TECHNICAL BULLETIN: DESIGN OF ROTOMOLDED PE PARTS

POLINTER

1 Introduction

Rotomolding is designed for obtaining hollow plastic parts of great size, practically having no competitors in molding bigger parts [1]. However, there are small products manufactured with rotomolding (for example balls and roll-ons), in which cases molds with many cavities are used [1].

Polyolefin, mainly polyethylene, are the dominating materials in the rotomolding market [1,2,3,4]. Polyethylene (PE), in its various forms, represents 85-95% of all rotomolded polymers [3,4].

Next we will present aspects that should be taken into consideration when designing plastic parts that are to be rotomolded with PE.

2 The mold.

- Large products such as tanks or parts with low appearance requirements, are manufactured in molds made of steel or aluminum sheets.
- Parts with greater appearance requirements or more complex are generally produced in molds made of cast aluminum [1,3].
- For higher quality requirements in the surface of areas, the molds may be manufactured with electroforming or deposition in vacuum techniques (nickel or copper-nickel) [2].
- The number of partition lines of the mold must be the minimum in order not to increase its cost and maintenance and thus the cost of the part [1,4], that could also increase due to excessive irregularities or rough edges, which have to be removed, created by the partition lines [1].

3 Guide / Aspects of the Design of Parts to be rotomolded with PE.

3.1 Nominal Thickness of the wall

- It should be such that it maintains the mechanical properties of the material, requires for the performance of the part without having long time cycles, seeking optimum efficiency and without degradation of the material [2].
- The thicknesses of the wall can be controlled by altering the speed of the equipment axles [3].
- By isolating some areas of the mold, the increase of the thickness between them is reduced, and greater thickness is obtained by directing extra heat.

In the following chart the nominal thickness values of the wall are shown for rotomolded PE parts [1].

Thickness	mm	Inches
Minimum	1.52	0.060
Optimal	3.18	0.0125
Maximum	12.70	0.500
Thickest known	50.80	2.000*

* Crosslinked PE.

3.2 Radio in corners

- Sharp corners should be avoided [2,4], just as in all types of plastic moldings.
- The recommended value of the radios of the corner is, at least, 75% of the nominal thickness of the wall in order to improve the resistance of the area (inner corners tend to be thinner and external corners thicker than the wall thickness) [2].

In the following chart shows the radii values on the corners for rotomolded PE parts [1].

Radius	External	Inner
Minimum	1.52 mm (0.060 in.)	3.20 mm (0.125 in.)
Better	6.35 mm (0.250 in.)	12.70 mm (0.500 in.)

3.3 Corner angles

- Acute angles should be avoided so the bridging of the powdered material does not occur [2,4].
- The corner angles rotomolded with PE should not have less than 45° [1].

Next we have the angles used in rotomolding with PE [2].

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Angle	Value
Minimum used	30°
Minimum recommended	45°
Good	90°
Better	120°

3.4 Minimum separation of the wall (double wall molding)

- The inner separation between surfaces (X in Figure 1) should be, at least, three times the nominal thickness of the wall (W) [2,4], however this relation should only be used in extreme cases [1]. The minimum standard separation should be five tomes the thickness of the wall (X≥5W) [1].

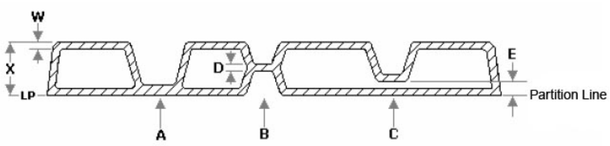

Figure 1. Design details of the flat or double wall, rotomolded parts.

3.5 Reinforcements

- They should be designed as corrugations instead of solid ribs [2].
- The corrugations should have a slight wall biasing to enable the unmolding [2].
- The width of the hollow rib (M in Figure 2) should be, at least, five times the thickness of the wall (W), (X≥5W) and the height (N) at least four times the thickness of the wall [1,3].
- The spacing between the ribs (O in Figure 2) should not be less than three times the thickness of the wall (O≥3W), although a spacing of 5 times W is better [1,].
- Special devices are also used called *kiss-offs*, which are very effective to give rigidity [3] A and B in Figure 1.
- The combined thickness of the walls in the *kiss-offs* (D in Figure 1) should be 1.75 times the thickness of the walls (D=1.75W) [1].
- In the case of pseudo-reinforcements (C in Figure 1), the separation (E) should be, at least, 3 time the thickness of the wall (E≥3W), although a spacing of 5W is better [1].

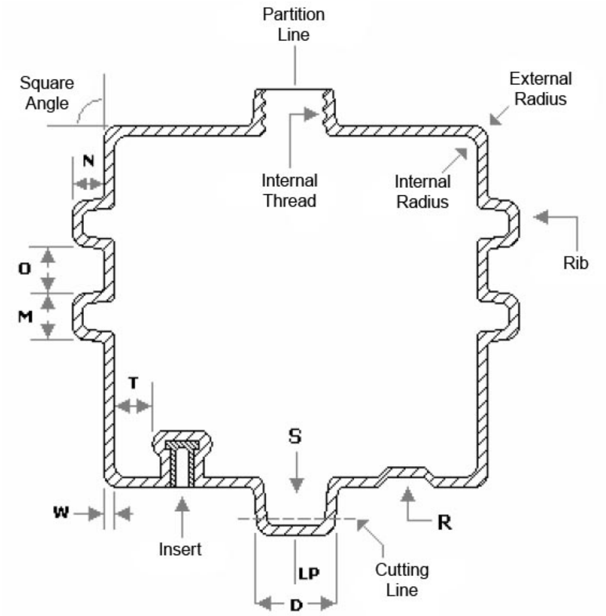

Figure 2. *Design details of hollow rotomolded parts.*

3.6 Unmolding angles

- Wall biasing – unmolding angles – should be included, especially in the male part pf the mold (inner surface), due to the fact that the shrinkage contracts the material above it [1,2]. The female (external part) does not usually need wall biasing, since the material shrinks pulling away from it [1,2].

The following chart registers the unmolding angles recommended for rotomolding of PE parts [1,3].

Angle	Inner Surfaces	External Surfaces
Minimum	1.0°	0.0°
Better	2.0°	1.0°

An extra grade will be needed in all cases in case of texturized molds [3].

3.7 Threads

- Rounded, thick profiles should be used both in inner and external threads [12,3].

- Acute angles on the tip and base of the thread should be avoided [2].
- It is possible to weld molded inserts by injection in the holes during rotomolding [1].
- Commercial substances inducing flow are often sprayed in the thread area, thus improving their reproduction and other details [3].

3.8 Metallic inserts

- Use high conductivity materials [2].
- Use textured surfaces (with bulges) to improve the adhesion to the plastic [2].
- The insert should be designed in such form that it remains anchored to the plastic [2].
- Make sure that there is an adequate space between the insert and any other surface, in order to prevent the bridging of the powdered material: the distance between the surface of the part and the part containing the insert should be at least 4 times the thickness of the wall [2]. See T in Figure 2.
- Place firmly the insert inside the mold [2].
- Avoid inserts with excessive spacing or too wide that might hinder the unmolding, due to the shrinkage forces [2].
- Be careful with the use of inserts in PE parts, if there is a possibility that the part is exposed to *stress cracking*, the resulting restriction when including the insert will introduce residual effects [3].

3.9 Venting

- The ventilation points are normally installed in the sections that will be removed upon the part finish [2].
- If the previous action is not possible, it will be necessary to weld the ventilation hole in a later operation [2].
- The ventilation ducts must be built with low thermal conductivity material (example: stainless steel or Teflon) [2].
- The ducts should be filled with glass wool, without compacting, in order to prevent leakage of the powdered material [2].
- The external opening of the ducts should be designed to prevent water from entering during cooling [2].
- The recommended size of the duct is of approximately between 10-15 mm in diameter per square meter of the volume of the mold [2].

3.10 Undercuts

- Undercuts are permitted where the shrinkage or flexibility of the material allows the release of the mold part [3].
- Ample unmolding angles in external undercuts will help loosen the material from the mold [3].
- Inner undercuts are not allowed since the material shrinkage will hinder the ejection of the part [3].
- The undercut indentations and the partition line should be placed on the same plane, the first one in parallel direction to the second one [1] (see Figure 2, where R is an undercut).
- The undercuts are frequently designed so that they may be removed with the material shrinkage, if the undercut is too deep an additional removable shield should be used before the unmolding [1].

3.11 Holes

- They cannot be molded as such in the rotomolding. A subsequent mechanization is needed after molding, using normal cutting tools [3], or using bolts on the shield that do not adhere to the resin [1].
- An embossing may be manufactured by molding a cylinder, whose tip is cut at the end leaving an opening [1]. See S in Figure 2.
- The diameter of the holes should be at least 5 times the nominal thickness of the wall (D=5W) [1].

3.12 Articulations

They can be manufactured by molding rings or drilling holes in the molded part in order to pass the pins which form part of the articulated union [1].
The following tolerances in the next part 2.13 should be considered for articulations.

3.13 Uniformity and tolerances

- Greater angles both in inner and external corners will result in greater uniformity of the wall thickness [3].
- The considerable shrinkage of the PE, typically 3-4% is allowed, with tolerances of 1-2% [3].

This shrinkage should be taken into account particularly in the partition line area(s) or part couplings of the mold, wherein it is impossible to control shrinkage [4].

- The thickness variations can be modified by adjusting the thermal conductivity of the mold, by sections, as desired [2].
- The uniformity tolerances of the wall are normally ± 20%, and with greater difficulty, ± 10% [1,2].
- Flatness tolerances are between 2-5%, being the best obtainable, due to the unilateral cooling of the rotomolding [3].

3.13.1 Minimizing the bending or curving of the part

- Avoid the variations in wall thickness [2].
- Make sure that the walls do not rind prematurely (the liberation of the mold is very effective) [2].
- The reinforcements (hollow ribs) can sometimes be used to counteract the tendency of bending or curving [2].
- Avoid, as much as possible, large flat sections [2,3,4]. Apply domed, curved, contoured, gridded pattern, and other designs [4].
- The use of curved surfaces is highly recommended to conceal bending or curving [3].

3.13.2 Other considerations for uniformity

- The tolerances can be fit through the use of over-dimensioned holes [1].
- The great linear thermal expansion ratio differences between two parts are also overcome with over-dimensioned holes [1].
- In order to compensate the support surface under the screw head, a washer is usually placed [1].
- In order to include a safety washer, the expansion and height direction must be considered [1].
- Never use a safety washer without its respective flat washer, due to the sensitivity of plastics to crack [1].
- For greater dimensional variations to those which can be fit in over-dimensioned holes, intertwined slots are used in the molds, along with a nut, bolt and washers. It should be noted that twined holes are more expensive for the tool than the round ones [1].

The following chart synthesizes the dimensional tolerance values used for rotomolding of PE parts, in the same reading are both in ± cm/cm as ± in/in:

Tolerance	Linear Dimensions*	Base /width of degradation	Hole diameter
Industrial	0.020	0.015	0.010
Possible	0.010	0.008	0.008
Of precision	0.005	0.004	0.004

* Lineal Dimention: high, weith and piece deep and its sections a long of wall. 0,250cm is permitted for liner variation

3.14 Miscellaneous

In spite of the difficulty to paint PE, it is perfectly possible to decorate rotomolding parts with this [3]:

- Special transfers can be applied to the mold and these, in turn, are picked up by the PE during a normal molding process [3].
- Alternatively, a graphic or image may be applied after molding with very effective decoration methods developed for such purposes [3].🕮

4 References

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