INTRODUCTION

Duromer resins are used without reinforcement in a number of casting applications which generally fall into the following categories:

a) EMBEDDING AND POTTING  Resins may be used for embedding botanical and zoological specimens, or other items of interest within glass-clear blocks for preservation or as ornaments. The excellent dielectric properties of polyester resins, and their ability to be cured at ambient temperatures, has led to their widespread use for potting or encapsulating electronic components.

b) DECORATIVE CASTINGS  Filled and pigmented polyester castings are extensively used for the manufacture of buttons, cutlery handles, buckets and artificial jewellery. The most significant use of polyester resins in this field is undoubtedly for button manufacture where, by the careful control of resin type and casting technique, effects ranging in complexity from simulated pearl to imitation horn may easily and convincingly be obtained.

c) REPLACEMENT FOR WOOD, STONE, ETC  By the careful selection of appropriate fillers, polyester resin-based casting compositions may be formulated to duplicate the appearance of many natural materials ranging from metals, timber and plaster through varieties of natural stone to simulated marble and onyx.

Duroplastics has formulated a range of these.

This Technical note is intended as a guide to the use of polyester resins in such applications and deals with the materials and processes involved. Further details may be obtained on request from Duroplastics.

RIGID MOULDS

Rigid moulds are used wherever there is sufficient draft and no undercuts to interfere with demoulding. The advantages of rigid mould are low tooling costs and long mould life. Some types used are fabricated from reinforced polyester or epoxy, cast epoxy, cast metal or cast urethane. When using moulds of this type it is important that a release agent be employed to facilitate mould release. In addition to the temporary release agents normally used, there are more permanent types such as Teflon finishes and silicone coating resins.

Construction of rigid mould varies with the choice of material. Cast metal moulds can only be made by competent tooling shops, whereas cast epoxy and urethane moulds are simply made by pouring a two-component resin system over a master, where it solidifies on curing. More difficult to make, but stronger and lighter, are the reinforced epoxy or polyester moulds. They are made by first coating the master with a layer of gelcoat which is brushed on and allowed to gel or solidify. A piece of fibreglass mat is then cut approximately to size and saturated with more resin (referred to as the tooling resin). Before it gels, it is laid over the master and 'worked' with a stiff brush to conform to the shape of the master. In this type of mould-making operation, it is very important to employ a suitable release agent on the master.

FLEXIBLE MOULDS

When undercuts or inadequate drafts make rigid moulds impractical, flexible moulds are recommended. The most widely used flexible mould material is silicone rubber. This material can be highly recommended because of its toughness and resistance to chemical attack and high exothermic temperatures. In addition, it has unique self-releasing properties which eliminate the need for release agents and subsequent degreasing operations.
Urethane elastomers are also used to make flexible moulds. They resemble silicone rubber in flexibility and toughness, but do not have quite the same longevity or release characteristics. Their relatively low cost is an important factor in recommending their use.

A newer and more recently used mould material is vinyl plastisol. Vinlys look and handle differently than silicones or urethanes. They do not gel and cure in the same manner and can be extremely flexible. They are supplied as liquids and must be heated slowly to an elevated temperature (usually 180°C) and the poured over the master, which must be preheated. When the casting cools, it can be stripped from the master and put into service. After the mould has deteriorated it can be remelted to pour a new mould. The high flexibility of vinyl plastisol lends itself well to moulds with deep undercuts, but due to its limited use there is little information available concerning the extent of its production life.

**FLEXIBLE MOULD-MAKING TECHNIQUES**

Good open-faced moulds can be constructed with relatively little effort, using a simple guideline. Use of a minimal amount of rubber and careful control of its uniformity in the construction of the mould box will ensure a mould pliable enough to strip easily from the polyester part. This requires more mould-building time but saves minutes on the demoulding cycle.

Construction of the two-part mould is slightly more difficult. It is imperative to ensure positive mould alignment in order to avoid a severe parting line which can result from differing rates of expansion of the top and bottom halves of the mould under heat and chemical attack from the moulding resins. There are two basic techniques that can be used to ensure positive alignment. The first entails creating on the bottom half of the mould a groove which completely surrounds the master. This can be done by bending a brazing rod to conform approximately to the shape of the master, suspended around its horizontal equator halfway between the master and the mould box. After the first half of the mould is cured, the brazing rod is removed and the second half of the mould is poured, creating an interlocking channel which ensures, positive mould alignment.

The second method utilises a permanent wooden frame that surrounds the master around its horizontal equator, halfway between the master and the mould box, on both the top and bottom halves of the mould. The wooden frames should be secured to the mould boxes, approximately 3mm short of the equator of the master. This method will prevent the rubber from shifting either inward or outward.

**RELEASE AGENTS**

Release or parting agents become necessary whenever sticking is anticipated, either between the master and the mould or between the mould and the polyester parts. In addition to providing anti-stick protection, the release should spread in such a manner as to prevent build-up or clogging of the master’s definition. Consideration must also be given to the effect that the release agent may have on the mould-making compound. Certain chemicals, for instance, can inhibit the cure and ruin the mould. The release agents used between the mould and the moulded parts have to meet slightly different requirements. They should provide anti-stick protection in very thin films, be ready for immediate use, and preferably should not cause post-finishing problems.

**WAXES**

Wax solutions are among the most common types of release agents, chiefly because of their low cost. Waxes will, however, promote poor adhesion of finishing coats applied to the moulded parts unless they are ‘degreased’ prior to the application.
SILICONES

Silicone oils will also work well as release agents and several are advertised as being 'paintable'. Use of this agents eliminates the degreasing step. Caution is advisable, however, because some oils will not work satisfactorily with all types of finishes.

PVA

Polyvinyl alcohol solutions, although slow-drying, make excellent release agents. These should be sprayed on the mould in uniform thickness, since they air-dry to a thin plastic film which could obscure mould details. This film has excellent solvent resistance which should increase mould life, and it is uniquely 'degreased' from the part by flushing with water.

FLUOROCARBONS

Fluorocarbon or 'Teflon' type releases have their own advantage, in that they need not be applies before each and every casting. As the mould becomes 'broken-in', re-application of the release becomes less and less necessary, and as many as two dozen parts may be made before re-spraying the mould.

FILLERS

Fillers will reduce the shrinkage of the resin mixture and provide a 'heat sink' for the heat generated during curing. Fillers can be used to impart special characteristics to the resin mixture and to modify the properties of the original resin. In electrical applications silica, quartz, mica and slate dust in various forms may be used to modify the electrical properties of the moulding. Surface hardness and compressive strength are improved by most fillers. Abrasion resistance is improved by alumina, superfine molochite and metal powders. The appearance of a cast can be changed for decorative and functional applications by calcium carbonate, slate dust, graphite, metal powders and many other fillers.

When a filler is employed, care should be taken to ensure that the filler is dry and does not inhibit the cure of the resins. In many cases it may be desirable to increase the amount of catalyst and/or promoter to ensure that full cure is obtained. The increased catalyst/promoter levels must be strictly controlled to avoid reintroducing crazing characteristics to the system.

GENERAL CASTING PROCEDURE

MIXING

The resin should be weighed into a suitable container and the fillers added in a free-flowing form. Care should be taken during the mixing operation to avoid air entrapment through controlled agitation. When the fillers have been dispersed in the resin, the mixing operation is ended and any entrapped air allowed to escape. A quick method of doing this is to slow the speed of the agitator until it is barely turning. This helps break up and release entrapped air bubbles. If low-density fillers are used, the compound cannot be left standing unagitated for more than a few hours or the filler will begin to separate and float to the surface of the resin. If this does occur, the filler can easily be redispersed with further agitation.
POURING

The amount of polyester needed to fill the mould should be drawn from the master batch into a clean container. Polyethylene buckets are excellent for this purpose, since they can be obtained in various sizes and are reusable. After the resin portion of the compound in the container has been calculated, the appropriate amount of catalyst (usually 1% of the resin weight) should be added, and thoroughly mixed, making certain to scrape the sides of the container. If the volume of compound is small, it can be hand-mixed with a spatula. Larger amounts may require motorised mixing for best results. Average mixing time in either case ranges between 30 seconds and one minute. The compound should now be poured into the mould, making sure to pour resin on top of resin, creating as little turbulence as possible, in order to avoid entrapping air on the surface of the mould. If a core is to be inserted in the mould, the mould should be poured almost full, the core inserted, and more material added if necessary.

DEMOULDING

When demoulding strength has been reached, the mould should be separated carefully from the part to avoid damaging delicate sections. To aid demoulding, all flexible moulds should be designed to be removed from their mould boxes in order to take full advantage of their elasticity. Whenever possible open-faced mould should be designed to support themselves without the mould box. If the part is difficult to remove, a skin mould can be made so that the casting can be inverted and the mould peeled back. Another technique used in demoulding is to blow compressed air between the part and the mould. This helps break surface tension and causes the part to rise up from the mould, thus avoiding stresses which occur when only one end of the part is grasped in an attempt to remove it from the mould.

EQUIPMENT

DISPENSING EQUIPMENT

When higher demand warrants increased production, several alternatives are available. The expansion of the hand-pour operation by the addition of one or more dispensing machines is currently the most accepted method in use. This type of equipment will quickly and airlessly mix and dispense the catalyst with the filled polyester, thus reducing waste and manpower and at the same time increasing mould turnover. A single machine, supplied with enough moulds, can produce 500 tonnes of parts per year.

CURING

To boost production and increase mould turnover still further, the installation of a radio frequency curing oven is very effective. When a mould filled with polyester enters the machine it is immediately heated, causing the polyester to gel. The elevated temperature also promotes a fast cure and rapid demoulding, yielding mould cycles of approximately 1-2 minutes. If the mould is made of silicone rubber or some other low dielectric loss material, it will have the added advantage of remaining cool during the RF treatment, and this, coupled with the shorter demoulding cycle, will aid greatly in prolonging the life of the mould.

CENTRIFUGAL AND ROTATIONAL MOULDINGS

Both of these techniques are used to make tubular or hollow castings. They utilise the centrifugal force created in a spinning mould to hold the resin against the face of the mould cavity until it cures. Centrifugal casting rotates on axis only, and can be used to make relatively simple castings of tubular configuration. Rotational moulding involves a double axis that can produce hollow castings of almost unlimited shape.