MIM

METAL INJECTION MOULDING
MATERIALS & TECHNOLOGY

POWDER METALLURGY

MIM CENTER OF EXCELLENCE
BAD LANGENSALZA

CONTACT US

ABOUT US

- Total plant area: 25.734 m^2
- Production space: 5.155 m^2
- Sinter conditions (atmosphere): 100% Nitrogen; 100% Hydrogen
- Certificates: IATF 16949, ISO 14001, OHSAS 18001, ISO 50001
- Expert for highly complex and precise MIM components in large volumes

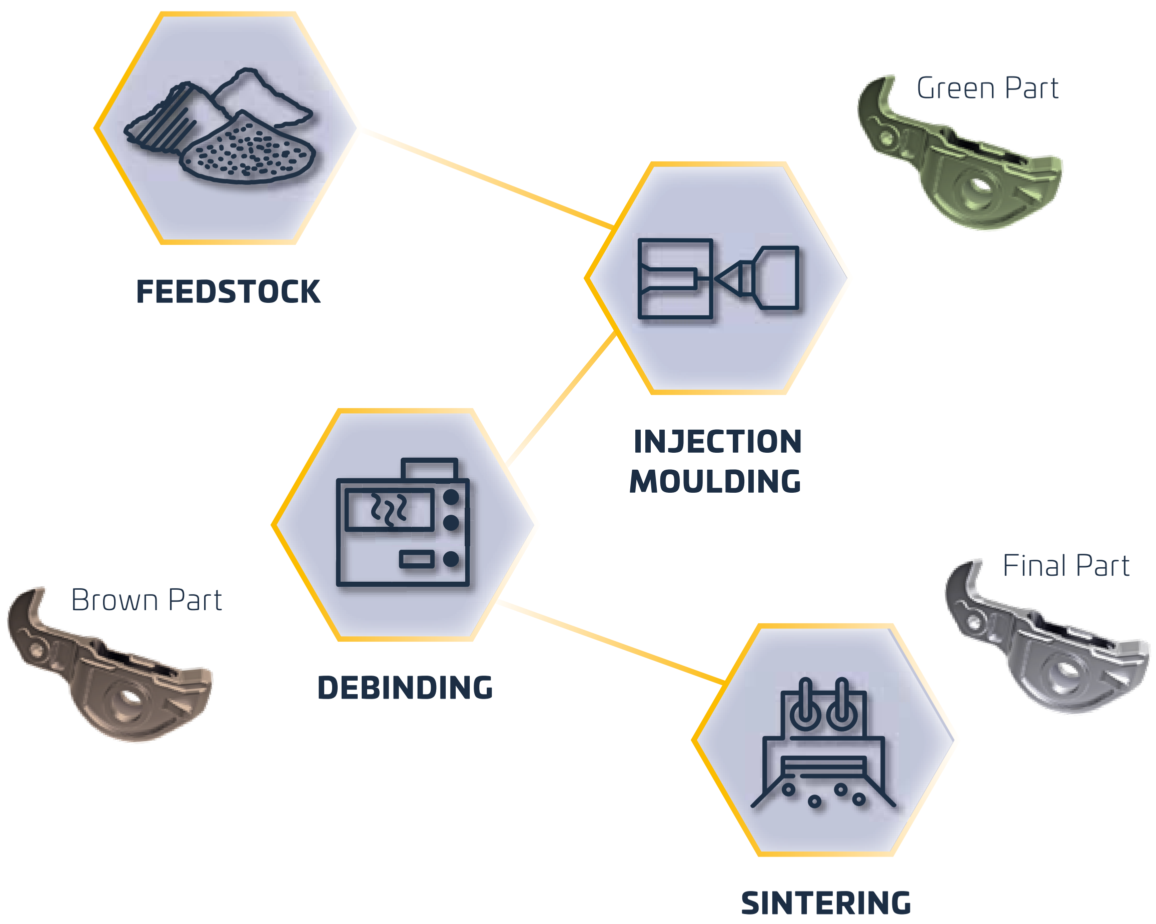
THE BENEFITS OF MIM

- High level of design freedom
- Cost efficient and fully scalable
- Superior quality
- Robust local supply chain
- Unique in-house know-how
- Wide range of materials

MIM TECHNOLOGY

Innovative components for solving technical challenges often require a complex design and outstanding material properties. This is why their implementation often fails due to excessive manufacturing costs.

With the design freedom of MIM (Metal Injection Moulding) technology, engineers and designers have a universal tool to give free rein to their creativity while also adhering to tight tolerances. Applications that were previously manufactured using more complex conventional processes can significant benefit from the cost advantages of MIM technology.



THE MIM PROCESS
AT A GLANCE

1 FEEDSTOCK PREPARATION

For the production of the feedstock, metal powders are first mixed together in accordance with the desired alloy. Next, thermoplastics and additives are mixed in and kneaded with the powder mix under heat to form a viscous mass. This is then cooled and processed into granules (feedstock).

In this process, the powdered metal material is decisive for the achievable mechanical and chemical properties of the finished part.
GKN has unique expertise in powder development and in monitoring the achieved feedstock characteristics.

2 INJECTION MOLDING

For the MIM process, specially modified thermoplastic injection molding machines are used, similar to those used for conventional plastic injection molding.

In this process, the feedstock is melted after dosing in the injection unit and compacted in front of the screw conveyor. Moving the screw forward presses the flowable compound under high pressure into the individual cavities of the mold system.

The mass in the cavaties then cool down and becomes solid. After cooling down to the demolding temperature, the tool is opened on the parting line. The green part is ejected from the mold and can be removed using adapted handling systems.

Green Parts are characterized by

- Ratio of approx. 10% binder and 90% metal powder
- Solidity comparable to thermoplastic parts
- Homogeneous powder distribution without particle alignment

3 DEBINDING AND SINTERING

In the subsequent debinding process, the synthetic binder material is removed from the Green Part. At GKN Powder Metallurgy, this first process step is carried out by a continuously operating sintering system.

In the debinding muffle, an injected catalyst is vaporized under temperature, forming the reaction atmosphere. The plastics depolymerize completely in this reaction atmosphere. In the course of the reaction, the binder continuously escapes from the molding as a gas, leaving behind an open-pored structure. This porous structure is called „Brown Part“.

Without interrupting the process, the Brown Part then enters the sintering muffle. There, the temperatures are raised to just below the melting point under precise conditions until the metal particles sinter. Both inert and reducing furnace atmospheres are used.

The conditions in the computer-controlled systems are monitored precisely. This allows us to master the 16 to 18 percent shrinkage of the components to the exact specification dimensions required by the customer.

ADVANTAGES
OF MIM TECHNOLOGY

For optimum utilization of the advantages of MIM, it makes sense to design in MIM dimensions as early as in the development phase. For designers, this means completely new possibilities in design and construction.

- Automated MIM processes make the large-scale production of highly complex components economically feasible and even meet the requirements of the automotive industry in terms of process reliability.
- Geometries can be designed for high-strength metallic materials and stainless steels.
- Heavy-duty applications made of plastic, aluminum or die-cast zinc can be replaced by high-strength MIM parts with virtually no restrictions.
- Cost-intensive joining and assembly processes may become obsolete, as with MIM even the complex geometries of assembly parts can be produced and realized directly in a finished part.
- It is possible to produce threads by primary molding (injection molding).
- By optimizing the component volume, it is possible to save material and therefore costs. Due to the weight reduction achieved, moments of inertia are also reduced which is beneficial for dynamically stressed applications.
- The smallest geometries can be reproduced in detail in MIM.
- Even new types of material alloys that are adapted to specific customer requirements can be processed economically.

STRENGTHS
OF MIM TECHNOLOGY

3-Dimensional Complexity:

The shaping process of the MIM method is very closely related to traditional plastic injection molding and allows the design of complex geometries. Combinations of drillings, blind holes, slots, grooves, internal and external threads, recesses, undercuts, surface structures and cavities are no problem for MIM. Equally sophisticated design elements cannot be achieved with alternative chipless shaping processes.

Weight Reduction:

Optimizing the components results in a lower part weight with the same functionality. The weight reduction consequently has a positive impact on the unit costs of the finished part.

High Productivity:

Particularly when it comes to the production of large quantities, the MIM process can fully exploit its cost advantages throughout the manufacturing process. Depending on the requirements, cost-intensive post-processing can be avoided even for very complex components. This process is therefore particularly suitable for largescale production.

WE ARE HAPPY TO ADVISE YOU!

MIM
TOLERANCES

Tolerances MIM* [mm]	
Nominal size X [mm]	Standard Tolerance [mm]
To 3	+/- 0.05
3 <X> 6	+/- 0.06
6 <X> 15	+/- 0.075
15 <X> 30	+/- 0.15
30 <X> 60	+/- 0.25
(* Tolerances for guidance only)	

Tolerance behavior of sintered MIM components
In principle, the standard tolerances shown in the adjacent table can be achieved after sintering, taking into account the 16 to 18 percent shrinkage of the components. The information provided is for guidance only, as the actual tolerances depend on the geometry and the material used and may therefore vary slightly. If even stricter tolerances are required, this may be achieved by designing the MIM components specifically. GKN additionally offers a range of non-cutting and cutting fine machining processes to meet the most demanding requirements.

MIM – The process in comparison with competing technologies
Consciously exploiting the strengths and advantages of MIM technology as early as in the design phase can lead to significant advantages over nearly all conventional technologies. These are usually evident in improved functions and cost savings.

MIM creates the conditions for simplifying entire assemblies by reducing the number of individual parts. In this way, sources of error in production are reduced, process reliability is improved and higher quality is guaranteed.

CONCLUSION

The MIM process has proven to be economically viable when complex molded parts with tight tolerances, demanding mechanical properties and high surface qualities are required!

MIM
SECONDARY PROCESSING

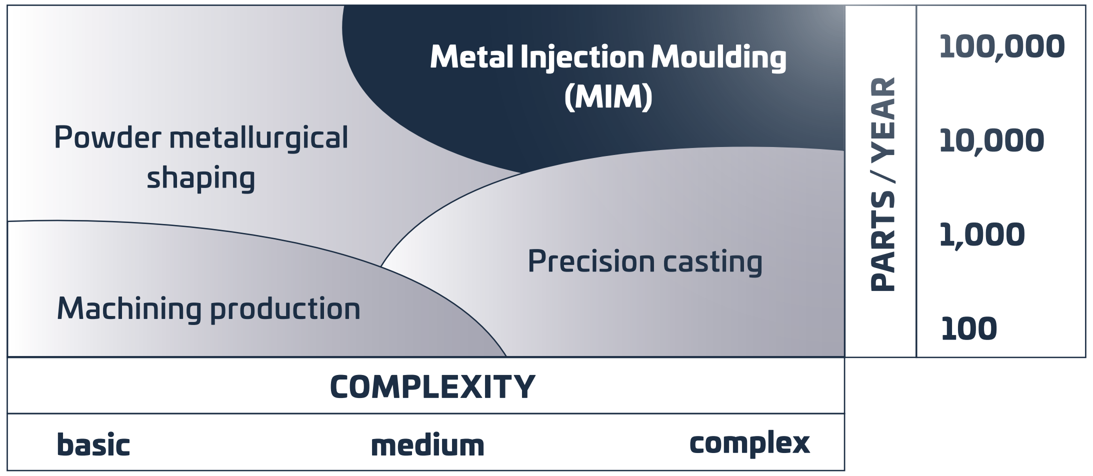
FINISHING AND REFINEMENT

MIM components can be further processed and enhanced in many ways. Among others, the following processes may be applied:

Thermal Treatment	Hardening, tempering, surface hardening, case hardening
Physical-chemical surface treatment	Nitriding, carbonitriding, nitrocarburizing, boriding, silicating
Chemical surface treatment	Pickling, chemical deburring, burnishing, etching
Mechanical surface treatment	Engraving, vibratory grinding, grinding, polishing, deburring, blasting
Application of non-metallic inorganic coatings	Chromating, phosphating, anodizing, enameling
Application of metallic coatings	Galvanizing, chemical metal plating, hot-dip coating, metal spraying, chromating
Application of organic coatings	Printing, pasting, varnishing
Application of anti-wear coatings	CVC coating, PVD coating

MIM PAYS OFF ...

... for large quantities



MIM components combine the outstanding properties of metallic materials with the complex design possibilities of plastics technology. The shaping by Metal Injection Molding (MIM) offers maximum freedom in terms of geometry and material. Undercuts, drillings and blind holes can be incorporated in any direction and wall thicknesses of 1 mm or less can be realized as well as bore diameters of just a few tenths of a millimeter.

Relief-like structures and engravings, such as company logos or item numbers, can be reproduced in detail. Even the use of expensive, high-strength alloys, corrosion-resistant or other high-grade stainless steels is now possible, since no costs arise from downstream machining. MIM components achieve high surface qualities (typical roughness Ra<1µm) without reworking.

The structure of the sintered parts allows for galvanic and electrolytic surface finishing (nickel plating, electropolishing, etc.) without pretreatment. Depending on the alloy, common heat treatments may also be applied to enhance wear resistance and stability.

APPLICATIONS

FOR MIM

Defense

- Trigger mechanisms
- Ammunition
- Functional components for handguns

Luxury

- Components for watches
- Eyeglass frames and hinges
- Jewellery with intricate designs

Automotive

- Turbocharger components
- Sensor and actuator housings
- Hinges, locks, gear parts
- ABS and airbag components

Medical

- Surgical tools
- Orthopedic and dental implant
- Housings and functional components for medical devices

Industrial

- Valve and pump components
- Gears, clutch components
- Fasteners, levers, grippers

CASE HARDENABLE STEELS

Material	Sintered R_m [MPa]	Sintered $R_{p0.2}$ [MPa]	Sintered A [%]	Sintered Hardness [HV 10]	Sintered Density [g/cm³]	Thermo-treated R_m [MPa]	Thermo-treated $R_{p0.2}$ [MPa]	Thermo-treated A [%]	Thermo-treated Hardness [HV 10]	C [%][1]	Ni [%][1]	Cr [%][1]	Mo [%][1]	Mn [%][1]	Si [%][1]	Cu [%][1]	Fe [%][1]	Substance no.: DIN	AISI/SAE	Other	Properties	Applications
IMET Ni 2	280	140	25	90	> 7.40	By arrangement				< 0.1	1.90-2.20						Rest		ASTM MIM - 2200	Carbonyl iron with 2% nickel	Good stability, fatigue resistance, high surface hardness	General mechanical engineering
IMET Ni 8	350	200	15	90	> 7.40	By arrangement				< 0.1	7.50-8.50						Rest			Carbonyl iron with 8% nickel		
IMET Ni Cr Mo 2	650	400	3	200	> 7.40	By arrangement				0.12-0.23	0.40-0.70	0.40-0.60	0.15-0.25				Rest	1.6523	AISI/SAE 8620	21 NiCrMo 2	For highest-duty parts, high surface hardness	Gear segments, ring gears, camshafts, tools, mechanical engineering

CORROSION-RESISTANT STEELS

Material	Sintered R_m [MPa]	Sintered $R_{p0.2}$ [MPa]	Sintered A [%]	Sintered Hardness [HV 10]	Sintered Density [g/cm³]	Thermo-treated R_m [MPa]	Thermo-treated $R_{p0.2}$ [MPa]	Thermo-treated A [%]	Thermo-treated Hardness [HV 10]	C [%][1]	Ni [%][1]	Cr [%][1]	Mo [%][1]	Mn [%][1]	Si [%][1]	Cu [%][1]	Nb [%][1]	Fe [%][1]	Substance no.: DIN	AISI/SAE	Other	Properties	Applications
IMET 316 L	450	160	40	105	> 7.60					< 0.03	10.00-14.00	16.00-18.00	2.00-3.00	< 2.00	< 1.00			Rest	1.4404	AISI 316 L	X 2 CrNiMo 17 13 2	Very good corrosion resistance, austenitic, non-magnetic, low hardness, good toughness, good polishability, and image accuracy	Apparatus engineering, chemical industry, watches and jewelry, medical technology
IMET 430 L	350	200	20	190	> 7.40					< 0.08		15.50-17.50		< 1.00	< 1.00			Rest	1.4016	AISI 430	X 6 Cr 17	Good strength and corrosion resistance, ferritic	Automotive industry
IMET 17-4 PH	800	700	3	250	> 7.50	1000	950	2	350	< 0.07	3.00-5.00	15.00-17.50		< 1.00	< 1.00	3.00-5.00	0.15-0.45	Rest	1.4542	SAE J 467 (17-4PH)	X 5 CrNiCuNb 17 4	Good corrosion resistance, martensitic, ferromagnetic, temperable by precipitation hardening	Pump parts, medical technology, automotive industry, mechanical engineering, aviation, and marine industry

TEMPERED STEELS

Material	Sintered R_m [MPa]	Sintered $R_{p0.2}$ [MPa]	Sintered A [%]	Sintered Hardness [HV 10]	Sintered Density [g/cm³]	Thermo-treated Rm [MPa]	Thermo-treated $R_{p0.2}$ [MPa]	Thermo-treated A [%]	Thermo-treated Hardness [HV 10]	C [%][1]	Ni [%][1]	Cr [%][1]	Mo [%][1]	Mn [%][1]	Si [%][1]	Fe [%][1]	Substance no.: DIN	AISI/SAE	Other	Properties	Applications
IMET Ni 2C	450	250	5	170	> 7.40	1000			600	0.40-0.70	1.90-2.20					Rest			Carbonyl iron with 2% nickel	Very good surface, good stability	Various applications (e.g., mechanical engineering, weapon parts)
IMET Ni 8C	700	350	3	320	> 7.40	1000			600	0.40-0.70	7.50-8.50					Rest			Carbonyl iron with 8% nickel		
IMET Cr Mo 4	600	350	4	110	> 7.40	1350	1150	2	450	0.32-0.43		0.90-1.20	0.15-0.30			Rest	1.7225	AISI/SAE 4140	42 CrMo 4	High strength and toughness, wide tempering range	Mechanical engineering, weapon parts, gear parts
IMET 8740	600	350	5	180	> 7.40	1600	1100		450	0.45-0.55	0.50-0.80	0.40-0.60	0.25-0.40	<0.1	0.30-0.55	Rest	1.6546	AISI/SAE 8740	40NiCrMo2 2		Wear-resistant, heavy-duty parts for mechanical engineering and automotive industry
IMET CR 6	950	630	5	250	> 7.40				650	0.80-1.05		1.35-1.65				Rest	1.3505	AISI/SAE 52100	100 CR 6	Tool steel for cold work, high wear resistance, high hardness	General mechanical engineering

[1] Mass percentage

R_m: Tensile strength $R_{p0.2}$: Yield point A: Elongation at break

SOFT MAGNETIC STEELS

Material	Sintered R_m [MPa]	Sintered $R_{p0.2}$ [MPa]	Sintered A [%]	Sintered Hardness [HV 10]	Sintered Density [g/cm³]	Thermo-treated Rm [MPa]	Thermo-treated $R_{p0.2}$ [MPa]	Thermo-treated A [%]	Thermo-treated Hardness [HV 10]	C [%][1]	Ni [%][1]	Cr [%][1]	Mo [%][1]	Mn [%][1]	Si [%][1]	Cu [%][1]	Fe [%][1]	Substance no.: DIN	AISI/SAE	Other	Properties	Applications
IMET Si 3	450	300	20	160	> 7.40					< 0.10	2.50-3.00						Rest	1.0884		Carbonyl iron with 3% silicon	Relatively high permeability	For pole shoes and relay parts (when rapid demagnetization is required)
IMET FN 50	400	150	25	110	> 7.40					< 0.10	49.50-50.50						Rest	1.3926		Carbonyl iron with 50% nickel		Pole shoes, relay parts, rotors, stators, etc.
IMET F S	220	100	40	60	> 7.40					< 0.10							Rest			Carbonyl iron	High polarization	

ALLOYS FOR HIGH-TEMPERATURE APPLICATIONS

Material	Sintered R_m [MPa]	Sintered $R_{p0.2}$ [MPa]	Sintered A [%]	Sintered Hardness [HV 10]	Sintered Density [g/cm³]	Thermo-treated Rm [MPa]	Thermo-treated $R_{p0.2}$ [MPa]	Thermo-treated A [%]	Thermo-treated Hardness [HV 10]	C [%][1]	Ni [%][1]	Cr [%][1]	Mo [%][1]	Si [%][1]	Mn [%][1]	V [%][1]	Fe [%][1]	Substance no.: DIN	AISI/SAE	Other	Properties	Applications
IMET GHS-4 [*]	700	550	1	310	>7.70					2.0-2.4	38.0-42.0	11.0-13.0	5.0-7.0	1.5-1.9	0.8-1.3	0.8-1.0	Rest			PI Ni 40 Cr 12 Mo 6	High operating temperature, wear-resistant	Turbochargers
IMET 310N [**]	650	380	7	220	>7.55					0.20-0.50	19-22	24-26		0.75-1.30	<1.5		Rest	1.4848	ACI HK 30	G- X40 CrNiSi 25 20	Operating temperature up to 850°C	Turbochargers

[*] Heat- and wear-resistant alloy
[**] Heat-resistant alloy

Material	Sintered R_m [MPa]	Sintered $R_{p0.2}$ [MPa]	Sintered A [%]	Sintered Hardness [HV 10]	Sintered Density [g/cm³]	Thermo-treated Rm [MPa]	Thermo-treated $R_{p0.2}$ [MPa]	Thermo-treated A [%]	Thermo-treated Hardness [HV 10]	C [%][1]	Cr [%][1]	Co [%][1]	Al [%][1]	Ti [%][1]	Mn [%][1]	Si [%][1]	Fe [%][1]	Ni [%][1]	Substance no.: DIN	AISI/SAE	Other	Properties	Applications
IMET N 90 [***]					> 7.8	1100	650	≥ 10	≥ 300	≤ 0.13	18.0-21.0	15.0-21.0	1.0-2.0	3.0-4.0	≤ 1.0	≤ 1.0	≤ 1.5	Rest	2.4632	SAE J775 (HEV-6)	NiCr 20 Co 18 Ti	Nickel-based alloy for highest-temperature applications	Turbochargers

[***] Superalloy

TOOL STEELS

Material	Sintered R_m [MPa]	Sintered $R_{p0.2}$ [MPa]	Sintered A [%]	Sintered Hardness [HV 10]	Sintered Density [g/cm³]	Thermo-treated Rm [MPa]	Thermo-treated $R_{p0.2}$ [MPa]	Thermo-treated A [%]	Thermo-treated Hardness [HV 10]	C [%][1]	Cr [%][1]	W [%][1]	Mo [%][1]	V [%][1]	Fe [%][1]	Substance no.: DIN	AISI/SAE	Other	Properties	Applications
IMET M2	1100	700	1	480	> 7.70				800	0.95-1.05	3.80-4.50	5.50-6.75	4.50-5.50	1.75-2.20	Rest	1.3342	AISI M2	SC 6-5-2	Wear-resistant high-speed steel	Cutting blades, nozzles

[1] Mass percentage

R_m: Tensile strength $R_{p0.2}$: Yield point A: Elongation at break

NOTES

CONTACT US

GKN POWDER METALLURGY-
AT A GLANCE

World leading provider of metal powder solutions

gknpm.com

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