RESEARCH ARTICLE OPEN ACCESS

Throw out Crack Defect in Metal Injection Moulding Process for Automotive Parts

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Abstract:

MIM (METAL INJECTION MOULDING) technology is basically powder metallurgical based injection molding process. It is the one of the advanced technologies in the present world to produce complex metallic parts with high density and with close tolerances in dimensions as well as metallurgical aspects. There by the manufacturing time and also the total cost of the component is greatly reduced. The accuracy involved in MIM is higher and consistent compared to other methods of manufacturing.Identified the flow line and crack issues at molten metal powder merging area in AUTOMOTIVE PARTS by using of designed mould. So we need to avoid these two problems by proper design of tool (mould).crack is the very critical issue to avoid in injection molding process.In our project we designed the flash pocket. By introducing of flash pocket in the tool itself to avoid the flow line and crack issues. Crack is one of the major quality complaint issues in manufacturing industries.which includes various steps to make the tool(mold) in the most economical method with high degree of accuracy in its functional aspects within the given time. This project report gives a brief information about design and manufacturing process of Metal Injection Molds. Finally we can calculate the total cost of required mold for manufacturing.

Introduction

MIM (METAL INJECTION MOULDING) technology is a powder metallurgical based injection moulding process and by using of this technology one can produce automobile parts all over the world. This is one of the advanced technologies in the present scenario to produce complex metallic parts with high density and with close tolerances in dimensions as well as metallurgical aspects. It can be possible to produce Fire arm, Automobile, Electronic components, Computer peripherals, Aeronautical spare parts, Defense field etc.

MIM is one of the emerging technologies in the present world to produce complex metallic parts with minimal wastage of material and with negligible secondary operations (say zero).

Advantages of this technology are

a) Complex shapes
b) High volumes
c) Cost effective solutions
d) Easy manufacturability of engineering features
e) Close tolerances
f) High density
g) Less production lead time
h) Flexibility in design change

Since, conventional and traditional mechanical processes are time consuming and leading to more wastage, the Metal Injection Molding Process finds its suitability in manufacturing field.

MIM PRODUCTION PROCESS:

MIM Technology consists of the following Processes:

a) **Compounding**: The suitable metal powder and binders are mixed to get the flow properties in order to facilitate the metal powder to fill the cavity in the mold.
b) **Molding**: The metal injection molding takes place here.
c) **Debinding**: The binders, which are added in the compounding stage will be removed from the molded parts
d) **Sintering**: The debind parts are sintered in a shield furnace to get the final product.

e) **Post sintering appraisal**: The sintered parts are inspected visually, dimensionally and metallurgically.
f) **Secondary operations**: The MIM parts are subjected to CNC and Conventional operations such as machining, sizing, surface finishing, ,surface treatment operations, heat treatment, and inspection to achieve the customer requirements.

Final inspection: Final inspection will be carried out by Quality Assurance (QA)-Department. Parts will be subjected to inspection as per the plan which is approved by the customer.

LITTERETURE SURVEY

Metal Injection Moulding (MIM) is a very recently developed process, compared to the investment casting technique.In Italy MIM technology is quite new: Metrocast Italian has been the first Italian company to act as a subcontractor of metal injection moulded parts, back in 1995.

The first studies about PIM (Powder Injection Moulding) are made in the USA and dates back to the 1920s; they refer specially to CIM (ceramic injection moulding). Afterwards, during Second World War, the results of these studies are applied to metal powders (Fe-Ni) and the first metal injection moulded parts are manufactured.Starting from the 1950s also in Russia has been developed a similar process, but only with ceramic powders. Become an industrial process, since 1970 MIM found in the United States more and more applications in those fields where complex shaped and high properties components are required. The process spreads rapidly in Japan, and finally in Europe too.

M.I.M. is cost-effective for the production of large volume orders of small and complex shaped steel components with weight which varies from 0.5 grams up to 50 grams max. After having mixed fine metal powders and a thermoplastic binder to form a pelletized moulding compound, this mixture, called "feedstock", is then injected into a mold cavity.The plastic binder is used only as a carrier to the metal powder in order to obtain by injection the desired geometry: after injection, the binder is no longer needed.

Tooling

Tooling for MIM components is almost identical to those used in plastics injection moulding. One important difference in tool construction lies in that the dimensions on the mold are larger than the final part dimension, which is to account for the shrinkage during sintering . To achieve a dimension of say 1mm in the final part, the mold dimension corresponding to that feature 'ds' from a green density 'dg', linear shrinkage associated with sintering, Y is given by the formula Y=DL/L-(dg/ds)1/3

The mold shrinkage factor, MSF (green dimension/sintered dimension) =1/ (1-y).

Injection molding being hydrostatic process should ideally lead to uniform shrinkage in all three directions . However for complex components, as usually the case in MIM, the shrinkages are no longer isotropic. The anisotropy arises due to several reasons including powder orientation, gravity, thermal gradient during sintering etc,, in such cases, the exact MSFs for each particular dimension are found by initial trials and slight modifications in the tool or in the feedstock are made to get to the final dimensions. Several designs such as knurls, threads, logo, etc are usually incorporated in the mold that makes MIM highly competitive on complex parts. Sprue, runner size and gate location are important.

Design factors affecting mold design for circular components it is common to go for tangential or fan gates to achieve good concentricity after sintering. Large components are gated at several locations, while small components are usually molded using large number of cavities. Location of gate and parting line are determined depending on the components of the tool including core and cavity determine the parting line. Any mismatch between the two will lead to flashing during molding. The flash results in a burr after sintering.

MOULDING

- Over flows
- Ejector positions
- Gate positions
- Parting line

It Is the selection of the parting line, the most efficient for the mould construction? Have the core and cavity been designed in easiest manner for machining in available equipment? Will any slender blades or pins deform under cavity pressure or flow? Is the cavity of adequate strength to resist internal cavity pressure? Have the material been specified for the core and cavity and other parts of the mould?Are all the necessary parts hardened? Can all parts of the tool be dismantled and separated in the event of the tool break down or modification? Have all the allowance for molding shrinkage been provided? Will the tool dimensions produce the moldings within the tolerance? Is the ejection stroke sufficient to clear the molding from the tool? Have sufficient ejector pins been provided to prevent sticking, cracking or distortion of the molding? Is the ejector mechanism suitable for the particular machines ejector system? Have adequate guide pins been provided? Are the runners and the gate sizes sufficient? Has a specification chart been made for the expandable parts such as springs-rings switches, etc..? Have adequate cooling channels been provided? Is the plate thickness sufficient to withstand the pressure?

TERMINOLOGY

Before manufacturing the mould should know following terms:

- CORE: it is the male impression of mould situated on moving half, after the injection component on this side.
- CAVITY: it is the female impression of mould situated on fixed half side.
- RUNNER: runner is a channel machined on mould plate connects the spur with the entrance to the impression.
- GATE: A gate is a small opening through which the melt enters the impression.
- PARTING SURFACE: these are the surfaces of the mould plate adjacent to the impression which butts together to from a seam and prevent loss of material from the impression.
- SHRINKAGE : material expends when it is heated upon cooling to the same temperature it will contact to the same volume .shrinkage is the reduction in dimensions which a component under goes after molding it expands as % or as inch/inch(mm/mm).

ASSEMBLY

After all parts are manufactured, inspected and found right the assembly is started. Assembly is a highly skilled operation done by the toolmakers. It is to fit each and every part into their respective position and to produce a good working tool. Care should be taken while assembling, since mishandling may result in damage of parts, thereby resulting in wastage of cost, labour and time.

Points to remember:

The guide bushes and pillars are fitted with lubrication into their respective bores.

The core and cavity are slid into their respective plates and Clamped from backside. The ejector pins are placed in the proper holes. Ejector back plate is clamped with ejector guide bush in alignment with ejector guide pillar. Spacers are placed on either sides of the ejector assembly. Feet buttons are fitted into the bottom of ejector back plate. Main clamping screws are inspected for its length. Sprue bush is inserted and locating ring is clamped onto top plate.

MOULDING PARAMETERS

After final assembly, the mould is taken for tryout. Before loading in an injection molding machine, some important things to be checked.

Mould manufacturing check list:

- Are all the parts secured properly & tightly?
- Is the cavity polished in the direction of how
- Are any negative tapers in the inserts?
- Is ejection system actuation proper?
- Is the die set actuation proper?
- Is the locating ring diameter suit the machine hole?
- Is the cooling circuit proper without any leakage?
- Is the tie-bar tightened properly?
- Are the proper lifting holes are provided?

When the tool is subjected to the actual working conditions, the performance is noted and if there are any defects they will be reworked if necessary. Core, cavity & feed system was heated to a temperature of 80 - 120oc by circulating hot oil through the channels provided . At the same time molding material is kept for preheating ,(about 40-60oc) to remove moisture and then loaded to the injection unit. The mould should also be preheated (80-120oc) to avoid wrapl flow marks on the cores &cavity.

Tool clamping:

There are two methods of securing the tool to the press platens namely direct bolting and clipping. The first system employs bolts which pass through holes in to back plate & threaded holes is pulled by a bolt and later engaging a conveniently positioned threaded hole in the platens , with one end on packing & other on the tool back plate.

Debinding

After molding binder is removed from the compact by debinding.The polymers are removed gradually without effecting the integrity of the compact by slowly heating the compact to decompose and evaporate the binder. Debinding involves two steps namely, solvent and thermal debinding. In solvent debinding, the soluble component of the binder system is removed by immersing the component in the solvent. During solvent debinding the polymer on the surface first dissolves, exposing the inside core of the part to the solvent. The solvent then diffuses into the green component and dissolves more of the remaining soluble polymer.

The solvent containing the soluble polymer then diffuses out of the component. The part with higher volume to surface area takes longer time to debind than the part with lower surface area to volume ratio. After solvent debinding the components undergo thermal de-binding where in the insoluble portion of the binder system is removed. During this process, the binder first turns into liquid and then is degraded into low molecular hydrocarbon.

Sintering

Is carried out in the same cycle as that of thermal debinding or after a pre-sintering cycle. Pre-sintering involves heating the component just beyond the thermal debinding temperature (900-1100° C) to provide enough strength for handling. Sintering involves the elimination of the void spaces remaining after removal of binder by making the particles shrink together. Sintering in effect is densification step that imparts strength to the compact. Sintering is usually performed.

In a controlled atmosphere furnace or a vacuum furnace at temperature that causes rapid elimination of the pores previously filled by the binders. Sintered products can further be densities, heat-treated or machined.

COMPONENT INSPECTION

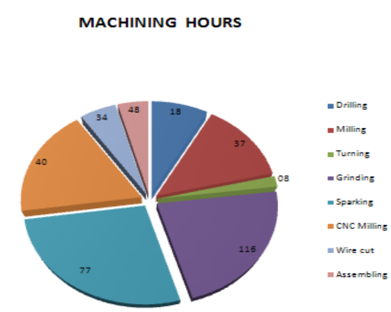
The quality of the any product can be measure in terms of standard items of drawing. This process is called inspection it gives the measurement of a product or its quality in terms of prescribed standards. Inspection compares material, product of performances with established standards it also reflects on the quality of each part after each process is completed. This is called stage inspection. Inspections of product are mainly inspected after hardening. Should be carried out thoroughly because any slight dimensioned variation affects the accuracy of component.

Mainly inspection in two stages:

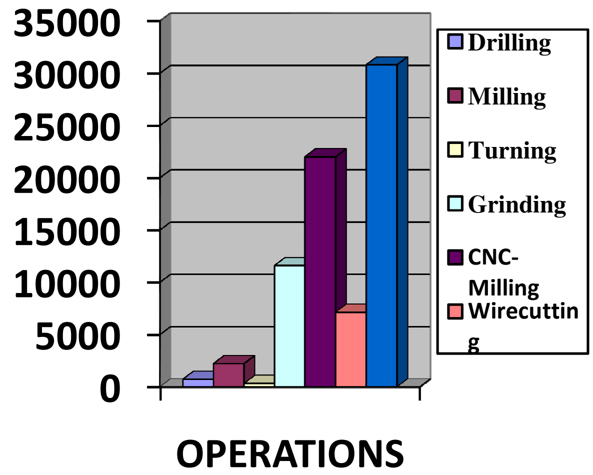
1. Post sintering appraisal- Before secondary Operation
2. Final inspection- After secondary operations.

The method of inspection used in this product was room inspection or centralized inspection.The various samples of the product were inspected using precision devices and also inspected by Common measuring instruments like micro scope, vernier caliper, slip gauge, digital vernier, height master, profile projector, CMM, stander gauges & fixtures etc.

MACHINING HOURS CHARTS



MACHINING COST PI CHART



CONCLUSION

This project report on **'Single cavity metal Injection Mold'** this gives the general idea of tool making by explaining the various aspects, from designing process to machining.

Identified the flow line and crack issues at molten metal powder merging area in UZI PRO FRONT WALL part by using of designed mould. So we need avoid these two problems by proper design of tool (mould).crack is the very critical issue to avoid in injection molding process.

In our project we designed the flash pocket. By introducing of flash pocket in the tool itself to avoid the flow line and crack issues. Crack is one of the major quality complaint issues in manufacturing industries.

As a whole this project has helped in improving our overall skills as a Toolmaker and also helped us in presenting our views, regarding this particular trade and project.

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- http://www.flomet.com/capabilities_emi.php
- http://www.beckettmim.com/materials/

SOFTWARE

- ♣ PRO-E -WILDFIRE-04 – For tool and component designing.
- ♣ ZWCAD -2009 - For manufacturing tool
- ♣ DELCAM - For CNC milling.
- ♣ E-SPIRIT – For sparking.
- ♣ MS OFFICE - For preparing project report.
- ♣ HASCO STANDERD – For tool design.