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ADVANTAGES AND EFFECTIVENESS OF THE POWDER METALLURGY IN MANUFACTURING TECHNOLOGIES

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Powder metallurgy is the manufacturing science of producing solid parts of desired geometry and material from powders. Although the process has existed for more than 100 years, over the past quarter century it has become widely recognized as a superior way of producing high-quality parts for a variety of important applications. This success is due to the advantages the process offers over other metal forming technologies, advantages in material utilization, shape complexity, near-net-shape dimensional control, among others. Commonly known as powder metallurgy, it may also be referred to as powder processing considering that non-metal powders can be involved. Powders are compacted into a certain geometry then heated (sintered), to solidify the part.

Key words: powder metallurgy, manufacturing, metalography, hardness

INTRODUCTION

Powder metallurgy (PM) is a continually and rapidly evolving technology embracing most metallic and alloy materials, and a wide variety of shapes. PM is a highly developed method of manufacturing reliable ferrous and nonferrous parts.

Created by mixing elemental or alloy powders and compacting the mixture in a die, the resultant shapes are then heated or "sintered" in a controlled atmosphere furnace to bond the particles metallurgically. The high precision forming capability of PM generates components with near net shape, intricate features and good dimensional precision pieces are often finished without the need of machining.

By producing parts with a homogeneous structure the PM process enables manufacturers to make products that are more consistent and predictable in their behaviour across a wide range of applications. In addition the PM process has a high degree of flexibility allowing the tailoring of the performance requirements – Figure 1.

These include:
- Structural pieces with complex shapes,
- Controlled Porosity,
- Controlled performance,
- Good performance in stress and absorbing of vibrations,
- Special properties such as hardness and wear resistance,
- Great precision and good surface finish,
- Large series of pieces with narrow tolerances [1].

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Figure 1 Example of high degree the flexibility of powder metallurgy [1]

The unique flexibility of the PM process enables products to be made from materials that are tailored to your specific needs. By using specially selected materials this capability enables refinements to be engineered into the mechanical properties of the part [1,2].

POWDER METALLURGY PROCESS

The general sequence of operations involved in the powder metallurgy process is shown schematically in the following organigram (Figure 2) [3,4].

The component powders are mixed, together with lubricant, until a homogeneous mix is obtained. The mix is then loaded into a die and compacted under pressure, after which the compact is sintered.

An exception is the process for making filter elements from spherical bronze powder where no pressure is used; the powder being simply placed in a suitably

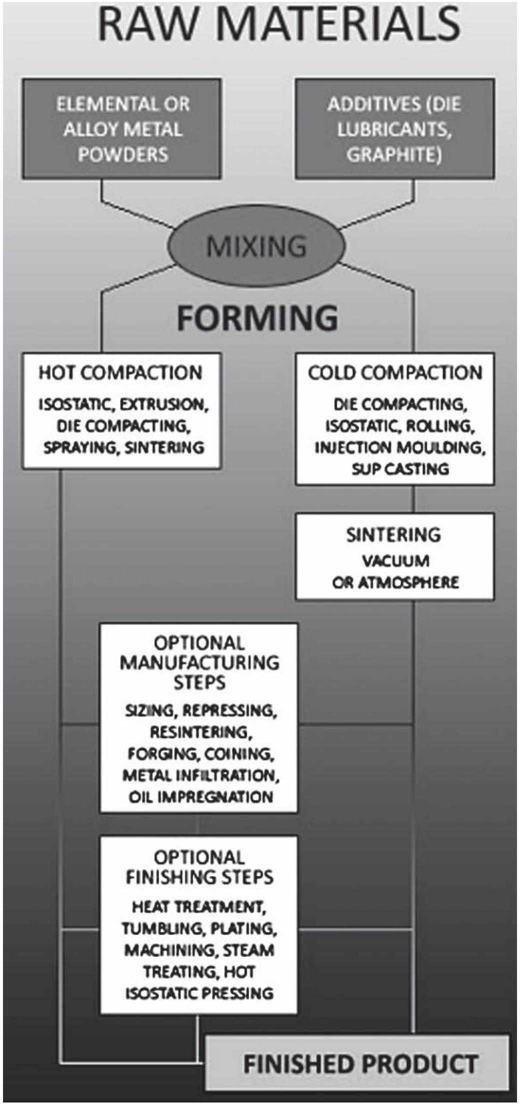

Figure 2 Powder metallurgy process [4]

shaped mould in which it is sintered. This process is known as loose powder sintering [4].

MIM – Metal Injection Moulding

MIM – Metal Injection Moulding is a novel manufacturing technology that allows highly complex parts to be obtained completely reliably and precisely, with mechanical properties similar to those of any machined, microfused or laminated materials (Figure 3).

The Metal Injection Moulding production process combines the advantages of sinter processes with the flexibility of processes that use thermoplastic injection. It provides a vastly superior quality than either process and achieves densities that can be as high as 99 % [5].

Application of MIM production process – within company manufacturing processes

Application the production process of MIM allows to product of so called powder green compact, whose chemical structure, strength characteristics are (nearly)

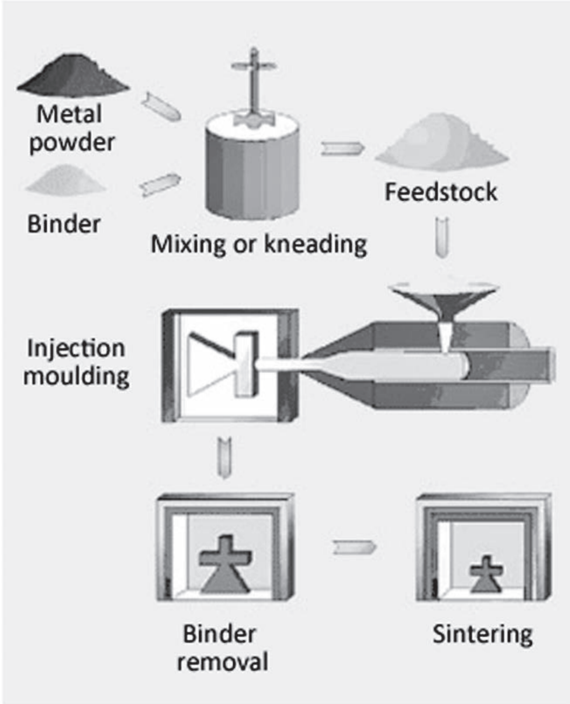

Figure 3 Process of Metal Injection Moulding – MIM [15]

identical to the currently used (conventional) material – 16MnCr5 (Table 1) [5].

Table 1 **Material data sheet – polyMIM 16MnCr5 [5]**

Characteristic composition – sintered material / wt.%				
Si	Mn	Cr	C	Fe
max. 0,5	1 – 1,3	0,8 – 1,1	0,14 – 0,19	bal.

Characteristic properties		
	sintered material	heat treated material
Densitty / g/cm^3	7,4	-
Yield strength / MPa	320	600
Tensile strength / MPa	380	1050
Elasticity / %	15	8
Hardness / HV	120	380

The characteristics of microstructure the powder material (based on the material data sheet – polyMIM 16MnCr5), is shown on Figure 4 [5].

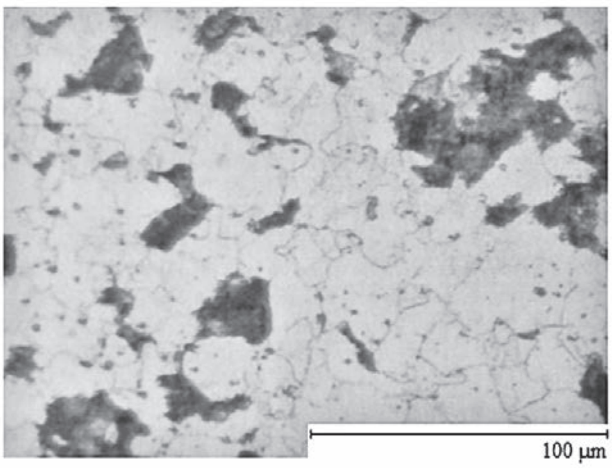

Figure 4 Characteristics of microstructure – polyMIM 16MnCr5 [5]

METALLOGRAFIC EVALUATION OF SINTERING PROCESS

Table 2 shows evaluated characteristics on the sintered samples.

Table 2 **Metallographic evaluation of sintering process [5]**

Sample number	Hardness in core / HB	Microstructure	Porosity	Surface defects / mm
1	184-190	F+P	2.	-
2	145-158	F+P	3.	-
3	170-205	F+P	2.	-

* Note: F – ferrit, P – pearlite. [16]

- hardness of the surface/in the core (measured by micro hardness tester LECO LM 700AT, according to the standard STN EN ISO 6507-1: 2005, by the method HV 5),
- microstructure (observed on the metallographic microscope OLYMPUS GX51),
- porosity (evaluated according to the standard GOST 801-78),
- surface defects [5].

Porosity of sintered samples, is shown on Figure 5.

METALLOGRAFIC EVALUATION OF CEMENTATION PROCESS

On the sintered, subsequently cemented samples have been evaluated the following characteristics (Table 3):

- hardness in the core (measured by micro hardness tester LECO LM 700AT, according to the standard STN EN ISO 6507-1: 2005, by the method HV 5),
- microstructure (observed on the metallographic microscope OLYMPUS GX51),
- porosity (evaluated according to the standard GOST 801-78),
- decarburization,
- surface defects [5].

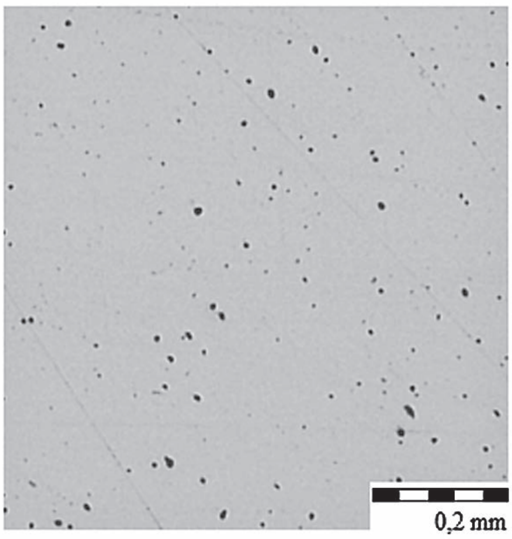

Figure 5 Porosity of sintered samples [5]

Table 3 **Metallographic evaluation of cementation process [5]**

Sample number	Hardness in core / HRC	Micro structure	Porosity	Surface defects / mm
1 / b	36,0	M	2. - 4.	0,01
2 / b	35,5	M	2. - 4.	0,01
3 / b	34,0	M	2. - 4.	-

* Note: b) – samples after the sintering process, subsequently cementation process, M – martensite.

Hardness measurement

Prescribed requirements:

- layer regulation: 0,6 – 0,8 mm,
- carbidic chain regulation: max. 5,1,
- oxide layer regulation: max. 0,02 mm,
- allowable percentage of residual austenite regulation: max. 5 % - Figure 6 [5].

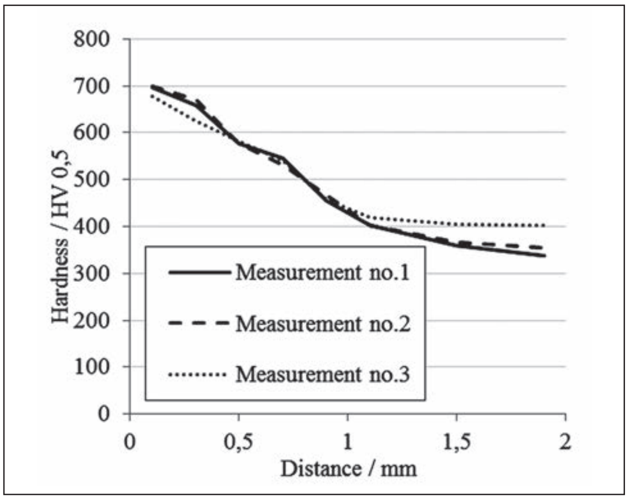

Figure 6 Hardness measurement of samples after cementation process [5]

Measured/final values:

- line 1Eht 550 HV 0,5 = 0,67 mm,
- line 2Eht 550 HV 0,5 = 0,62 mm,
- line 3Eht 550 HV 0,5 = 0,66 mm,
- core hardness → 34 – 36 HRC,
- layer microstructure → medium rough Martensite/ rough Martensite+residual austenite – Figure 7 [5].

CONCLUSION

The first consideration in powder metallurgy is the powders used for the manufacturing process [6]. Several

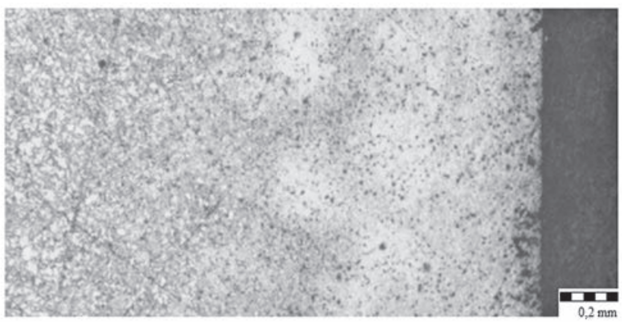

Figure 7 Microstructure after cementation process [1]

different measures are used to quantify the properties of a certain powder. Powders can be pure elements or alloys. A powder might be a mixture of different kinds of powders. It could be a combination of elemental powders, alloy powders, or both elemental and alloy powders together. Material and the method of powder production are critical factors in determining the properties of a powder. It should always be remembered, when working with powders, that the powder itself may be a potential hazard. Some powders may be flammable and/or present health risks to workers. Safety precautions should always be taken when handling or storing powders. Also, be sure to follow any regulations regarding the handling, storage, or disposal of powders. Powder selection and processing will depend on cost, desired purity and mechanical properties of finished product. Environmental control is critical in proper storage and handling of powders. Contamination of powder can result in powder degradation and should be avoided. High surface areas cause powders to react readily with outside materials. This can have various results, oxidation for example, caused by oxygen present in the air [7-9].

Cementation process has been evaluated (based on the metallographic evaluation) as acceptable, considering the fulfillment of company conditions/requirements:

- acceptable decarburization layer (into the deep ca. 0,018 mm),
- acceptable depth range of cemented layer (0,62 – 0,67 mm),
- acceptable percentage of residual austenite in microstructure of cemented layer (ca. 5 %) [10-12].

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Note: The responsible for English language is Mgr. Lucia Gibľáková from Iluminata Linguistics.