Special Project 96

Prototype Tooling

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The Product Design Special Project entitled **'Prototype Tooling'** is hereby approved as partial fulfilment for the degree of Master of Design.

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1. INTRODUCTION

Tooling is a prime consideration in the decision making process involved in the planning of the manufacture of any product. It is obvious that because the tooling costs are part of the manufacturers investment, these costs must be recovered as part of the price of the product. Therefore before the decision is made to produce a product, the manufacturer must make very detailed plans with regard to the identification of the required tooling and the estimating of the tooling cost. When the tooling costs have been determined , they will be combined by estimates on manufacturing costs, marketing costs , a desired profit margins and various other considerations. It cannot be over- emphasized at this point how important it is that the forecasted costs be accurate. This is particularly true for the estimated tooling costs. In most industries the tooling costs represent substantial part of the investment. Consequently, an error or an underestimate of the total tooling costs could mislead the management into undertaking an unprofitable venture.

The use of plastics as tooling materials has provided many new opportunities for the tool engineer to advance the state of the art and improve tooling costs. The very dynamic nature of the plastic industry promotes constant change and improvement . Through the continued development of new materials, new applications and new tool fabrication techniques, the plastic tooling industry has steadily grown

2.BASIC CONCEPTS OF TOOLING WITH PLASTICS

Tools can be fabricated from either metal or plastic. While both of these materials can be worked or formed to an identical shape, there are some great differences in the methods used to arrive at a desired shape with either metal or plastic. In making metal tools the material is either cast or extruded to a rough shape and machined or hand finished to the desired configuration. Another method of making metal tools is to stretch sheet metal to the desired contour by the use of a forming tool. The stretched sheet becomes the tool. In most cases, the manufacture of metal tooling requires expensive equipment and considerable hand work.

The basic concept of making plastic tools is quite different. The materials used in plastic tooling are resins in the liquid state that are capable of forming solid, stable shapes through the use of a suitable catalyst or hardener. This permits the use of plastic tooling materials to be formed to a net configuration . Normally, hand finishing is kept to a minimum.

3.PROTOTYPE TOOLING

With increasing competition , greater pressure on R&D departments to design good products in less time, and increasing tooling costs, accurate and lifelike prototyping has become essential.Testing of actual products under actual situations has become necessary.Investing in hard tooling without actual testing is now becoming uneconomical. Also reworking on tooling is time consuming and very expensive. Plastic tooling is a very promising tooling method for accurate prototyping .

Prototype tooling can be categorized as follows-

3.1. Epoxy tooling.

3.2. Flexible plastic tools and molds.

3.3. Metal arc spray mold making.

3.1.Epoxy tooling -

Epoxy tools are of two types - laminated plastic tools
cast plastic tools

The materials used for plastic tooling fall under three general categories depending on their function

a. Casting compounds -

casting of plastic tooling compounds represents the quickest and easiest method of making plastic tools.The use of casting compounds permits simply mixing the two components in their proper ratio and pouring of the mixture slowly into the cavity. Casting compounds are usually of low viscosity (10000 centipoises or less)in order to facilitate pouring without entrapment of large amounts of air.They are usually filled systems incorporating the use of metallic powders or clays as fillers. Casting compounds require minimum of 16 hours cure at room temperature.

b. Gel coats or surface coats-

Gel coats are specifically formulated to be applied to the surface of the model in a thin layer (1-2 mm) When properly backed up by either a laminate or a casting , the gel coat becomes the surface of the tool. Gel coats are usually characterized by their high degree of thixotropy and high viscosity when in a liquid state. Thixotropy is the ability of a material to adhere to vertical surfaces without sagging or running off. A wide variety of fillers are incorporated into a gel coat system to provide specific properties. A metallic filler such as silicon carbide may be incorporated into a gel coat system to provide abrasion resistance.

c. Laminating systems -

Laminating compounds are specifically formulated to impregnate fibre glass cloth during the process of making a fibre glass laminated tool. Consequently these materials are normally low in viscosity,have some degree of thixotropy, and have the ability to wet or penetrate fibre glass cloth. The use of laminating compounds enables large tools to be made with very low material cost. Because laminating is a time consuming operation, laminating compounds normally have a pot life of a minimum of 30 minutes.Laminated tools are much lighter in weight than either metal or cast plastic tools.

Depending on their chemical composition epoxy tools can be classified as

a. Polyesters- Polyester resin compounds are used in tools and molds in applications where dimensional accuracy is not a critical factor. Two main advantages of polyesters are that they can be cured rapidly and they are substantially lower in cost than other thermosetting materials used in tooling. The main disadvantage of polyesters is their high shrinkage.

b.Epoxies- Of all the thermosetting plastics used for tooling,the epoxies are proven to be the most versatile. The advantages of epoxies as tooling materials are their low shrinkage,high flexural and compressive strength,dimensional stability,good resistance to corrosion,weathering and ordinary chemicals. Because epoxies are excellent adhesives,epoxy tools can be easily repaired with the same material from which they are made.

Preparation of model surface-

Plastic tooling materials reproduce every detail of a model surface including even the most minute surface detail such as wood grain and finger prints. The finish on the surface of the tool can only be as good as the original model. For this reason,great care should be exercised to ensure that the model surface is perfect. Thermosetting materials are also excellent adhesives,hence a parting agent or mold release must be applied to the model before application of the tooling plastic. For metal models silicone grease can be used as parting agent. the plastic models either PVC or PVA (polyvinyl alcohol) is used. Thermosetting plastics rely on exothermic heat generated during the chemical reaction for complete curing.If plaster or wood models are not sealed properly,this may give rise to steam which penetrates and damages the parting film.

3.2. Flexible plastic tools and molds-

Flexible plastic tooling materials play an important role in the overall tooling picture. The use of these materials permits casting and molding of complex shaped parts that cannot be made on rigid tooling.Flexible tooling is used to greatest advantage on parts with intricate details,undercuts,and / or deep draw with very little draft. Flexible tooling is very useful in making cast metal parts as well as injection molded plastic prototypes.

There are basically four different types of materials commonly used for flexible tooling applications: the room-temperature-vulcanizing (RTV) silicone rubbers, the polyurethane elastomers,the polysulfides,and the latexes.Of these four materials, the RTV silicone rubbers have the most to offer as tooling materials.

The room temperature vulcanizing silicone rubbers are a highly versatile family of elastomers.Some of the significant characteristics of silicones which makes them so useful as tooling materials are:

a.retention of properties over a wide temperature range,
b.outstanding release properties,
c.excellent resistance to chemicals,
d.low shrinkage,
e.the ability to be molded and cured at room temperatures,
f.easy and safe handling characteristics.

The making of silicone RTV molds involves the following processes:

a. Model Preparation

The pattern can be made in wood, plaster, plastic or metal. It should be free of defects prior to the casting of a silicone rubber mold. Silicone molds are very difficult to repair or touch up. The next step is to construct a framework around the framework. The frame work should be on a level surface to ensure that the casting is of uniform thickness. All surfaces to be exposed to the RTV silicone rubber casting compound are then coated with suitable release agent.

b. Weighing and mixing

The amount of material required to make the mould is carefully calculated. A clean container with a capacity of approximately four times the volume of silicone rubber required to make the mold should be used.The RTV casting compound is then weighed into the container, and catalyst is added.A typical compound-to-curing agent ratio is 10:1 parts by weight. Increasing the amount of catalyst will cause the material to cure faster and will result in a mold with greater flexibility.

c. Deaeration

Because the stirring action results in air entrapment in the mixed components, it is advisable to deaerate the compound prior to pouring. Deaeration is best achieved by placing the silicone compound in a vacuum chamber and applying vacuum.

d. Pouring

The RTV casting compound is then slowly poured into the mold cavity. Enough RTV silicone should be used to fill the mold cavity to a point atleast 8 mm above the highest point of the pattern.

e.Curing

The curing of RTV silicone casting compounds can be accomplished in 24 hours at room temperature.However,in order to achieve optimum physical properties,a post cure at elevated temperatures (90 - 175 deg.) is sometimes recommended.

f.Removal of pattern

The silicone mould is cut along the parting line to remove the pattern.Resins are measured in the proper quantity and mixed.The mixed resin is poured into the vacuum chamber through the gate, made in the silicone mould.Molten metal can also be poured if the desired article is to be a metallic one.The mould is moved to a heating chamber,where the resin is cured.The casting is removed from the silicone mould.The gate and risers are cut to get the article.

3.2.2 Spin Casting

In this method silicone RTV moulds are used to cast high strength metal products.This process is used for pressure die-casting zinc alloys,high strength zinc-aluminium alloys,led and tin based alloys and aluminium.

Spin -casting can be used to manufacture and /or prototype both functional and decorative products.Molds can be made and prototypes be cast in as less as three hours to a maximum of a day depending on the nature of complexity.Design changes in size,function fit ,or appearance are quickly reproduced without making a large tooling or machine time investment.Spin-casting provides a highly cost-effective alternative to limited-run precision die casting and other casting or fabrication techniques.

Spin-casting is done in six steps:

1. Mould preparation: Parts or models are laid out on a disc of uncured silicone rubber. Depending upon mode/pattern thickness and shape, cavities may be cut or moulded by hand to accomodate the part. The uncured silicone material is soft and hand-mouldable like clay.

The mould parting line is formed at this stage and can be built up or lowered around any section of hte model/pattern. At this time, cores and pull-out sections can also be incorporated, if required.

Mould parting compound is sprayed on the moulds and "Acorn" nuts are arranged around the edge where- like pins of a die - they precisely position the mould halves to each other.

2. Vulcanization : After preparation, the mould is placed in a ring shape vulcanizing frame. This frame is placed in an electrically heated vulcanizing press for curing. Hydraulic force clamps the mould frame shut between the heated platens, forcing the silicone into all crevices and around all details of the model / pattern. The heat cross-links the uncured silicone resulting in a tough, resilient, dimensionally accurate and heat and chemically resistant mould. After vulcanization the mould is easily flexed to release the patterns (and later, parts) from the cavities. This is true even for patterns with a wide variety of undercuts.

3. Gating and venting : The gates, runner system, and air vents are easily cut into the rubber with a sharp knief or scalpel. If the initial spin casting tests show a need for faster flow or more air venting the in-gates can be cut thicker and air vents may also be drilled into the cavity to aid in removal of entrapped air or gases. Similar gating and venting systems are used for both metals and plastics, so both materials can be cast in the exact same mould for evaluation.

4. Spin - casting : The mould is placed in the casting machine where it is automatically centred. The mould is then pneumatically clamped and the spin speed, clamping pressure and cycle time set.

5. Pouring and setup : After the spin cycle starts, the liquid metal or plastic is poured into the casting machine. Pressure caused by the centrifugal force pushes the liquid through the moulds runner system, completely filling every section, corner, detail and surface finish in each mould cavity.

6. Parts removal and mould recycling : After metals solidify and plastics set up, the parts are quickly removed from the mould. With metal, 50 to 60 cycles per hour are readily made; with plastic, 10 to 15 cycles are typical. For clean - up , the gates , runners and vents are readily broken away by hand. Many parts are ready for assembly or use, or for painting, plating or coating, with no further clean - up, because spin casting is a precision casting process.

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