INVESTMENT CASTING: LOST WAX PROCESS

What is investment casting ?

Historic

The precision casting by lost wax process, called investment casting is an ancestral process born more than 3000 years ago in Mesopotamia for art statues.

For the industrial field it was born after the Second World War with the increasing market of turbines powered aircrafts. The development of refractory materials, nickel base mainly which are expensive and difficult to machine, launches the lost wax process casting into the industrial world.

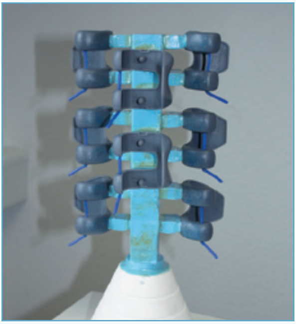
Indeed, thanks to its possibility to obtain complicated parts and precise dimensions, this casting process was well adapted for these new needs required by aircraft engines.

For, it has never stop to progress and to enter several new markets.

The process

The wax pattern, which exactly looks like the metal part to be manufactured, is injected in a tooling, generally in aluminium. This allows important batch series with good shapes and dimensions reproductions.

Each injected pattern will lead to a metal part. So, if the need is 500 pieces for example, 500 wax patterns have to be injected.



These waxes are then glued on wax bars, called "trees", which constitutes an assembled set called grapp.

After, these grapps are coated with ceramic layers by successive operations of dipping in liquid ceramic and spraying of dry refractory sand. About ten layers are made which create a sort of shell of approximately ten millimetres wide which covers completely the wax grapp.

Then, after a few days drying time this ceramic shell with its wax is put in an oven (autoclave) to melt the wax. Finally, we obtain an empty cluster in which the melting metal will be poured.

Before the casting operation, the cluster is heated in a furnace at 1 000°C for one to two hours. This cooks the ceramic, burns the eventual rest of wax and gives to the shell the good temperature to resist to the casting without any problem.

In parallel of this pre-heating, the metal melting is done. This operation is done in electric induction furnaces. The T° is around 1 500°C and the casting is done under protective atmosphere. For the titanium casting, vacuum furnaces are used.

When the grapp is at the right T° and the melting bath also, the casting could be done. The pouring is made by gravity, usually by reversing (turning) of the furnace.

Then, just wait for the cooling.

After the cooling, we break the cluster (the ceramic shell). Sand blasting is done to eliminate the last pieces of ceramic.

The parts are cut from the tree and the finishing could be done. This is several operations like grinding, sand blasting, milling...

Heat treatment and eventually, if required by the customer, HIP treatment (Hot Isostatic Pressure) are realized.

To finish the manufacturing, the dimensional controls and non destructive checking are done. These are X-ray inspection, fluorescent (or coloured) penetrant inspection and visual control.

Shipping to the customer or to a sub-contractor finishes the work of the foundry company.

Advantages – Limits

Advantages

The main advantage of this casting process is to avoid the maximum of machining operations thanks to its dimensional precision.

This process is very accurate and the possibility to obtain very tight dimensions on the rough parts leads to the cancelling of some very expensive machining operations. It's mainly interesting on very high quality alloys as for example stainless steel or, of course, Co-Cr alloys.

If the precision is not finally enough for the useful of the part, the necessary extra material for the machining is reduced comparing to the ones which have to be added with the other casting processes. So, win of material and time.

On very hard and expensive materials this will have a great impact on the part's final cost.

The surface roughness, generally around 3.2Raµ is very fine for a casting process and allows for example to have to polish the parts. Or at least, leads to a less expensive polishing.

More, investment casting gives the possibility to get very thin walls of parts or complicated details as for example diamond pins, streaks or teeth....

To finish, due to no constraints of demoulding, complicated shapes are allowed in lost wax foundry.

Numerous alloys are able to be cast with this process but in medical field, the main used are generally "Co-Cr" (ASTM F75 – ISO5832-4) and austenitic stainless steel (F1586 – ISO 5832-9). Eventually titanium alloys like TA6V (ISO5832-3) but this material requires a more complicated process. Hardening stainless steel 17.4Ph (AISI 630) is used for instruments.

Limits

Technically lost wax casting gives especially advantages. However, very thin walls, very deep holes, some sharp edges, long and thins parts… are not easy or impossible to be made. At least not with economical results.

As well, pieces with too much differences of thickness or not really designed for casting, will have metallurgical defects or deformations (twist).

The cost for injection tooling, mainly for small batches, could make investment casting not profitable process.

However, in this case, rapid prototyping processes like thermojet (stereolithography) or silicon moulds could be used.

Then, lead times for developing are generally a little bit long and could be negative.

The Medical Field Applications

The medical field, orthopaedy mainly, is a great user of this manufacturing process.

Knee prosthesis, tibial and femoral components generally cast in "Co-Cr" are parts manufactured by hundreds of thousands each year worldwide.

Cups for hips, mainly double mobility cups due to their complicated external design, but as well, shoulders components, elbow or ankle joints, trauma (staples) are usual cast parts.

Instruments and ancillaries, in stainless steel, are more and more cast. This decreases the cost of machining.

To finish, titanium parts are possible to be cast, with special equipment. For instance, trial implants manufactured in this material decrease a lot the weight of the instruments boxes.

The quality guarantees

The first control made on a casting component is visual inspection. The general aspect is so checked.

Then, to guarantee the metallurgical quality of the parts, several controls are made before shipment.

These controls are insured by the quality department who commits itself in this field.

Penetrant inspection (zyglo by fluorescent or coloured method) is 100% done to detect the external (surface) troubles.

X-ray inspection is operated to find the eventual internal defects.

Mechanical tests, on test bars, are done to validate the mechanical properties (tension-compression, ductility…).

More complicated analyses could be operated like grain sizes determination, macrograph or micrograph inspections, hardness or tribology controls…

The dimensional aspect is generally verified on the first samples and then, in series product, controlled with gauges.

Partner

MediMet is located in Stade close to Hamburg – Germany. Orthopaedy is the only one business sector of this company which produces rough parts for prosthesis, mainly in Co-Cr alloy, by investment casting with lost wax process.

The company is turned to export sales and has the quality agreements ISO9001 and 13485.

www.medimet.de

MediMet
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