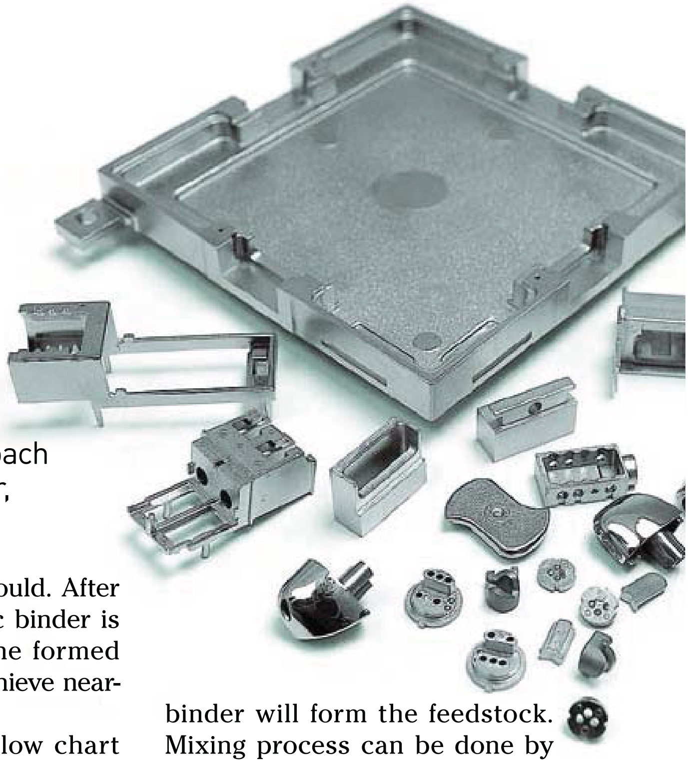
Metal Injection Moulding:

Metal Malleability



An innovative way for manufacturing metallic parts, MIM brings cost reduction and also new ways to approach certain materials. By **Liang Chee Hoo**, senior manager, technology, AMT.

Injection moulding is a productive and widely used technique for shaping plastic. Until recent times, injection moulding was only applied to polymers that melt on heating. The technique cannot be applied to shape metals, which have higher strength, stiffness and operating temperature.

Shaping of metals with 2-D geometry was traditionally done by applying powder metallurgy. It is also known as pressed and sinter method.

Dawn Of A New Era

Metal Injection Moulding (MIM) uses the shaping advantage of injection moulding but is applicable to metal. This process combines a small quantity of polymer with metal powder to form feedstock that can be moulded.

The moulding process allows the metal-polymer feedstock to take the shape of a mould. After shaping, the polymeric binder is then extracted and the formed shape is sintered to achieve near-theoretical density.

Figure 1 shows a flow chart for the MIM process. It starts by mixing selected metal powders and binders. The metal powder usually has a small particle size between 3 to 20 um to aid sintering. These powders may come with different shape, spherical or irregular.

Gas atomised and water atomised powder are the most common powder used in MIM process. The binder is usually based on a common thermoplastic such as wax or polyethylene, but cellulose, gels, water, and various inorganic substances are also in used. Usually, the binder system consists of two or more components. Typical binder content is approximately 40 volume percent of the mixture.

The mixture of powder and binder will form the feedstock. Mixing process can be done by using a sigma/planetary mixer or a twin-screw extruder. A twin-screw extruder is always preferred as it provides feedstock with better homogeneity.

Quality of the feedstock is the most crucial determining factor in obtaining quality MIM part. The homogeneity and viscosity of the feedstock are the parameters to be controlled carefully during the mixing process.

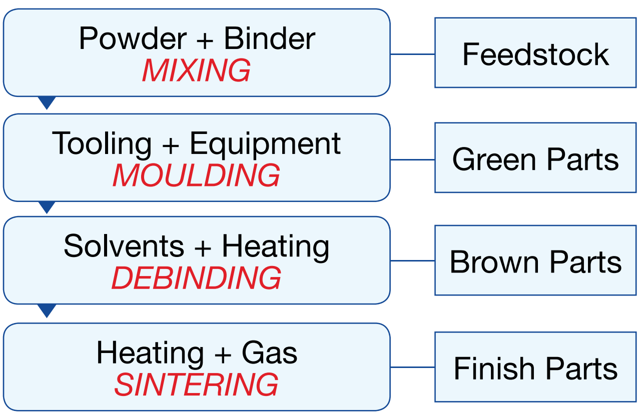


Figure 1: Flow chart of MIM process

MIM 101

The moulding process is the same process as per plastic injection moulding. Dependent on several parameters, the moulding pressures are typically 600 bar or more. Pressure is maintained on the feedstock during cooling until the gate freezes to reduce formation of sink marks and shrinkage voids. After cooling in the die/mould, the component is ejected and the cycle repeated.

After the injection process, the shape of the component is formed. The binder had served its purpose and it needs to be removed. The process of removing the binder is termed debinding. A wide array of options exists for binder extraction.

Thermal debinding is the easiest

Figure 2: If the set of hinge components used in mobile phone application were to be machined, the cost may go up by more than 20 times

to envision. The component is slowly heated to decompose the binder. Many variations exist, and the most popular alternative is to immerse the component in a solvent that dissolves some binder, leaving some polymer behind to hold the component in place.

The remaining polymer is then thermally extracted during the second stage thermal debinding process or part of sintering cycle. Another popular option involves catalytic phase erosion of the binder. The debound part is highly porous and brittle in nature.

The next step is sintering, which can be incorporated directly into a thermal debinding cycle. Sintering process involves firing the debound component to a temperature close to the melting point of the metal. Sintering bonds the particles together, leading to densification and therefore causing the shrinkage of the components. The shrinkage is within the range of 12 to 18 percent.

Often, sintering serves the dual role of densification and chemical homogenisation. In the latter role, mixed powders (mechanically blended) are moulded and sintering causes them to form homogeneous alloys by long-range atomic motion.

Usually sintering shrinkage is uniform and isotropic, so the moulded component is oversized to deliver the desired final dimensions. The process is always performed

Case Study 1
Reducing Cost

Figure 3: A magnetic valve body is a good illustration of MIM's capability to integrate different components into a single joint body

A magnetic valve body (Figure 3) is a good illustration of MIM's capability to integrate different components into a single joint body. Prior to the use of MIM to fabricate this magnetic valve body, the body is actually made up of four single pieces; two powder metallurgy parts, a turned part, and a machined part.

These four parts are then welded together to form the magnetic valve body. Functional, by using MIM, the magnetic flux leakage had been reduced and therefore the performance of the valve is enhanced. Besides the improvement in function, the cost of manufacturing the body had been reduced as well. The saving is estimated in the range of 30 to 50 percent.

Case Study 2
Bi-Materials Injection Moulding

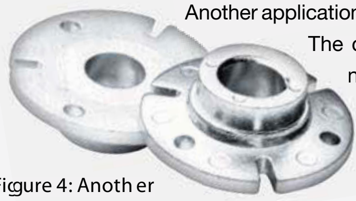


Figure 4: Another application of the MIM is bi-materials injection moulding

Another application of the MIM is bi-materials injection moulding. The component is made up of two materials, a non-magnetic ring and a magnetic disc. As these two materials have different property in nature, it cannot be process together through the conventional technique.

Without using the MIM process, the outer ring needs to be made through powder metallurgy, and the inner disc can be machined or made through powder metallurgy. The two pieces are then welded together to form the integrated component.

However, by using the bi-materials MIM process, the two materials can be integrated during the injection process. All subsequent process, debinding and sintering, can be carried out together. Through this, the cost saving is achieved as it reduced the cost of fabricating two components and the welding process.

Case Study 3
Undercut

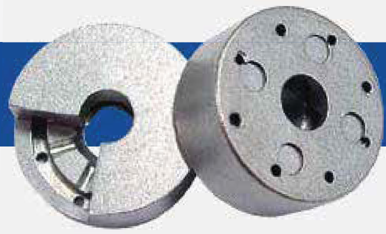


Figure 5: A complex undercut feature made possible with the application of In-coring

MIM is sometimes selected to create the 'impossible feature', ie: undercut, in injection moulding process. These undercut features cannot be moulded through injection moulding process because the insert or the slider cannot be retracted after the formation process.

With the used of In-coring technology, these features are made possible. Figure 5 depicts a component with intricate under channels. By applying the technology, the internal channels are formed by using removable polymer, followed by MIM process.

Once the green body of the part is formed, the polymer will be removed through chemical and thermal method. The difficulties in this technology are the forming of the undercut features without distortion, and the removing of the polymers without cracking and disfiguring the internal surface.

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