ENTEC

GUIDE TO

ROTATIONAL MOLDING

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INTRODUCTION TO ROTATIONAL MOLDING

Rotational molding first started in the late 1930's with the development of plasticized PVC but didn't become popular until the 1950's when powdered polyethylene grades that were designed specifically for rotational molding, and hot air ovens were developed. With this new material and equipment, it was possible to rapidly advance the production of hollow parts, which was heavily utilized by the toy industry.

Rotational molding differs from other plastic processing methods in several ways. First, plastic powder is used instead of pellets and the powder melts in the mold instead of being forced into the mold under high pressure. Because of this low pressure, rotational molds are less expensive than injection or blow molding molds. The mold is rotated in 2-directions in order to coat the mold surface and melt the powder and build up the desired wall thickness. Parts produced by rotational molding are hollow and virtually stress free because they are molded without any external pressure. Very large hollow parts are ideally suited to the rotational molding process.

ADVANTAGES OF ROTATIONAL MOLDING

- HOLLOW PARTS CAN BE MADE WITH NO WELD LINES
- MOLD AND TOOLING COSTS ARE LOW
- SUITABLE FOR SHORT OR LOW VOLUME PRODUCTION RUNS
- LITTLE TO NO RESIN WASTE OR SCRAP
- EASY TO CONTROL WALL THICKNESS
- ELIMINATES THE NEED FOR SECONDARY TOOLING
- CAN PRODUCE VIRTUALLY ANY SIZE PART, FROM SMALL TO VERY LARGE
- PROVIDES EXCELLENT SURFACE FINISH AND SURFACE DETAIL
- CAN MOLD-IN METAL INSERTS
- CAN MOLD PARTS WITH UNDERCUTS AND INTRICATE CONTOURS
- DOUBLE WALL CONSTRUCTION IS POSSIBLE
- MULTILAYER PRODUCTS ARE POSSIBLE

APPLICATIONS

Rotomolding allows for the production of a wide range of fully or partially closed parts and the parts can be flexible or rigid depending on the specific resin being molded and the wall thickness of the part. Rotationally molded parts find use in many common industries, markets, and applications.


PLAYGROUND EQUIPMENT


INDUSTRIAL, AGRICULTURAL & COMMERCIAL STORAGE TANKS


PACKAGING CONTAINERS


HOUSINGS FOR CLEANING EQUIPMENT


CANOES & KAYAKS

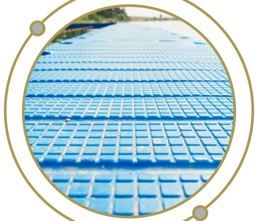

LARGE TRASH CANS


TRAFFIC BARRIERS


PORTABLE OUTHOUSES


TOTE BINS


SURF BOARDS


DOCK FLOATS

DESIGN – ALMOST ENDLESS POTENTIAL

While rotomolding offers the designer much freedom and flexibility in part design because of the ability to eliminate design concerns that can be found in parts produced with other processing methods. Rotomolding can produce parts with consistent wall thickness, thicker corners for added strength, double-wall construction and the ability to easily incorporate inserts. However, there are a few areas that should be given special consideration when designing parts. These include flat surfaces, undercuts, threads, inserts, radii of corners, and narrow passages.

Large flat surfaces can create warpage problems. If possible, parts should be designed to avoid flat sections and, where necessary, they should be broken up with ribs or domes to keep warpage to a minimum.

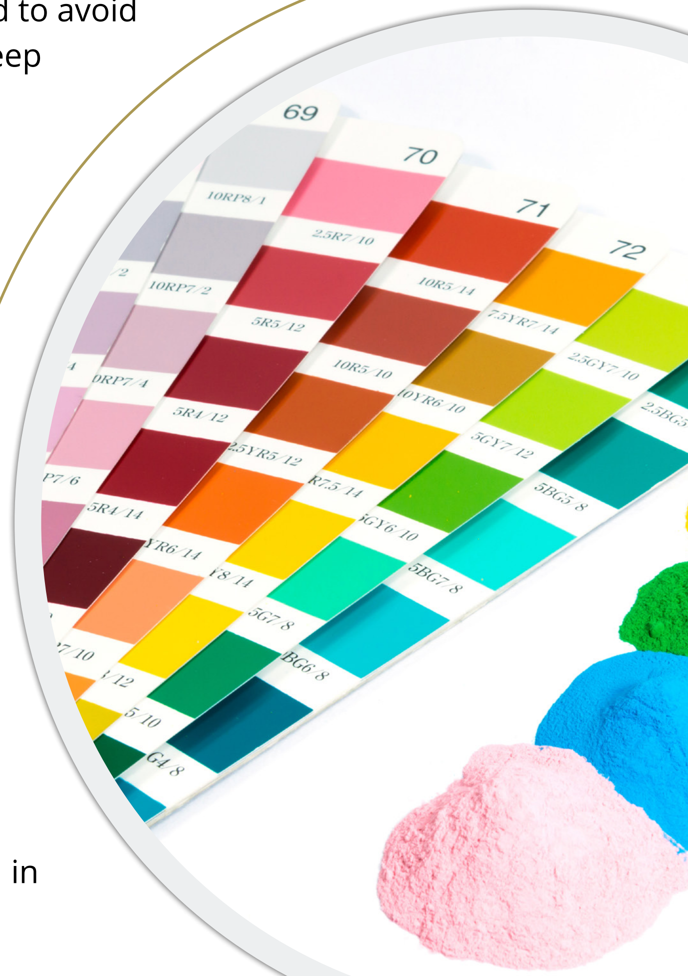
Undercuts should be held to a minimum in rigid parts. If undercuts are necessary, the mold should be parted to allow for easier removal.

Threads should either be a round bottle or a modified buttress. Round bottle threads fill easily but buttress should have generous radii on the edges of the threads.

Inserts should be positioned in the mold using jigs or magnets before the resin is added. Care should be taken to minimize built-in stresses around metal inserts. Metal inserts should be degreased before they are inserted into the mold.

Well radiused corners are recommended to prevent molded-in stresses and part thickening in the corners. A radius of 0.250 to 0.187-inches is recommended.

Molding parts with narrow passages should be avoided as the resin does not easily fill in these areas and could result in parts having voids or incomplete fill.



RESIN CHOICE

The base resin selection is very important since it is the foundation of the process and must be selected to meet the performance requirements of the application. Things to consider when selecting the resin include strength, rigidity or flexibility, temperature resistance, indoor or outdoor use, color, and special requirements.

Polyethylene is the most common material used in rotational molding, but polypropylene, polycarbonate, nylon, acetal, and polyesters are also used. A number of other plastic resins have been rotational molded, but their use is very limited. Because of the longer cycle times, resins for rotational molding typically include additional antioxidants as well as UV stabilizers for long life in outdoor applications.

Polyethylene is a particularly good material for rotational molding. When used as a fine mesh powder, polyethylene's melting characteristics easily form a solid part. Polyethylene has good heat stability to withstand the relatively high temperature and long heating cycles of rotational molding. Parts formed from polyethylene have an excellent combination of strength, toughness and other mechanical properties.

Read More | The Different Types of Polyethylene Resins for Rotational Molding

Polyethylene offers the following characteristics that have made them the most widely used powders for rotational molding:

- They are easily ground to 35 mesh powder
- They have good thermal stability
- They have good oxidation resistance
- They have good mechanical and thermal properties, including impact
- They can be stabilized to offer excellent UV / weather resistance
- They have good resistance to a wide range of chemicals
- They are relatively low in cost
- They are easy to color
- They can be cross-linked to improve thermal and chemical resistance

RESIN CHOICE

The most important properties of polyethylene rotational molding materials are the melt flow index and density. Melt index is measured at 190°C with a load of 2.16 kg, with units of grams / 10 minutes, and gives an indication of the molecular weight of the material. A higher melt index represents a lower molecular weight while a lower melt index represents a higher molecular weight. The typical melt index range for rotational molding polyethylene is 3 to 7 grams /10 minutes.

Density, in units of grams / cm^3, is an indication of the crystallinity of the polyethylene resin. The higher the crystallinity, the higher the mechanical properties, and melting point, of the resin. A density of 0.940 to 0.950 g/cm^3 is common for many polyethylene rotomolding products, but lower and higher density grades are also used depending on the required properties of the parts.

Rotational molding materials provided by Entec Polymers are designed for optimized processability and properties in rotational molding. These products are produced utilizing prime quality materials and additives by a process designed to yield consistent material, box-to-box, and shipment-to-shipment.

Polyethylene is available in several types depending on the desired end properties needed.

- Low Density Polyethylene (LDPE): Tough and flexible
- Medium Density Polyethylene (MDPE): Better properties than LDPE, but not as high as HDPE
- High Density Polyethylene (HDPE): Highest mechanical properties and chemical resistance
- Polyolefin Elastomer (POE): These are high flexibility, high impact polyethylene elastomers
- Cross-Linkable Polyethylene (XLPE): Contains a crosslinking agent that reacts during molding and provides a product with higher thermal and chemical resistance and environmental stress crack resistance

MOLDS FOR ROTATIONAL MOLDING

Since rotational molding is a low-pressure process and the molds require no drilling of cooling lines, these molds can be relatively simple. Because of this simplicity, the cost of a rotational mold is a fraction of that for a comparable injection or blow mold.

Two-piece molds are the most common, but three-piece molds are sometimes required to facilitate proper removal of the finished parts. Molds can be as simple, such as a round object like a ball, or complex with undercuts, ribs and tapers.

Selection of rotational molds depends on the size, shape and surface finish of the part to be molded, as well as the number of molds required for a particular application. Molds should be as thin-walled and lightweight as possible.

TYPES OF MOLDS

The most important property of a rotational mold is that its interior surface has to be completely non-porous. Cast aluminum molds are the most commonly used molds in the rotomolding industry but stainless steel, sheet steel, cast and machined nickel and cast and machined beryllium copper are also used. High strength aluminum alloys can also be used.

Cast aluminum or electroformed nickel-copper alloys are recommended for small to medium sized parts and have good heat-transfer characteristics and are cost effective when several molds of the same shape are required. The main drawbacks to cast aluminum molds are they can be porous and easily damaged.

Sheet metal molds are normally used for larger parts or prototype molds because of their low cost. They are easy to fabricate, and, in many cases, the sections of the mold need only be welded together. Sheet metal molds are cost effective when larger single-mold parts are required.

Other molds, such as cast beryllium copper are used where fast molding cycles or superior chemical resistance are required.

The four main types of flange-mating surfaces are shown in the figure below. Each mold must be in two or more sections requiring good parting lines to have proper fit of the mold sections. The mating surfaces should be machined smooth for a good fit and the molds should be stress-relieved before the parting lines are matched.

PARTING LINES

Even with the best parting line, a good clamping system is required. The most common clamping system for small-to-medium sized parts is the "C" vise clamp. Spring-loaded clamps, welded onto the sections of the mold, are another commonly used option. As the molds get larger, nuts and threaded bolts are normally used.

MOLD MOUNTING

Many types of clamping devices are used. Where individual molds are mounted without a spider, C-clamps or vice grips are clamped onto the parting line flange. Molds are often mounted on a steel spider and held together with a group of bolts or adjustable clamps.

INSULATION LIDS & COVERINGS

When openings are required in rotationally molded pieces, insulating lids or inserts can be used. Basically, an insulating material is applied to an area of the mold to keep the powder from fusing at that point. PTFE and silicon foams are commonly used.

Thin-walled sections can also be obtained by covering a section of the mold with an insulting material that results in a small amount of powder sticking to the mold. The wall thickness can then be controlled to some extent by changing the type or thickness of the insulating material.

VENTING

Because of the inherent build-up of gas in the heating cycle of the rotational molding process, most rotational molds require a venting system in order to obtain a high-quality part. Depending on the size of the mold, vents can range from 1/8" to 2" inside diameter. A common rule of thumb is to use a 1/2" inside diameter tube for each cubic yard of part volume. Vent tubes should extend to the center of the mold and the inside end should be loosely packed with glass wool to prevent the unfused powder from exiting the mold early in the heating cycle. In order to be efficient, vent tubes must be kept clean. If the packing becomes clogged with plastic powder the vent tube will no longer function to equilibrate pressure.

Since vents leave holes in the molded parts, they should be located in an area that may be cut out of the finished part or in an area where a patch does not reduce the aesthetic value of the end product. Proper venting will allow the part to be heated and cooled at atmospheric pressure which will eliminate blowholes at the parting line. Proper venting will prolong the contact of the cooling part with the inner surface of the mold, resulting in a shorter cooling cycle and less post-mold warpage. Lower pressure differential also results in longer mold life.

Read More | Venting Molds in Rotational Molding

MOLD RELEASE

In order to obtain satisfactory mold release, it is recommended that the mold cavities be kept clean and that a proper mold release agent be used. In addition, most rotational molds are designed with little or no draft angle, so it is important to properly condition the molds with a release agent. Molds are commonly cleaned with a solvent and a light abrasive cloth to remove all foreign particles and residue left on the mold surface. Molds that have been used with plastics other than polyethylene may require special cleaning. Sand blasting with aluminum oxide or glass beads has been proven to be very effective.

After the mold is cleaned, a light coating of mold release agent is applied and baked-on to ensure a good coating. In general, most mold release agents work best when they are applied to a warm mold (130°F or higher). The mold release should be sprayed onto a rag, and the rag is then used to apply the mold release to the desired areas of the mold. If mold release is used incorrectly, it can lead to quality issues such as warping, surface pitting, release build-up and dimensional issues.

Read More | Mold Release in Rotational Molding

ROTOMOLDING EQUIPMENT

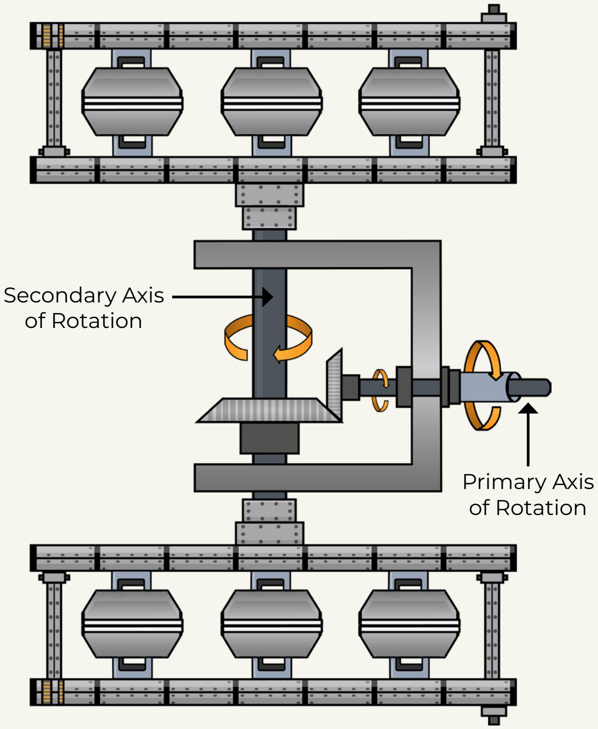
The equipment used in rotational molding is relatively simple but has many variations. The most common type of rotomolding machine is a multiple-spindle or carousel machine. Carousel machines are usually wheel shaped. The spindles, each carrying a single large mold or a group of molds, are mounted on a central hub and driven by variable motor drives.

The carousel consists of a heating station or oven and a cooling station. In many cases, the carousel also is equipped with an enclosed chamber and a loading and unloading station.

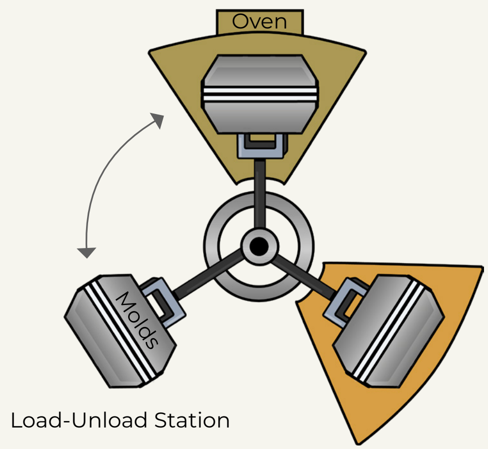
The shuttle-type machine is commonly used to rotationally mold larger parts. A frame for holding one mold is mounted on a movable bed. The bed is on a track that allows the mold and the bed to move into and out of the oven. After the heating cycle is complete, the mold is moved into a non-enclosed cooling station.

The clamshell utilizes an enclosed oven that also serves as the cooling station. This machine uses only one arm and the heating, cooling and loading/unloading stations are all in the same location. Other types of equipment include "open flame" and "rock-and-roll."

Schematic of a system used to obtain mold rotation in two perpendicular planes



Carousel Type Machine



HEATING STATIONS

Mold heating methods include hot-air, convection, hot-liquid conduction, infrared radiation and direct gas-jet flames. Hot air is a commonly used heat source for rotational molding. Either gas-fired, oil-fired, or electrical heaters can used to heat the air. Nowadays, most rotomolding ovens are fired by natural gas, using blowers to distribute heat throughout the chamber. Typical oven temperatures are 400° to 850°F and ovens must be well insulated to minimize heat loss. Hot-air convection is the most commonly used heat source, although hot-liquid conduction and infrared radiation are also used.

MOLD COOLING STATIONS

Molds are cooled by air, water and oil. Spraying with water is the most common method of cooling the mold and is conducted while the mold is biaxially rotating. Water spray produces rapid and uniform cooling.

The cooling station may use a combination of forced air for initial cooling followed by a water system. This is done to prevent too rapid of cooling which can result in warped parts.

ROTATIONAL MOLDING PROCESS CONTROL

At first examination, the rotational molding process seems simple. Those who have had experience producing parts by rotational molding understand that rotomolding is a complex manufacturing process because there are many variables that can affect the quality of articles produced.

Because of the variety of parts made by the rotational molding process and the different types of rotational molding machines and molds used in the process, it is impossible to establish universal molding conditions that are optimum for all circumstances.

In order to achieve consistent, high quality rotationally molded parts, it is important that proper molding conditions are used and that all variables in the manufacturing process be controlled as closely as possible. Each rotational molding cycle must be performed under the same conditions as the previous cycle, in order to obtain parts with consistent properties and dimensions.

Because different parts are often placed on the same arm or different arms of a multi-arm machine, the molding cycle is often a compromise to achieve acceptable quality for all parts being simultaneously molded.

PULVERIZED RESIN QUALITY

The majority of rotational molders prefer resin powder with a 35-mesh particle size. The powder is produced by grinding or pulverizing. Pulverizing is one of the key considerations for rotomolding resins and is one of the primary factors in producing high quality parts. Blade design, blade gaps, mill temperatures, speed, and proper maintenance of the pulverizer all play a role in the quality of the powder. Poor quality pulverizing results in powder with tails and hairs causing the particle shape to look like a ‘comma’. These tails will cause the resin to clump together and create flow and fill problems during the molding resulting in defects such as voids, surface porosity, and poor impact strength.

Pulverized powder quality can be evaluated by conducting a flow test. In this test, 100 grams of resin is poured into a 10 mm funnel in a circular motion while holding the opening of the funnel closed with a flat object. The funnel is then opened, and the time is measured to determine when all of the powder is out of the funnel. A typical flow time for a good, high-quality powder is 22 to 30 seconds. If the flow time is longer than this, the powder quality should be evaluated, and adjustments made to the pulverizing operation.

DRYING

Polyethylene does not readily absorb moisture, and therefore, under normal conditions, pre-drying of the pulverized powder is not required. Under high humidity conditions, or when specialty grades such as a flame retardant resins are used, drying may be necessary.

MEASUREMENT OF CHARGE

Production of consistent parts requires that each step of the rotational molding process be repeated precisely every cycle. It is especially important that the same weight of polymer be added to the mold for each part. The bulk density of pulverized polyethylene for rotational molding has some variability and therefore, material should be measured on a weight rather than a volume basis.

OVEN PROCESS

Proper cure of the rotationally molded part requires sufficient heat to melt the polyethylene for a long enough time duration to completely fuse the material. The oven temperature must not be so high that the polyethylene is oxidized and degraded.

While the molder would like the oven temperature to be as high as possible to shorten the heating time, keeping the oven temperature as low as possible gives optimum part appearance and toughness, reduces the cooling required, and reduces thermal stress on the mold. The rotational molder must decide what combinations of these variables results in acceptable part quality and productivity. In general, polyethylene rotational molding materials should process between 480 and 600 °F depending on the wall thickness, shot weight, and material grade of the part being produced. The molders experience with existing molds and specific molding machines may suggest slightly different conditions. The oven time is driven primarily by wall thickness and will vary depending on the equipment and tooling type. You can reduce the trial and error involved in establishing time/temperature parameters by measuring the PIAT (Peak Internal Air Temperature).

Read More | Monitoring the Internal & Peak Internal Air Temperature during the Rotomolding process

New rotational molding ovens are being designed to improve manufacturing efficiencies and provide better process control through automation advancements. Carousel and shuttle ovens are available with auto cycle indexing based on mold temperature measurement systems. Carousel rotational molding ovens equipped with additional positions for precool, final cooling, and additional loading / unloading stations promote faster process cycles. These faster more efficient cycles can reduce energy costs per part by reducing time the oven is empty.

COOLING PROCESS

Like heating cycles, there is no universal best cooling cycle. For a multi-arm molding machine, the cooling time should not be any longer than the heating time in order to be the most efficient. However, high cooling rates increase the potential for warped parts. Because polyethylene is a semi-crystalline polymer, the degree of crystallinity is partly controlled by the cooling rate of the part. Rapid cooling results in parts with overall lower crystallinity, however, low crystallinity occurs at the mold side of the part and higher crystallinity occurs at the inner surface of the part. This difference in crystallinity is a major cause of part warpage. This is why slower cooling, with both air and water spray has been found to help minimize warpage.

Higher density, high performance polyethylene resins in the 0.942 to 0.952 g/cm3 range tend to be more crystalline and have a higher shrinkage rate. These materials may need to be cooled more slowly to prevent warpage (example: no fans / water for a period of time at the start of the cooling cycle), and every attempt should be made to hold the part against the mold surface until the release point. This is best determined by monitoring PIAT trace during the cooling cycle.

TROUBLESHOOTING GUIDE

While rotational molding is a fairly simple process, is not free of processing issues and part defects. However, most problems encountered can be easily solved with adjustments in processing conditions.

The following Troubleshooting Guide provides a list of common processing problems and part defects and their most reliable remedies. These troubleshooting tips are primarily for polyethylene and polypropylene rotational materials but may also be applied to other materials.

PROBLEM	PROBABLE CAUSE	POSSIBLE SOLUTION
WARPED PARTS	Inadequate venting.	Provide adequate venting of 3/8”- 1/2” diameter vent per cubic foot of molded volume, especially for thin-walled parts.
	Non-uniform cooling of part caused by resin pulling away from mold.	Rotate mold during cooling cycle. Provide adequate venting and make sure vents are not clogged. Use less mold release. Check for too effective mold release agent. Avoid large flat panels in part design if possible. Reduce cooling rate during initial part cooling cycle. Increase the cooling medium temperature, air cool, and then water cool. Apply air pressure through spine during cooling.
	Non-uniform cooling caused by uneven wall thickness in the part.	See suggested remedies under problem heading “Uneven wall thickness of molded parts”.
	Non-uniform cooling caused by sections of the mold being shielded from heat and cooling medium.	Mount mold to eliminate shielding problems. Add baffles to direct heat and cooing into recessed or shielded areas.
	Uneven cooling caused by clogged water nozzles.	Check and clean nozzles on a periodic maintenance schedule.
	Over-cured part. Degradation of the resin due to high temperature and/or excessively long heating cycle.	Decrease oven temperature or heating time.
	Highly under-fused part. Some degree of under-fusion is advisable especially in the case of low melt-index resins to prevent degradation; however, highly under-fused parts can cause significant loss of impact strength.	Increase oven temperature or total heating time. Increase heat transfer rate by using thinner mold walls or make the mold from materials with greater heat transfer coefficient (steel or aluminum).
	Improper coloring.	Select pigment and pigment loading that does not affect resin. Use pre-colored compounded resin.
	Resin type.	Use proper resin having adequate melt index and molecular weight distribution for application.
	Moisture on resin or pigment.	Use only dry powder and / or pigment.
BLOW HOLES THROUGH THE PART OR RINGWORM EFFECT UNDER THIN WALL SURFACE OTHER THAN AT THE PARTING LINE.	Porosity in the cast aluminum mold.	Obtain better quality castings. Drill through void and drive pin or weld from inside. Relieve from outside by drilling into void. Remove parts from mold while warm to the touch. This helps to drive moisture out of the pores.
	Pores or holes in welds.	Use proper welding rod and procedure. Weld inside surface first to get good penetration.

PROBLEM	PROBABLE CAUSE	POSSIBLE SOLUTION
POOR IMPACT STRENGTH	Resin selection not correct.	Use lower density or lower melt index resin.
	Density increases during slow cooling.	Increase cooling rate to maintain a lower density.
	Part design not appropriate.	Review and alter mold design if necessary. Eliminate sharp corners and narrow passages.
	Insufficient fusion of resin.	Increase oven time and / or temperature.
	Improper coloring.	Select pigment and pigment level that does not affect impact. Use pre-colored compounded resin.
	Over-cure of resin. Degradation of resin due to long-term high temperatures.	Decrease oven temperature or heating cycle.
PARTS STICK IN THE MOLD	Insufficient amount of mold release agent or the release agent has deteriorated with use.	Reapply or use more release agent. Old release may have to be removed and a new one applied.
	Ineffective release agent or mold release does not withstand elevated temperatures.	Use suitable mold release agent that is effective for resin and temperature used. Apply according to supplier's instructions.
	Mechanical interference during part removal.	Locate mold parting line at undercut or taper side walls of mold.
	Roughness and porosity of mold surface provide areas where resin may adhere.	Refinish damaged mold surfaces, plug, weld, and sand smooth.
	Presence of resin at parting line due to internal mold pressure forcing semi-molten resin through parting line.	Provide adequate venting, 3/8" to ½" diameter vent per cubic foot of mold volume is suggested, especially for thin-walled parts.
	Build-up of degraded resin in the mold may be caused by burning of thin-walled sections.	Clean mold periodically. Reduce oven temperature.
	Shrinking onto large deep inserted areas.	Provide adequate taper to mold walls. Use effective mold release on insert areas. Remove part while warm. Provide adequate means for applying force to separate mold halves.
	Undercuts in mold.	Design mold to place undercuts at parting lines so that molds have draft angle for part removal.
	Low shrinkage value for resin.	Use higher density polyethylene grade.

PROBLEM	PROBABLE CAUSE	POSSIBLE SOLUTION
EXCESSIVE FLASHING AT MOLD PARTING LINE.	Internal mold pressure during heating cycle tends to force semi-molten resin out through the parting line.	Provide adequate venting and make sure vents are not clogged. Remate mold parting line and adjust mold clamp pressure evenly. Clean mold flange to prevent gapping and apply new mold release on flange. Reduce internal air pressure if used. Use lower melt index resin.
BUBBLES ON THE MOLD PARTING LINE.	During the first stages of cooling there will be a rush of air into the part to fill the resultant partial vacuum. If there is inadequate venting, air will penetrate the molten resin at the parting line, becoming trapped as the part wall solidifies.	Vent the mold to atmospheric pressure. Relocate vent to middle of mold. Use glass wool in the vent tube. Use PTFE as vent tube. Make sure vent tube is adequate size.
	Poor mold parting line.	Remate molding parting line and adjust mold clamp pressure evenly. Clean mold flange to prevent gapping and apply new mold release on flange.
DISCOLORATION OF INTERIOR SURFACE OF PART.	Degradation of resin due to high temperature and / or excessively long heating cycle.	Decrease oven temperature or heating cycle or purge part with inert gas (nitrogen). Use resin with proper amount and type of antioxidant. Check pigment for heat stability.
POWDER BRIDGING OR NOT FILLING NARROW PASSAGES OF MOLD.	Mold design incorrect.	Modify mold by increasing width to depth ratios across the mold opening. Design corners of mold with more generous radii. Avoid ribs with less than 4X wall thickness.
	Poor pourability (dry flow) of resin.	Make sure powder has acceptable pourability and bulk density.
	Powder does not melt or flow properly.	Use finer mesh powder or resin with a higher melt index.
	Cold spots on mold.	Avoid any shielding mold areas. Check for mold wall thickness uniformity.
	Improper mold rotation.	Use correct ratio and rotation speed.
BLOW HOLES THROUGH PART AROUND INSERTS.	Poor fit on inserts allowing moisture or vapors to be trapped around insert and expand, blowing a hole in the part.	Refit inserts and relieve to allow trapped gases to escape to the outside of the mold. Drill a small hole through the insert bolt to relieve gas pressure.
	Bridging of resin because of close dimensions.	Change inserts dimensions or location to allow powder to flow without bridging.

PROBLEM	PROBABLE CAUSE	POSSIBLE SOLUTION
POOR PART STIFFNESS.	Part wall too thin.	Add more powder to initial charge.
	Resin selection not correct.	Use resin of higher density.
	Part design not appropriate.	Review and alter mold design if necessary.
	Under fused parts.	Increase oven temperature or total heating cycle. Increase heat-transfer rate by using thinner mold walls or make the mold from materials with greater heat-transfer coefficient (steel or aluminum). Try filling molds while hotter.
LIGHTENING EFFECT IN COLORED PARTS.	Moisture in pigment or resin.	If dry blending, dry pigments or use pigments from unopened container. Use pre-compounded colored resin powder. Dry resin completely or replace.
	Static build-up.	Add small amount of mineral oil to resin or add commercially available anti-static additive. Make certain that all mixing and molding equipment is adequately grounded with high surface copper cable.
	Pigment not ground properly.	Use 100-mesh pigment or pulverize pigment prior to mixing. Use pre-compounded colored resin powder.
SPECKLED COLORS AND LUMPS OF PIGMENT IN DRY BLENDED COLORS.	Insufficient blending.	Break up agglomerates of pigment before blending. Use high intensity mixer. If unable to achieve a desirable color balance, use a pre-compounded colored resin powder.
LONG OVEN CYCLES.	Heat-transfer rate not adequate to melt all resin due to excessively thick mold.	Increase heat transfer rate by using thinner mold walls or make the mold from materials with greater heat transfer coefficient (steel or aluminum).
	Heating not efficient.	Increase air velocity around mold during heating cycle. Check oven for air leaks.
	Low oven temperature.	Increase oven temperature. Recalibrate instruments on a regular schedule.
	Resin powder too coarse.	Use finer mesh powder.
	Poor melt flow.	Use higher melt index resin.
	Extended cooling.	Reduce air-to-water cooling ratio.

PROBLEM	PROBABLE CAUSE	POSSIBLE SOLUTION
LONG TERM PART FAILURE.	Part over cured during molding.	Decrease oven temperature or heating cycle.
	Photo-degradation of part caused by ultraviolet light from sun or internal lighting.	Use UV stabilized resins in application. Add suitable UV stable pigment.
	Stress-cracking due to multi-axial stresses in part. Cracking may have been accelerated by chemical environment and /or temperature.	Use polyethylene grade with good environmental stress crack resistance (ESCR). Modify design around the areas containing inserts. Examine parts in field use to determine adequacy of design around stress concentration points.
	Inadequate resin additive system.	Antioxidant type and level of concentration may be inadequate. Reduce level of internal mold release if used.
	Color changes due to oxidation. Light colored parts may look yellow or pink.	Reduce oven temperatures.
	Improper colorants or blending.	Use colorants that disperse well in base resin. Use pre-compounded colored resin powder for optimum dispersion or color and stabilizers.
UNEVEN WALL THICKNESS OF MOLDED PARTS.	Improper mold rotation.	Vary ratio and speed of rotation of mold to obtain even coverage and adequate number of powder tracking's.
	Mold shielding.	Mount molds to eliminate shielding.
	Uneven mold wall thickness.	Use care in designing molds to prevent excessive variations in mold wall thickness (thin spots attract more resin).
	Inadequate powder properties. Low bulk density, no powder pourability, large amount of fluff, particles may have many tails that entangle into clumps during molding.	Obtain an acceptable quality powder. If using bulk powder storage, empty stage silos before refilling to prevent accumulation of fine particles in storage silo.
	Buffeting or air flow in deep dished areas.	Avoid deep dished areas whenever possible. Reduce thickness of mold in dished areas. Open handles so air can flow through kiss-offs in mold.

PROBLEM	PROBABLE CAUSE	POSSIBLE SOLUTION
HIGHLY UNDER FUSED PARTS WITH MANY SMALL BUBBLES IN WALL OR ROUGH POWDERY INSIDE SURFACE.	Oven temperature not high enough to drive air bubbles out of part walls.	Increase oven temperature or total heating cycle.
	Heat transfer rate not adequate to melt resin.	Increase heat transfer rate by using thinner mold walls or make the mold from materials with greater heat transfer coefficient (steel or aluminum).
	Resin powder too coarse.	Use finer mesh resin powder.
	Moisture in mold.	Reduce moisture content in mold by running with warm molds and dry molds before charging powder.
	Poor mold design.	Design shallow recesses with generous radii on edges. Pre-heat recessed areas with torch for 30-seconds before charging. Add heat deflectors or thermal pins.
	Improper mold rotation.	Change ratio and / or speed of rotation.
	Melt index of resin too low.	Increase melt index of resin.

References:

1. "Introduction to Rotational Molding Seminar", Dr. Glenn Beall, Association of Rotational Molders, Chicago IL.
2. Rotational Molding Troubleshooting Manual, (ARM-102-1089), Association of Rotational Molders, 1989, Chicago, IL