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T.Rudnytska
S.Chubur

METAL INJECTION MOLDING AS INNOVATIVE POWDER METALLURGY TECHNOLOGY

Vinnytsia National Technical University

Анотація: *У статті розглядається MIM технологія як альтернатива традиційним методам обробки.*
Ключові слова: *лиття, обробка, метал, сплав, полімер, альтернативні методи, екструзія.*

Abstract: *The article considers MIM technology as an alternative to conventional machining processes*
Keywords: *molding, processing, metal, alloy, polymer, alternative methods, extrusion.*

Introduction

Metal injection molding (MIM) is a proven, innovative powder metallurgy technology that offers the capability of mass-producing complex-shaped metal parts consistently and reliably.
The MIM process allows us to manufacture metal parts of almost any shape using an injection molding process, as easily as though it were plastic. This process lets us elegantly combine the geometrical freedom of plastic injection molding with the outstanding rigidity and wear characteristics of metals.

Metal injection molding is applicable in a vast assortment of areas: gearbox parts, watches, jewelry, eyeglass parts, surgical instruments, tweezers, dental braces, firearms, small and micro-sized parts for mobile phones, computers, or other devices.

Statement of basic materials

Metal Injection Molding is a relatively new production method that was developed in the 1970s. In the MIM process, fine metal powder is mixed with a thermoplastic resin called the binder, and the mixture is then processed into a molded body with a complex shape by the same injection molding method as that for general plastic. After that, the binder is removed from the molded body by heating or using a solvent, and the resulting molded body is sintered at high temperature to obtain the final product. Compared to conventional powder metallurgy, MIM can make a product with higher density, which is to say increased strength.

This manufacturing method allows to produce metal parts with complicated shapes and small tolerances, with the ease and automation of the injection molding machine. The process however requires some extra steps to accomplish this.

Metal injection molding is best suited for the high-volume production of small metal parts. As with injection molding, these parts may be geometrically complex and have thin walls and fine details. The use of metal powders enables a wide variety of ferrous and non-ferrous alloys to be used and the material properties (strength, hardness, wear resistance, corrosion resistance, etc.) to be close to those of wrought metals. Also, because the metal is not melted in the MIM process (unlike metal casting processes), high-temperature alloys can be used without any negative affect on tool life. Metals commonly used for MIM parts include the following:

Low alloy steels	Cobalt alloys
Stainless steels	Copper alloys
High-speed steels	Nickel alloys
Irons	Tungsten alloys
	Titanium alloys

The metal injection molding process consists of the following steps:

1. *Mixing*: At the mixing stage, both metal powder and the polymeric binder (thermoplastic types) are combined into a homogeneous mixture “feedstock”;
2. *Injection molding*: Injection molding machines inject the molded part, also called the “green part”. The mold dimensions are calculated by applying a "shrinkage factor" which is around 15-20% for most materials to the part drawing;
3. *Debinding*: Debinding is a process whereby the binder is removed from the molded part, leaving behind the metal 'skeleton' that retains the molded shape, using either pressure or heat, but it always stops before the material turns completely into a liquid. This remaining element is known as the 'brown' part;
4. *Sintering*: Finally, the brown parts are sintered. The metal powder particles will be bonded together and consequently, this step provides the strength in the finished product.

Applications for MIM Processes

There are several applications where injection molding comes in handy. For example, one common consideration with metal fabrication is the wall thickness of the item you need to produce.
If the wall is very thin – for example, 100 micrometers – your item is a good candidate for metal injection molding.

Metal injection molding is also a process to consider if you’re interested in a more eco-friendly way of mass-producing products. Although some of the older injection molding machinery generates toxic emissions such as formaldehyde, the newer machines are much cleaner and produce far less waste than CNC machining, and other processes do. In fact, with a little work and a few revisions, MIM processes might be even cleaner in the future.

There are several advantages to the metal injection molding process, especially when comparing it to other methods such as CNC machining. This process makes it much easier to produce complex metal parts that are sometimes impossible to create using other metal fabrication processes. The MIM properties are roughly equivalent to wrought alloys, and you can manufacture net shapes with minimal waste.

Metal injection molding is great for producing very intricate parts quickly and efficiently. The metal injection molding process is efficient, easily repeatable, and cost-effective. In a single step, intricate parts can be mass-produced in high volume and shaped to perfection, after your first production run, setting up future runs is fast and easy.

When it comes to fabricating high-volume parts and small, complex parts, MIM is more cost-efficient and a lot less time-consuming than most other metal fabrication methods. Both production time and finishing time are relatively short.

Conclusion

MIM technology is a promising production method in modern science and engineering. It is worth mentioning the following advantages of Metal Injection Molding technology:

- Capability to produce mechanical properties unobtainable by other methods
- Feedstock is re-useable if it is not processed after molding
- Series production of smaller components with weights from 0.3 g to 150 g
- Complex components with a wall thickness down to 0.1 mm
- Mechanical strength of workpieces equal to conventional manufacturing processes
- Avoids production costs and the use of expensive assembly and connection techniques
- Significantly lower costs for complex components
- 25% to 65% less expensive than conventional production processes
- Minimal material loss

As mentioned, MIM technology has a wide range of applications across various industries. Of course, it requires significant capital investments. However, as a result, due to its efficiency, it is worth implementing in Ukrainian enterprises, which will also greatly facilitate the process of reconstruction after the war.

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Рудницька Тетяна Григорівна – старший викладач кафедри іноземних мов, Вінницький національний технічний університет, e-mail: rudnytska@vntu.edu.ua

Чубур Сергій Олександрович — студент групи 1ГМ-22б, Факультет машинобудування та транспорту, Вінницький національний технічний університет, м. Вінниця, e-mail: serhichubur15@gmail.com

Rudnytska Tetiana Hryhorivna – an Assistant Professor of Foreign Languages Department, Vinnytsia National Technical University, e-mail: rudnytska@vntu.edu.ua

Chubur Serhii Oleksandrovych – a student of group 1ГМ-22б, the Faculty of Mechanical Engineering and Transport, Vinnytsia National Technical University, Vinnytsia. e-mail: serhichubur15@gmail.com.