Rotational Molding

The rotational molding is a high temperature and low pressure plastic forming process. The powder is inserted into the closed split mold and rotated in biaxial to produce a hollow part. The schematic of rotational molding process is shown in figure 1.

Working Principle

The plastic material in the form of powder is inserted into the mold. The mold is heated in an oven and rotated biaxial until the powder has melted. The molten powder is adhered to the mold wall and makes a thin layer. The mold is opened and finished part is removed. The mold is rotated at different speeds in order to avoid the accumulation of molten powder. The amount of time required to heat the powder at molten temperature in to the oven is important. If the oven is heated for long time, powder will degrade and it will affect the mechanical properties. If the mold is heated short time, the powder may not be completely melted, resulting in large bubbles in the powder. The formed part must be cooled through the air so that it solidifies slowly. The formed part will shrink on cooling, and facilitating easy removal of part. The cooling rate must be kept within a certain range. The water cooling should be avoided, because formed part may shrink and warped after cooling.
A mold release agent should be used to quickly remove the formed part. Mold release can reduce cycle times and defects of finished product. Three different types of mold release agent may be used i.e. sacrificial coating (silicones), semi-permanent coating, (polysiloxane), and permanent coating (polytetrafluoroethylene).

**Process Parameters**
- The amount of powder
- Heating temperature and time
- Rotational speeds
- Cooling rates

**Material Used**
Thermosets and thermoplastic material can be used, for example: low density polyethylene (LDPE), high density polyethylene (HDPE), polypropylene, and polyvinyl chloride (PVC).

**Applications**
Additives for weather resistance, flame retardation can be incorporated. Products that can be manufactured include storage tanks, bins and refuse containers, airplane parts, road cones, footballs, helmets, and rowing boats.

**Advantages**
- Allows complex mold split lines.
- Allows molded threads and mold-in inserts.
- Allows a wide range of surface finishes (textured, smooth, or polished).
- Very little waste.
- Low residual stresses
- Tooling is less expensive
- Suitable for both low-volume prototypes and high-volume production runs
Disadvantages

- Slow production speed. It usually takes about one hour to complete the process
- Lower precision

Blow Molding

Blow molding is a manufacturing process that is used to produce hollow plastic parts by inflating a heated plastic until it fills a mold and formed the desired shape. The schematic of blow molding process is shown in figure 2.

Working Principle

In this process, the thermoplastic in the form of small pellets or granules is first heated above the melting temperature and molded into a preform using injection molding process. These preforms are used to feed into the blow mold. The preform is heated above the glass transition temperature and formed into a hollow tube which is called parison. The parison is then clamped between two mold halves and inflated by high air pressure until it conforms to the inner shape of the mold. The air pressure is required as 60 to 140 psi depending upon the material used. The preform is always stretched from the center of the part during the process. This is a single stage process, as both preform manufacturing and bottle blowing are performed in the same machine. The formed part solidified as it is cooled inside the mold. The mold halves are separated and the final product is removed. Final part may be trimmed.

![Figure 2 Blow molding](image)
Generally, mold can be made of metal. Cycle time depends upon the finished part wall thickness. If the part wall thickness is 1.5 mm, the cycle time will be 40 to 50 seconds.

**Process Parameters**

- Amount of plastic material
- Melting temperature of plastic material
- Air pressure required
- Cooling time

**Materials Used**

Different types of thermoplastic material are used, for example: High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), Polypropylene (PP), Polyvinyl Chloride (PVC), Polyethylene Terephtalate (PET), and Polycarbonate (PC).

**Applications**

Different types of plastic products can be manufactured by this process such as bottles in different shape and size, jars, and containers, ducting, fluid oil tanks, mugs, and toys.

**Advantages**

- Low tooling cost
- Fast production rates
- Ability to mold complex part with uniform thickness
- Little scrap generated
- Large hollow shape can be produced
- Produced parts can be recycle

**Disadvantages**

- Limited to hollow parts
- Thick parts can’t be manufactured

**Machining of Plastics**
Most of the finished plastic products are produced directly by molding processes. But some of the complex plastic products that can’t be directly manufactured by the molding process and require finishing operations to give final shape, to improve dimensional accuracy and final finish. The life cycle of plastic products are very short, and if limited numbers of plastic product are molded for specific application then machining becomes more economical. All plastic materials (thermosets and thermoplastic) can’t be machined, because some of the plastic materials are soft and flexible in nature. The machining of plastic material depends on the two factors i.e. cutting tool material and rigidity of the material being cut. The machining of plastics is different from metal due to its rigidity. The rigid plastic materials can be machined easier; but more flexible and softer plastic materials are very difficult to machine. The softer and flexible plastic materials can also be machined with the application of specially designed jigs and fixtures.

It is well known that the plastics have lower thermal conductivity therefore heat generated during machining can’t dissipate quickly. At higher machining speed, plastic may soften due to heat induced during machining and the machined surfaces may get smeared. Therefore, cooling medium (air or lubricant) is required during the machining. Generally, compressed air is used for machining of plastics. Because lubricant or liquid coolant may react with the plastic material during machining and it can degrade the mechanical properties or surface quality. A strong jet of compressed air or coolant serves three purposes i.e. it cools the workpiece as well as cutting tool, it helps to remove chips quickly and improves the surface finish of machined surface.

An important point is to be noted that while the machining of thermoplastics produces continuous swarf, but thermosets produce chips form. The chips are always removed rapidly in order to carry away as much heat from the surface as possible.

The high speed steel (HSS), carbon steel, and carbide tool materials are commonly used for machining of plastic materials. Machining with carbide tool may improve the surface finish of plastic product. A large number of machining methods (such as turning, drilling, milling, threading and tapping, sawing, and grinding) can be used for plastics which have been discussed as follow:

**Drilling:** All types of hard plastic material can be drilled. Generally, standard twist drill is used for drilling of plastics. During drilling of thermosets, cracking around inlet and exit hole edges
are common. Moreover, higher drill point angle induces more stress along thickness direction as compared with lower drill point angle. Therefore, especially designed twist drill (drill point angle may be varies from 60° to 90°, and rake angle 0°) should be used for drilling of plastics. The heat generated by the drill causes the thermoplastic to expand and shrink up on cooling. Hence, to maintain the drilled hole sizes, allowance has to be made in drill sizes (0.002 to 0.16 mm depending upon the drill size). The operating variables (feed rate and cutting speed) should be high so that the material can be easily drilled and chips are removed quickly. Drilling forces (thrust force and torque) slightly decrease as the cutting speed increases. At higher cutting speed, surface finish will improve. Drilling with carbide tool materials gives better surface finish. While drilling with thick sheet (thickness 3 times greater than drill diameter), cooling air or lubricant should be used.

Reaming: It can be carried out after drilling or boring operation to provide both accuracy and good surface finish. Generally, spiral-fluted reamers are used. The reaming can be done dry, but use of water coolants will improve the surface finish. Standard cooling oils or lubricants should be avoided.

Threading and Tapping: Threading should be done using single point with carbide insert. The coarse series of threads should be used because less frictional heat will be generated. Tapping is the process of cutting internal threads. The tapping speed should be low. It is also recommended that oversized tapes should be used because of elastic recovery of plastic materials. Coolant may be used for both threading and tapping operations.

Sawing: Band saw and circular saw with buttress thread or widely spaced thread should be used in order to easy removal of chips. The speed of the saw blade should be used in the range of 300 to 900 m/min for better cut. Feed rate should be high. It should also minimize the friction between the saw blade and the work, and even blocking of the saw. A clamping fixture should be used in order to avoid vibrations and consequent rough cutting or even rupture. Tungsten carbide saw blades provide an optimum surface finish.
**Turning:** Turning speed should be in the range of 90 to 180 m/min and low feed rate should be preferred. Fine grained C-2 carbide tool is generally used for turning operations. Sharp tool bits with 10 to 15° clearance angles and 10 to 20° positive rake angles should be used for better operations.

**Milling:** Two flute end mills, face mills and shell mills with inserts as well as fly cutters can be used. Down-milling is normally recommended to reduce heat by dissipating it into the chip. Fast table travel and high spindle speed will improve the surface finish, but low travel speed will generate excessive heat that can cause melting. Fixtures should be used for providing adequate support to the workpiece. Mist type water cooling is recommended.

**Grinding:** It is rather difficult to grind the thermoplastics due to high amount of heat generated and it results in the clogging of the abrasive wheel. A low grade grinding wheel with open grain spacing with the application of coolant should be used. Generally, hard materials are better ground with finer grit size wheels and soft materials are better suited for grinding with coarse grit wheels. The wheel specification, 54 and 46 grits are recommended for thermosets and thermoplastics, respectively.

**Advantages**
- Plastic product can be manufactured with short lead times
- Ability to manufacture low volumes economically
- Thicker wall sections can be machined
- Heavy molded plastic can be machined
- The power required to machine plastics are low
- Chips can be recycled

**Disadvantages**
- Soft and flexible plastic can’t be machined easily
- Relative high cost of block plastic material
- High volume of chips to be removed
- For increase in production by machining will require robust jigs and fixtures
- Heat generated in the machining process can’t dissipated quickly
- Dust producing plastics require an effective dust collection system