100Cr6	100Cr6-HT	4140	Fe-3Si	Alloy 52	Permendur	Permalloy 80
Standard			AISI 4605	AISI 4605-HT		AISI 52100	AISI 52100-HT	AISI 4140-HT	Fe-3Si	Fe-50Ni	Fe-50Co-2V	
MPIF Standard / ASTM (B883)		MIM-2200	MIM-4605	MIM-4605-HT	MIM-2700			MIM-4140-HT	MIM-Fe-3%Si	MIM-Fe-50%Ni	MIM-Fe-50%Co	
DIN Standard						1.3505	1.3505	1.7225		1.3926		
Typical Applications		Structural Strength Applications							Soft Magnetic Properties			
Nominal Composition	%C	0.1 max	0.4 - 0.6	0.4 - 0.6	0.1 max	0.80 - 1.05	0.80 - 1.05	0.35 - 0.45	0.05 max	0.05 max	0.05 max	
	%Mo	0.5 max	0.2 - 0.5	0.2 - 0.5	0.5 max			0.15 - 0.30				3.5 - 4.2
	%Si	1.0 max	1.0 max	1.0 max	1.0 max				2.5 - 3.5	1.0 max	1.0 max	
	%Cr					1.35 - 1.65	1.35 - 1.65	0.9 - 1.20				
	%Ni	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5	6.5 - 8.5					49.0 - 51.0		79.0 - 81.0
	%Cu										Co 48.0 - 50.0	
	%Others										V 2.5 max	
	%Fe	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal	Bal
Mechanical Properties (Typical)												
Ultimate Strength, 1000 psi (MPa)		42 (290)	60 (415)	239 (1650)	60 (415)	131 (900)	-	200 (1380)	77 (530)	66 (455)	30 (205)	79 (545)
Yield Strength (0.2%). 1000 psi (MPa)		18 (125)	30 (205)	215 (1480)	30 (205)	73 (500)	-	155 (1070)	57 (390)	23 (160)	20 (140)	39 (270)
Elongation, % [in 1 in (25 mm)]		40	15	2	26	5	-	3	20	30	< 1.0	25
Hardness		45 HRB	62 HRB	48 HRC	69 HRB	230-290 HV	700 HV	46 HRC	80 HRB	50 HRB	80 HRB	70 HRB
Density, g/cm^3		7.6	7.5	7.5	7.6	7.5	7.5	7.5	7.4	7.7	7.7	7.8
**Magnetic Properties (Typical)												
Max permeability, µ max		2300							6000	27000	5200	77000
He, Oe (A/m)		1.5 (120)							1.0 (80)	0.2 (16)	1.5 (120)	0.1 (8)
Br, kG (T)		8 (0.8)							12 (1.2)	10 (1.0)	14 (1.4)	4.8 (0.48)
B at 1,990 kG (T)		14.5 (1.45)							14.5 (1.45)	14 (1.4)	20 (2)	6.5 (0.65)
B at 39,780 kG (T)		20 (2)							19 (1.9)	15 (1.5)	22 (2.2)	7 (0.7)

**Reference from: MPIF Standard

Material Table

		Conductive Material						Heavy Alloy			Super Alloy		
Common Designation		Copper	50W50Cu	60W40Cu	70W30Cu	80W20Cu	90W10Cu	90W-Fe-Ni	92W-Fe-Ni	95W-Fe-Ni	Inconel 713C	Nimonic 90	F75
Standard								90W-Fe-Ni	92W-Fe-Ni	95W-Fe-Ni	AMS 5391	AMS 5829	ASTM F75
MPIF Standard / ASTM (B883)													
DIN Standard											2.4671	2.4632	
Typical Applications		Heat Dissipation						High Density / Low Thermal Expansion Coefficient			High Temperature Strength		High Temperature Strength + Biocompatibility
Nominal Composition	%C							0.1 max	0.1 max	0.1 max	0.03 Max	0.13 max	0.35 max
	%Mo										3.70 - 4.70		5.0 - 7.0
	%Si											1.0 max	1.0 max
	%Cr										11.50 - 13.50	18.0 - 21.0	27.0 - 30.0
	%Ni							7.5 max	5.0 max	3.0 max	Bal	Bal	1.0 max
	%Cu	99 min	50	40	30	20	10						
	%Others		50	60	70	80	90	W 90.0	W 92.0	W 95.0	Al 5.40 - 6.80, Ti 0.40 - 1.20, Nb 1.70 - 2.30	Co 15 - 21, Ti 2 - 3, Mn 1 max, Al 1 - 2	Co Bal
	%Fe							4.0 max	5.0 max	3.0 max	2.50 Max	1.5 max	0.75 max
Mechanical Properties (Typical)													
Ultimate Strength, 1000 psi (MPa)											110 (758)	160 (1100)	99 (680)
Yield Strength (0.2%). 1000 psi (MPa)											100 (689)	102 (705)	80 (550)
Elongation, % [in 1 in (25 mm)]											3	19	4
Hardness											100 HRB	28 HRC	25 HRC
Density, g/cm^3		8.7	11.9	12.9	14.1	14.6	15.4	17	17.2	17.7	7.8	8.1	8.8
Thermal Properties (Typical)													
CTE µm/m, 25°C - 400°C		16.5	15.1	14.1	11.5	10.3	8.1						
Thermal Conductivity (W/mK, 25°C)		320	230	220	180	135	95						

- Actual property values depend on product specifications, including density, microstructure, purity, and processing, which in turn vary with specific components.
- Materials are not restricted to those mentioned above. Please contact us for more details.
- HT denotes heat treatment

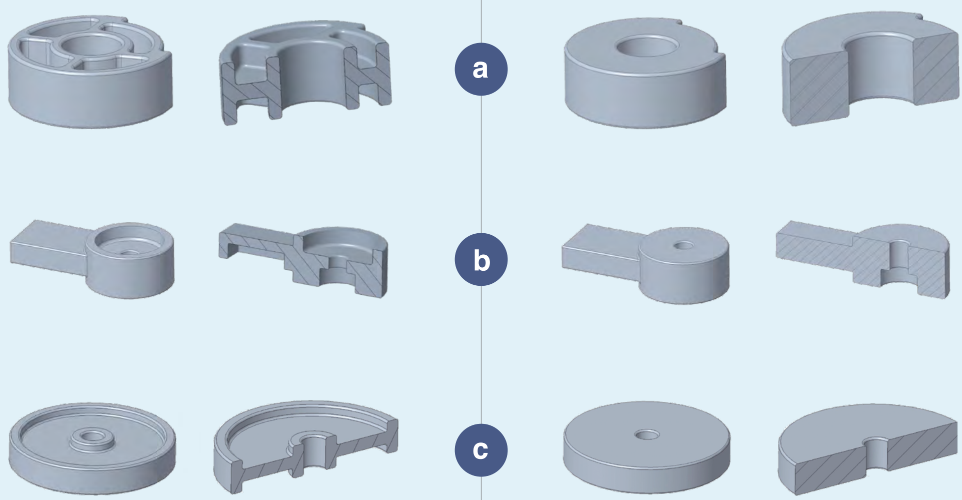
Design Guidelines

It is important to consider the following guidelines when designing parts for the PIM process. By adhering to these simple design guidelines, designers can take advantage of the PIM process and subsequently reduce manufacturing costs.

1. Coring and Holes

Avoid material concentrations. Provide coring and holes to allow weight reduction and structural improvements as illustrated in diagrams (a) to (c).

Preferred | **Not Recommended**



2. Uniform Wall Thickness

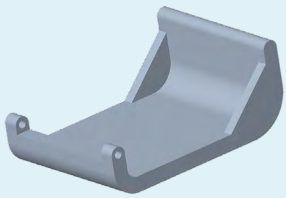
Maintain the uniform wall thickness as much as possible. At those cross-section, a minimum thickness of 0.3mm is recommended.
Avoid abrupt changes in wall thickness which may result in distortions, voids and stress concentrations.

Preferred | **Not Recommended**

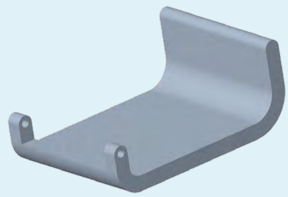
3. Cantilevered Section

Design ribs across the cantilevered section to prevent slumping during sintering. Otherwise, subsequent straightening operations will be required and may add cost.

Preferred

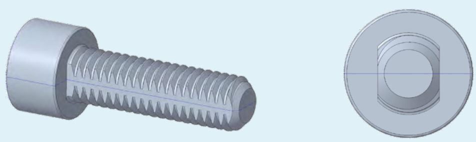


Not Recommended



4. Flats on Threads

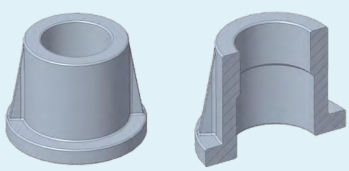
Molded parts may form flash along the parting line that can damage the thread accuracy. To eliminate such problems, design flats on external threads along the parting line surfaces.



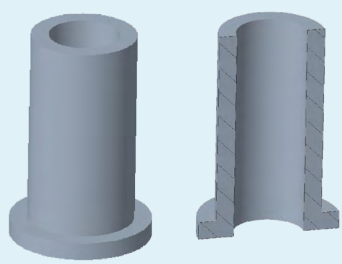
5. Aspect Ratio

Components with an aspect ratio of less than 2 are recommended. Higher aspect ratio designs can be molded by incorporating ribs to strengthen the structure and thereby preventing distortion.

Preferred



Not Recommended



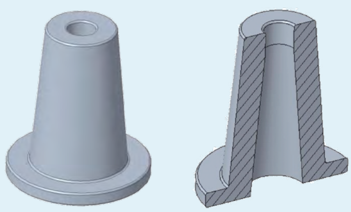
6. DFM Recommendation

Design for Manufacturing (DFM), is an engineering approach that optimizes product designs to be easily, cost-effectively, and reliably manufactured at scale.

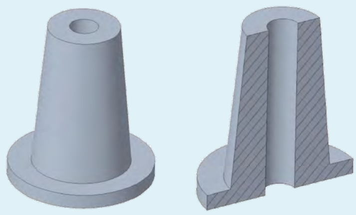
i. Draft Angle

Internal holes should be designed with tapers to enable efficient injection molding.

Preferred



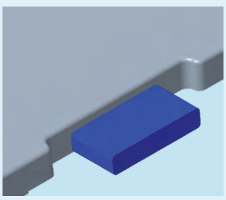
Not Recommended



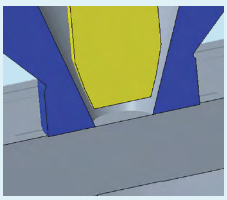
ii. Parting Lines

When assigning tolerances, give consideration to parting lines, gate locations, moving cores and slides, wall thickness variations, etc. For example, a gate will leave a mark on the finished part. Therefore, it is advisable to avoid placing the gate on a critical surface and there will be parting line mismatch of 0.001 inches.

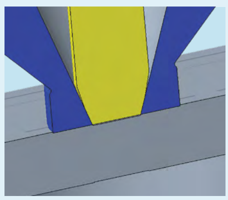
iii. Preferred Gate Types



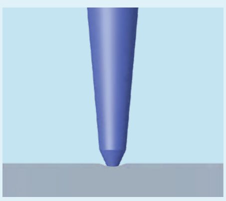
Side Gate



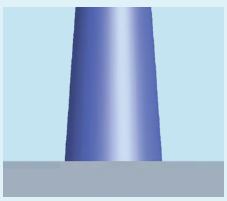
Hot Valve Gate – Opened



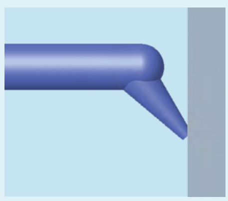
Hot Valve Gate – Closed



Pin Point Gate



Direct Sprue Gate



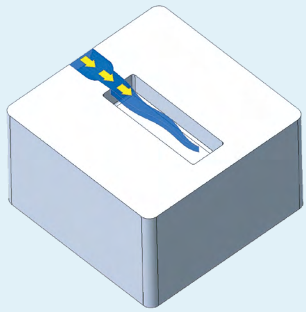
Tunnel Gate

iv. Material Flow

Avoid designing elongated features parallel to the gating direction in area where the material first enters the cavity during the injection molding cycle. Changing the direction of flow upon exit from the gate into the cavity eliminates jetting and insures laminar flow. Thus, optimal mold filling can be achieved.

Preferred

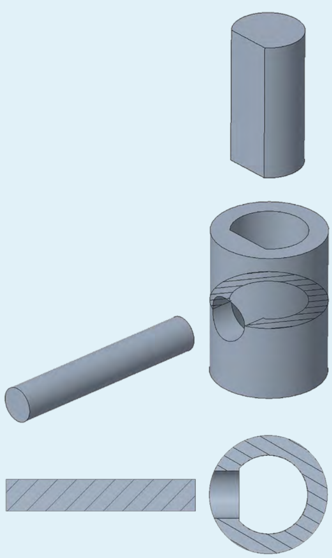
Not Recommended



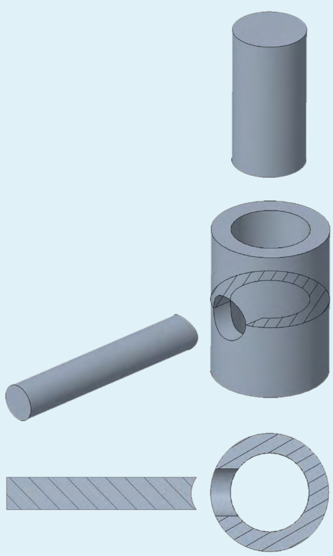
v. Intersections of Perpendicular Holes

Holes are incorporated into PIM components through the use of shaft (or pin) elements in the injection molding tool. The intersection of two holes becomes difficult because of the possibility of misalignment of the two shafts (or pins) creating the holes during injection. This can be alleviated by making one of the intersecting holes a D-shape.

Preferred

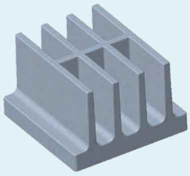


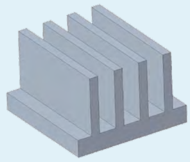
Not Recommended



vi. Sharp Edges

Cracks are easily formed at the intersection of sharp edges due to stress concentrations. Rounded corners and rounded intersecting surfaces are preferred.



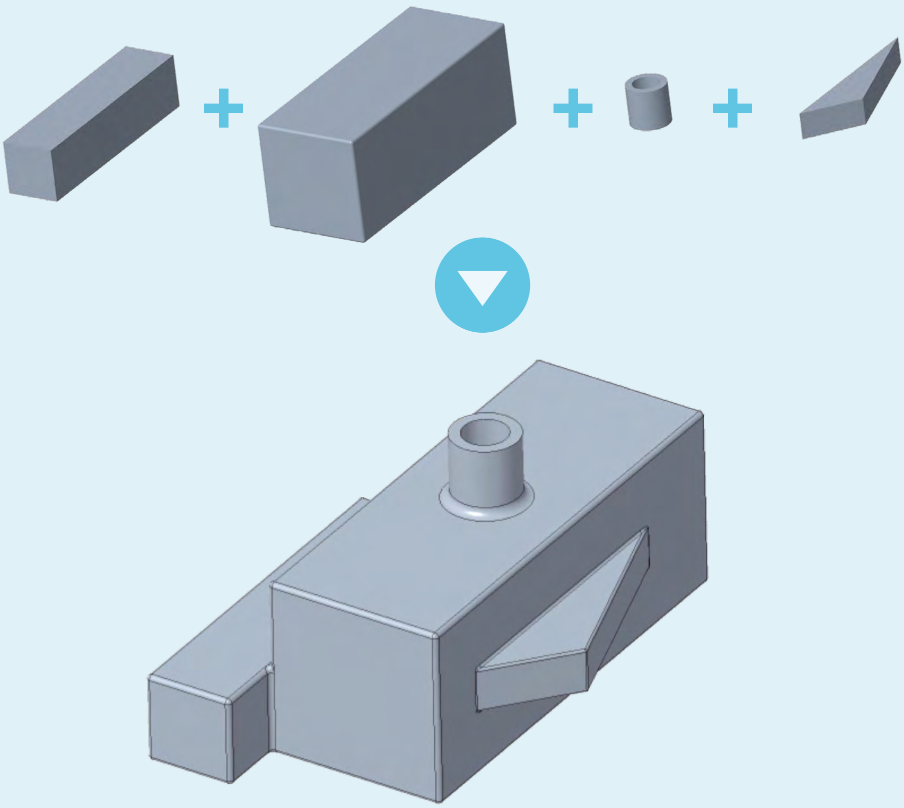


7. Part Size Recommendation

It is advisable to incorporate features that control the weight of the final PIM part to less than 250g (8.82oz). This can be done through holes, cores and other weight reduction methods.

8. Integration

The figure below shows the combination of parts for multi-functional applications. Such considerations contribute substantially towards cost reduction.



Additional Tips on PIM Design

Although complex geometries can be fabricated via PIM, only certain component characteristics prove to be both technically and economically viable.

- **Complexity**
  Components that require multiple axes for indexing and machining are most suitable for PIM process.

- **Integration**
  Integrating several components into a single part enhance performance and reduce cost.

- **Quantity**
  PIM is more ideal and cost effective for higher production volumes of >10,000 pieces per year.

- **Material**
  the PIM process is most applicable to materials that are difficult to machine, materials with multiphase microstructures, or high work hardening materials.

- **Material Wastage**
  As no secondary operation is usually required, the PIM process will have minimal or zero material wastage. The ability to regrind the feedstock also further minimize material wastage during injection.

- **Cost Saving in Raw Material**
  With metal powder as a raw material to mold all sizes of parts unlike machining where different sizes of bar stock needed for different part size, this allow significant cost saving on material inventory and the risk of obsolescence.

- **Tolerances**
  PIM process is able to achieve ± 0.3% of its dimension. If tighter tolerance is required, our team of engineers will help to incorporate the necessary secondary operations.

- **Performance**
  PIM process is able to achieve a better performance as compared to press-and-sinter (Powder Metallurgy) process.

- **Surface Finish**
  PIM can achieve a high quality surface finish (Ra 0.8µm or 32µin).

Geometry & Tooling Considerations

Depending on the geometry, size and production quantity of the component, a tool can have between 1 and 8 cavities. AMT guarantees tool life to 500,000 shots and offers a number of flexible tooling options to meet the customer's individual needs.

Include

- Plastic molding design rules
- Cores, holes and indents
- Draft or taper
- Room for ejector pins and gating
- Uniform cross-sections if possible
- Flat surfaces

Avoid

- Sharp fillets and edges if possible
- Placement of parting lines and weld lines in functional locations
- Dimensional tolerances tighter than ±0.3% (more precise tolerances are costly)

Dimensional Tolerance

Dimension		Percentage Tolerance	Unit Tolerance	
mm	inch	%	mm	inch
<1.20	<0.047	± 2.1	± 0.025	± 0.001
1.20 - 2.50	0.047 - 0.098	± 1.6	± 0.040	± 0.002
2.51 - 6.50	0.099 - 0.256	± 0.8	± 0.050	± 0.002
6.51 - 12.50	0.256 - 0.492	± 0.5	± 0.065	± 0.003
12.51 - 25.00	0.493 - 0.984	± 0.3	± 0.075	± 0.003
25.01 - 50.00	0.985 - 1.969	± 0.3	± 0.125	± 0.005
50.01 - 75.00	1.969 - 2.953	± 0.3	± 0.230	± 0.009

Dual Bore Capillary Rheometer

In-house Characterization and Analytical Capability

With the strong belief of wanting to deliver greater value to our customers, AMT has invested significantly in the Analytical Equipment to support R&D to stay ahead of the technology. AMT's continuous effort in innovating with new materials and processes has garnered numerous recognition worldwide.

- Mastersizer Particle Analyser
- Dual Bore Capillary Rheometer
- Specimen Grinder and Polisher – for porosity analysis to determine grain growth and density
- LED Microscope (up to 100x)
- Mold Flow Simulation
- X-ray Fluorescence (XRF) Chemical Analyzer
- Laser Marking
- Zeiss Scanning Optical System

LED Microscope

Quality Management System

AMT is certified to the following QMS:

- **ISO 9001**
  Customer-focused quality management and continual improvement.
- **ISO 13485**
  Compliance with medical device quality and regulatory requirements.
- **ISO 14001**
  Environmental management and sustainability compliance.
- **IATF 16949**
  Quality standards for automotive design and production


DNV
MANAGEMENT SYSTEM
CERTIFICATE

ISO 9001 Cert


DNV
MANAGEMENT SYSTEM
CERTIFICATE

ISO 13485 Cert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MANAGEMENT SYSTEM
CERTIFICATE

ISO 14001 Cert


DNV
MANAGEMENT SYSTEM
CERTIFICATE

IATF 16949 Cert

In-house Zeiss multisensor measuring machines

AMT adheres to the best practice in order to consistently deliver quality parts:

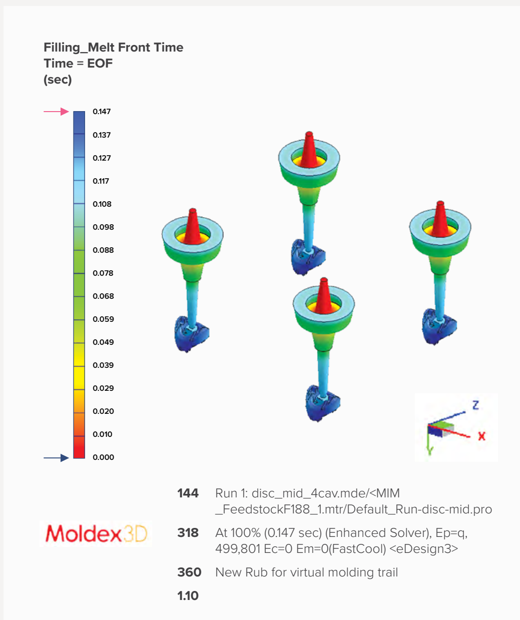
- The entire manufacturing process is subjected to stringent scrutiny to conform to international standards such as RoHS and REACH compliance, and specific customer requirements.
- We are equipped with various testing & measuring capabilities to enable continuous monitoring of dimensional data and statistics in the manufacturing process such as APQP, PPAP, FMEA, SPC and MSA.
- Together with our customer in the medical industry, we develop protocol and carry out the IQ, OQ and PQ Validation.

One-stop Solutions

At AMT, we understand our partners' frustration in managing multiple vendors. As your strategic manufacturing partner, AMT provides 1-stop solutions to all our customers in:

- Design For Manufacturability (DFM) Concept
- Mold Flow Simulation Study
- Prototyping (3D Metal Printing / Additive Manufacturing) Services
- Validation and Qualification Protocol
- In-house CNC Machining Capability
  - CNC Milling
  - CNC TurnMil
  - CNC Tapping
  - Surface Grinding
  - Cylindrical Grinding
  - CNC Honing
  - CNC HardTurn
- Customized Testing and Inspection
- Manage reliable local and overseas vendors with areas of expertise in:
  - CNC Machining - grinding, turning lapping, etc
  - Heat treatment - H900 profile, case hardening, full hardening, etc
  - Plating which - EN, nickel, gold, silver, etc
  - Finishing - passivation, electro-polishing, glass beading, sand blasting, etc
- Providing assembly services in white room or clean room
- Using automation and robotic systems to improve production efficiency

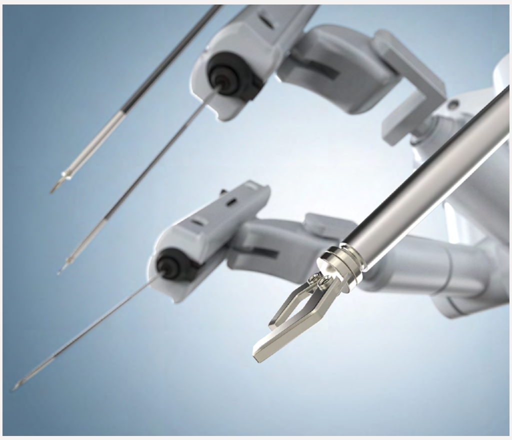
In-house CNC Milling



Mold Flow Simulation for 4-cavity Mold

Case Studies of Innovative Applications

Endoscopic Electrodes and Insulators



Robotic Assisted Surgery

Medical Applications

AMT has an innovative and creative MIM process to mass produce components for medical application; including robotic assist surgery, MIS endoscopy, surgical power tools and life science systems. Parts like jaws, clamps, graspers, staplers, needle holders, etc, typically have very complex geometries and shapes. Using the MIM manufacturing technology not only reduces manufacturing cost significantly as compared to full machining, it also allows these parts to be produced in large volumes (over 200,000 pieces per month).

WCuMIM® - Tungsten-Copper MIM

AMT has the capability to alloy tungsten and copper to capitalize and optimize the characteristics of the 2 materials. With this composite, we are able to achieve the following:

Thermal Conductivity

W80Cu20 : 200 W/mK

W85Cu15 : 190 W/mK

Coefficient of Thermal Expansion

W80Cu20 : 8.9 10^{-6} /K

W85Cu15 : 8.0 10^{-6} /K

Complex Inter-Connecting Channels

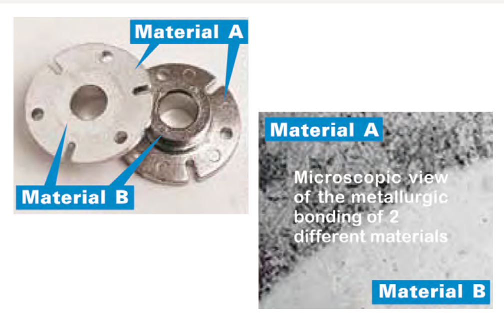
The MIM technology is ideal for the mass production of component such as this EPR Flow Block used in Gas Chromatography (GC) Systems. This is a highly complex part; with multiple through holes and inter-connecting right-angled internal channels. AMT was awarded the MPIF Grand Prize in 2018 for this innovation.

Ceramic Injection Molding (CIM)

AMT is able to utilize the Ceramic Injection Molding (CIM) process to mass produce ceramic components with complex geometries and thin wall thickness. These parts are used in Medical Endoscopy devices. The type of ceramic materials used included Zirconia, Alumina or Zirconia Toughened Alumina (ZTA).

Integration

Four individual components were integrated into a one-piece MIM component. Such a design modification resulted in better performance at reduced costs. This particular part was awarded the MIM Grand Prize by the MPIF in 2000.



Bi-Material Component

Through this innovation, AMT is able to co-inject two different materials to form an integrated two-materials component; hard & soft metal or magnetic & non-magnetic metal materials. By co-injecting the 2 materials together, interlocking features can be incorporated into the part, thus eliminating costly assembly operations. The product's performance can potentially be enhanced as the two materials are manufactured as a single component.

Integration

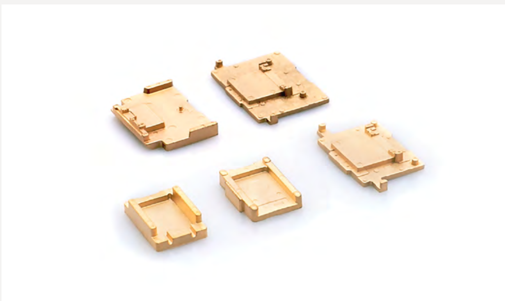
The new one-piece Mechanical Connector that incorporates the Body Base and Center shaft as an integral MIM component. With this mechanical connector that we developed for Emerson Process Management clinched the 2003 EPMA Award for "International Powder Metallurgy Components".

Thin Wall Capability

Using innovative solution, AMT is able to mass produce these complex geometry components with very thin wall thickness. With thin wall thickness of less than 0.7 mm (0.027 in), AMT has to control the distortion, shape retention, material integrity and all the dimensions during the MIM process. Our ability to mass-produce these parts won us the Year 2002 Award of Distinction by MPIF.

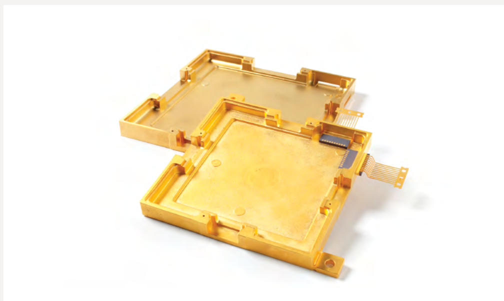
In-Coring®

AMT has developed and registered the patent to manufacture metal or ceramic parts with undercut features and internal channels using powder injection molding. This process, trademarked as In-Coring, allows flexible designs that reduce cost and increase productivity.



CuMIM® - Copper MIM

AMT owns the CuMIM® for the application of pure copper using the MIM technology. Utilizing the MIM technology, engineers can design unconventional copper heat sink with complex geometry. This allows the electronic component to be mounted while being used for heat dissipation. To date, AMT had delivered more than 5 million copper parts globally for use in this application.



High Aspect Ratio & High Precision

This 105mm (4.14in) by 105mm (4.14in) by 1.5mm (0.06in) fiber optic connector is made of Kovar. This component defied conventional MIM aspect ratio and size to meet specific dimension and hermetic requirement. This particular part was awarded the Year 2003 Award of Distinction by MPIF.

Design Handbook

Your Strategic Partner
in Manufacturing Innovation

- ISO 9001
- ISO 13485
- ISO 14001
- IATF 16949

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