Metal Injection Moulding (MIM)

Powder Injection Moulding

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MIM-Expert Group

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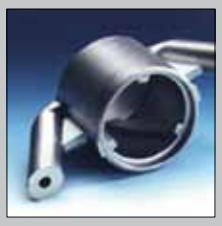
MIM = Metal Injection Moulding

Serial production of high strength precision components by injection moulding of metal powder offers possibilities and advantages which cannot be achieved with alternative manufacturing processes such as hot pressing, precision casting and machining except maybe with considerable efforts.

MIM = Quality plus Cost Effectiveness

- fabrication of small components



- free forming of highly complex geometries (3D)

- cost-effective production, usually even in small series

- no need for post treatment in most cases

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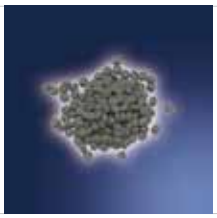
MIM = Fabrication in Just Four Steps

Metal powder of a defined composition is mixed with a thermoplastic binder and granulated to form a feedstock. Similar to plastics, this feedstock is injected into a mould. The binder is then removed from the green part and the powder-metal skeleton is sintered to a dense component at temperatures between 1200°C and 1400°C. The sintered part can generally be used directly. Alternatively, all conventional post treatments can be applied to the material in question.
The shrinkage occurring during sintering is allowed for in the design of the mould as an oversizing factor.

Feedstock Compounding



Granulate

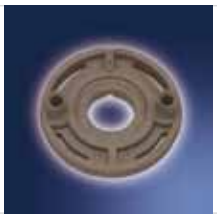
1

Granulate » **Injection moulding**

Green part

2

Green part » **Debinding**



Brown part

3

Brown part » **Sintering**

Sintered part

4

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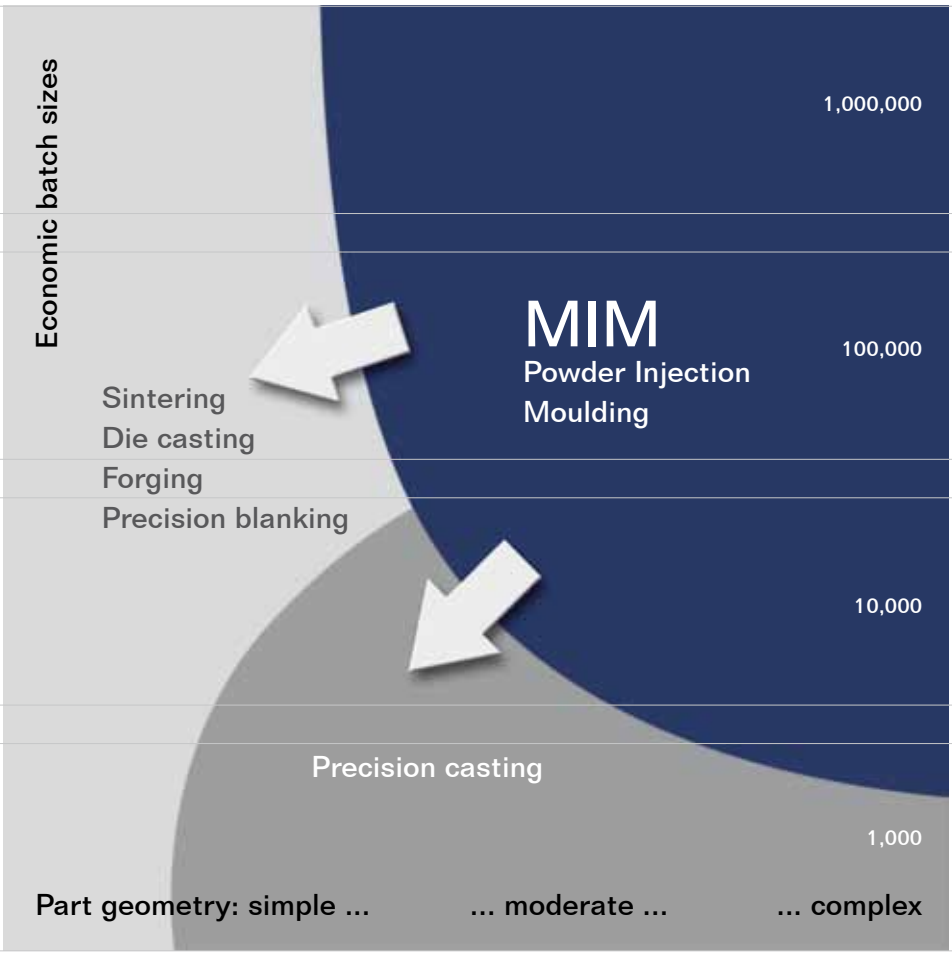
Process Definition

Metal Injection Moulding

MIM = Max. No. of Parts / Min. Postprocessing

The MIM process is especially suitable for components with complex geometries in large quantities since the process can be fully automated. Precision casting is also suitable for complex geometries, but results in higher tolerances. Due to the high manual effort required, it makes more sense economically for smaller production quantities. Other powder metallurgical production processes such as uniaxial pressing are also appropriate for large production quantities but only less complex geometries can be achieved by these processes.



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MIM = Tight Tolerances

MIM components should be designed with dimensions of 5 mm to 100 mm, wall thicknesses of less than 25 mm, preferably between 1 mm and 10 mm, and weights of between 1 g and 100 g. These are typical values which can possibly be adapted to your needs in discussion with the MIM company. The MIM industry is interested in assisting as early as in the stage of component engineering for achieving a suitable component design for the MIM process.

Nominal dimension [mm]	Tolerance [+/- mm]	Tolerance for	Precision
< 3	0.05		
3 - 6	0.06	Straightness, flatness and parallelism	0.5 % of the longest dimension
6 - 15	0.075		
15 - 30	0.15		
30 - 60	0.25		
> 60	+/-0.5% of nominal size	Angle	+/- 0° 30‘

Examples of

Flat-line buccal tube (Medical / dental)
Nickel-free stainless steel 1.4456
Weight 0.11 g

Hydraulic connector (Automotive)
Stainless steel 316 L
Weight 2.25 g

Port system for catheter (Medical)
TiAl6V4
Weight 6.33 g

Drive gear for sunroof (Automotive)
Steel 1.6546, coatet
Weight 93.6 g

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MIM = Materials for the Most Exacting Demands

Overview of some materials processed by MIM today

Material	C	Cr	Ni	Mn	Mo	Si	Fe
MIM Fe2Ni	≤ 0.1		1.5-2.5		≤ 0.5		Remainder
MIM-Fe2Ni0,6	0.4-0.7		1.5-2.5		≤ 0.5		Remainder
MIM-FeNi7	≤ 0.1		6.9-7.1				Remainder
MIM-Fe8Ni	≤ 0.1		6.5-8.5		≤ 0.5		Remainder
MIM-Fe8Ni0,6C	0.4-0.7		6.5-8.5	≤ 0.5			Remainder
MIM-FeCuNi			4.5-5.6				Remainder
MIM-4140 MIM-42CrMo4	0.35-0.5	0.9-1.2		< 0.9	0.15-0.3	< 0.4	Remainder
MIM-4340 MIM-40NiCrMo6	0.35-0.5	< 0.35	1.4-2.0	< 0.8	0.2-0.3	< 0.35	Remainder
MIM-4605	0.4-0.6		1.5-2.5		0.2-0.5	< 1	Remainder
MIM-8620 MIM-21NiCrMo2	0.12-0.23	0.4-0.6	0.4-0.7		0.15-0.25		Remainder
MIM-16MnCr5	0.14-0.19	0.8-1.1		1.0-1.3		< 0.4	Remainder
MIM-100Cr6	0.8-1.05	1.35-1.65					Remainder
MIM-420 MIM-X20Cr13	0.18-0.3	12.0-14		< 1		< 1	Remainder
MIM-4408 MIM-X90CrMoV18	0.75-0.95	16.0-18.0		< 1	< 0.75	< 1	Remainder
MIM-430 MIM-X6Cr17	< 0.08	15.5-17.5		< 1		< 1	Remainder
MIM-316L MIM-X2CrNiMo17132	≤ 0.03	16.0-18.5	10.0-14.0	≤ 2	2.0-3.0	≤ 1	Remainder
MIM-310 MIM-X40CrNiSi2520	0.2-0.5	24.0-25.0	19.0-22.0	< 1.5		0.75-1.75	Remainder
MIM-17-4PH MIM-X3CrNiCuNb174	< 0.07	15-17.5	3.0-5.0	< 1		< 1	Remainder
MIM-FeSi3	≤ 0.1					2.5-3	Remainder
MIM-Fe50Ni	< 0.1		49.5-50.5				Remainder
MIM-Ti	< 0.2						
MIM-M2 MIM-SC6-5-2	0.95-1.05	3.8-4.5			4.5-5.5		Remainder
MIM-F15			28.5-29.5				Remainder
MIM-HX	0.05-0.15	20.5-23.0	Remainder	< 1	8.0-10.0	< 1	17.0- 20.0
MIM-N90 MIM-Nimonic 90	< 0.13	18.0-21.0	Remainder	< 1		< 1	< 1.5
MIM-WNiFe			3.5-4.5				2.3-3.5
MIM-WCu10							
MIM-WCCo6							
MIM-WCCo10							
MIM-Cu							
MIM-CuNi			3.0-30.0				
MIM-CuNiH			14.0-16.0				4.3-6.1
MIM-CuFe			2.0-3.5				6.5-8.5
MIM-Titanium, cp2	< 0.08						
MIM-Titanium, cp4	< 0.08						
MIM-Ti6Al4V	< 0.08						
MIM-Ti6Al4V	< 0.08						
MIM-Ti6Al7Nb	< 0.08						

Table of Materials

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				Mechanical Properties		
Others	Equivalent to			UTS, MPa	YS, MPa	E %
	M-Fe2Ni-110	nickel-alloy steel	as sintered	> 260	>150	> 20
	M-Fe2NiC-205	nickel-alloy steel	30 HRC 55 HRC	> 800 > 1200	> 700 > 1000	> 5 > 2
		nickel-alloy steel	as sintered	> 410	> 280	> 20
	N-Fe8Ni-210	nickel-alloy steel	as sintered	> 380	> 210	> 20
	M-Fe8Ni-300 M-Fe8Ni-500	nickel-alloy steel	30 HRC 50 HRC	> 800 > 1300	> 700 > 1100	> 5 > 2
Cu 4.0-5.0		copper-alloy steel	as sintered	> 600	> 450	> 3
	DIN 1.7225 M-4140-400	tempering steel	as sinterec 25 HRC 50 HRC	> 700 > 750 > 1300	> 400 > 600 > 1200	3 3 2
	DIN 1.6944 M-4340-500	tempering steel	as sinterec 25 HRC 48 HRC	> 800 > 900 > 1600	> 650 > 750 > 1400	8 3 2
		tempering steel	as sinterec 40 HRC 55 HRC	> 600 > 1300 > 1900	> 400 > 1100 > 1900	> 5 > 5 > 2
	DIN 1.6523	case-hardening steel	as sintered	> 650	> 400	> 3
	DIN 1.7131	case-hardening steel	as sintered	> 550	> 400	> 3
	DIN 1.3505 M-52100-450 M-52100-630	ball-and-roller bearing steel	as sintered	> 900	> 500	> 5
	DIN 1.4021 M-420-1000H	stainless steel	48 HRC	> 1600	> 1300	> 2
	DIN 1.4112	stainless steel	> 55 HRC			
	DIN 1.4016 M-430-210	stainless steel	as sintered	> 350	> 200	> 30
	DIN 4404 M-316L-140	austenitic stainless steel	as sintered	> 450	> 140	> 40
Nb 1.2-1.5	DIN 1.4848	stainless steel	as sintered	> 800	> 450	> 16
Cu. Nb. Ta Nb+Ta: 0.15-0.45	DIN 1.4542 M-174PH-650	stainless steel	as sinterec 30 HRC 40 HRC	> 800 > 850 > 1200	> 660 > 700 > 1000	3 5 2
	DIN 1.0844 M-Fe3Si-55 M-Fe3Si-80	soft magnetic material	as sintered	> 500	> 300	> 20
	DIN 1.3926 M-Fe50Ni-200 M-Fe50Ni-400	soft magnetic material	as sintered	> 400	> 150	> 20
O2 < 0.4 N2 < 0.1	DIN 3.7056 M-Ti-400	MIM-titanium	as sintered	> 550	> 480	> 5
W 5.5-6.75 V 1.75-2.2	DIN 1.3342	wear-resistant steel	as sintered (50 HRC)	> 1200	> 800	> 1
Co 16.5-17.5		Fe-Ni-Co alloy	as sintered	> 450	> 300	> 24
Co 0.5-2.1 W 0.2-1.0	DIN 2.4665	superalloy	as sintered (solution annealed)	> 610	> 280	> 35
Co 15.0-21.0 Al 1.0-2.0 Ti 3.0-4.0	DIN 2.4632	superalloy	as HiPed	> 1270	> 790	> 33
W bal.		heavy metal				
W bal. Cu 9.5-10.5		heavy metal				
WC bal. Co 5.5-6.5		hard metal	as sintered 1900 HV 30	Bending compressive strength > 3100"		
WC bal. Co 9.5-10.5		hard metal				
Cu bal.		copper	as sintered	> 150		> 30
Cu bal.		copper alloy	as sintered	> 280		> 10
Cu bal.		copper alloy	as sintered	> 490		> 5
Cu bal.		copper alloy	as sintered	> 375		> 7
O2 < 0.25 N2 < 0.03	ASTM B348 ASTM F67	MIM-titanium	as sintered	> 440	> 350	> 22
O2 < 0.25 N2 < 0.03	ASTM B348 ASTM F67	MIM-titanium	as sintered	> 510	> 430	> 15
O2 < 0.25 N2 < 0.05	ASTM B348 ASTM F1472 M-Ti6Al4V-600	MIM-titanium	as sintered	> 850	> 750	> 12
"O2 < 0.25 N2 < 0.05"	"ASTM B348 ASTM F1472"	MIM-titanium	as densified	> 930	> 860	> 12
"O2 < 0.25 N2 < 0.05"	ASTM F1295	MIM-titanium		> 760	> 660	> 13

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MIM = Network of Experts

The MIM Expert Group is a specialist working committee of the Gemeinschaftsausschusses Pulvermetallurgie (Germany).

The parent associations are the Fachverband Pulvermetallurgie (FPM), Verein Deutscher Ingenieure (VDI), Deutsche Gesellschaft für Materialkunde (DGM), Deutsche Keramische Gesellschaft (DKG) and Verein Deutscher Eisenhüttenleute (VdEH).

The members of the group are industrial partners and research institutes. Manufacturers of MIM parts cooperate closely with partners from the fields of metal powder and feedstock supply, producers of injection moulding machines and furnaces for heat treatment as well as with research institutes.

At the moment, more than 35 members are organized in the MIM Expert Group, which meets twice a year. The Group's work concentrates exclusively on metal injection moulding (MIM).

Our major tasks are:

- Dissemination of the MIM technology (Technology Marketing)
- Further development of the MIM technology (Technology Development)
- Coordination of activities with other associations such as EuroMIM, the Metal Injection Molding Association (MIMA) and the Japan Powder Metallurgy Association (JPMA). (Networking)

Contact

Interested companies are encouraged to join us.
Applications for membership should be addressed to:

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