Injection Moulding with Metal.

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Introduction

The injection moulding of various metals has now reached the commercial application stage this article gives a brief overview of the two methods that are now proven in commercial application and becoming more widely used by industry for a wide variety of applications to replace the conventional die casting process and the materials used in casting.

Metal Injection Moulding (Sintering process)

The injection moulding of metals has been around for over 20 years but has only recently been considered by designers as an alternative to high pressure die casting its development and exploitation for commercial use began in the USA and in Switzerland it combines powder metallurgy with the injection moulding process and brings together the best of both types of the process.

It is now possible to produce high integrity metal parts in complex shapes and designs that exhibit properties such has close tolerances, lower porosity, smooth texture and finish with accurately reproduced detail and dimensions at a relative low-cost dependant on the production volumes. The metal injection moulding sintering process can eliminate or reduce machining operations and is ideally suited to the production parts in medium to large quantities, details or features that would normally have to be carried out in a secondary operation can now be incorporated into the design so eliminating the need for further operations to be carried out on the part.

The process also offers technical advantages over other conventional methods of manufacturing in the materials that can be processed and in the superior mechanical properties that they exhibit by using this method.

The design guides for mould tooling are similar to both die-casting and injection moulding tooling.

Typical metals that can be processed in this way include carbon, low alloy, steels stainless steel, tungsten, bronze, nickel and others.

The first stage of production involves the accurate mixing of the carrier a wax or polymer binder with fine spherical powdered metal particles these particles are made to a higher tolerance and standard of quality than those normally associated with the conventional sintering process this produces a compound or mixture that is suitable to be used in the injection moulding process.
In the next stage the compound is transferred to the moulding machine hopper this is then injected into the mould using the high pressure developed by the machine process.

Special screws and barrels are basically the only changes made to the conventional moulding machine the only major difference to the process is that the mould tooling is deliberately made oversize to compensate for contraction of the compound in the cooling phase and in the next stage of the process the removal of the binder.

After forming the parts in the injection moulding stage they are then transferred to an oven the mouldings at this point are called in the green state and are still relatively brittle depending on the binder that is used. The mouldings are then placed into an oven to vaporise the binder during this process support plates or fixtures are sometimes used to prevent the distortion of the parts that can occur at the temperatures used in this process after this the parts are referred to have being in the brown state. The final stage is the high temperature sintering treatment that releases the stored surface energy in the parts and fuses the metal particles together resulting in a high-density part that also has high strength characteristics.

After this stage the parts can worked in the conventional ways: machined, polished, plated and hardened, etc. The process is however limited in the size of the part that can be produced and parts are not generally made above 50sq mm.

**Metal Injection Moulding (Semi Solid Metal Processing).**

Semi solid metal processing was also developed in USA in the early 1970s and was originally termed rheocasting or semi solid metal processing to date three commercial developments have emerged semi solid forming, semi solid billet casting and Thixomoulding of these by far the most successful method have been the last that was developed by a company called Thixomat Inc. All three methods use the thixotropic flow characteristics exhibited by the partially molten metals to form shapes.

Thixomoulding uses the same principles as the sintered injection moulding process in that an injection moulding machine and mould tool is used in the process however that is where any other similarities end.

It would be a true to say that thixomoulding is metal injection moulding in the truest form as it actually uses pure metals only no carrier or binders are required, these pure metals are heated to a molten state and then injected into the mould under high pressure no other further processing is required to bring the part to its final form or shape unlike the sintering method.

The thixomoulding process uses a magnesium alloy has its feed stock (other alloys are under development) which is introduced to the machine in a ready-made pellet form just like plastic feed stock these are fed through a dosing unit into the throat section of the machine barrel that feeds the screw this area is protected by an argon blanket atmosphere to prevent oxidisation occurring to the alloy.

Inside the barrel the screw performs in exactly the same way as a conventional moulding machine except for using a modified screw and barrel that incorporates more heating sections and a larger than normal diameter of barrel with an increased wall thickness to withstand the extra pressures placed on this part of the machine coupled with the extra
heating this enables the feed stock to be turned into a molten slurry by the machine. The shearing action of the screw and the generated heat produced by the screw rotation along with the heating elements provides the required force and temperature to divide the dendrites from the root solid particles and rounds them this creates the thixotropic slurry consisting of spherical particles in a continuous molten state when the required amount of slurry as been accumulated in front of the screw tip and non-return ring injection takes place injecting the material at high pressure into a preheated mould to produce a part after cooling the part is then ejected from the mould and the machine proceeds to make another one.

No other post processing is required by the part and the dimensional requirements have been achieved without requiring any further processing or treatments.

Materials currently being used include AZ-91-D, AM-50A, AM-60B, AE-42, Zamak No3 and ZA-8.

The advantages of using this method as against the sintering process include increased mechanical properties, substantial reduction in porosity, greater dimensional accuracy and stability, thinner wall sections, the ability to design in core pulling and threads to create clearance holes, features or threaded holes, gas impermeable parts, RFI and EMI shielding improvements reducing the requirement for further secondary operations compared to other materials, increased thermal properties, weight reduction, no limit to part size compared to sintering, environmentally friendly, easy to use compared with casting no hot metals to transport and the sintering method no mixing required, lower production cost through a reduction in power usage and labour, easier to change over materials, faster start up and shutdown of the process.

The downside to this process at the moment is the range of metals that can be processed compared to the sintering method.

Information

For more information about the sintering process or the thixomoulding process contact the author.

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