TECHNICAL BULLETIN: ROTOMOLDED PE PARTS DESIGN

1 Introduction

Rotomolding is the process used to obtain hollow plastic parts. It is the best processing technique choice when molding large parts. However, small products can be also manufactured by rotational molding (for example balls and roll-ons). Usually in those cases multicavity molds are used. [1]

Polyolefins are the dominating materials in rotomolding market. [1, 2, 3] Polyethylene (PE), in various available grades, represents 85-95% of polymers used in rotational molding. [3]

Different features need to be taken into consideration when designing rotomolded plastic parts, as it is described next.

2 Mold

- Large products such as tanks or parts with low aesthetic requirements are manufactured in molds made of steel or aluminum sheets.
- Parts with greater aesthetic requirements or with a more complex geometry are generally produced in molds made of cast aluminum. [1, 3]
- For very high surface quality requirements, molds can be manufactured with electroforming or deposition in vacuum techniques (nickel or copper-nickel). [2]
- Mold design must consider the least possible number of partition lines in order to maintain a low mold and maintenance cost and thus a low part cost.[1] Part cost could also be increased due to excessive irregularities or flashings created by partition lines, that need to be removed or finished later by hand. [1]

3 Design of Rotomolded PE Parts: Guide/Features

3.1 Nominal wall thickness

- It should be guarantee a good product mechanical performance without producing long processing times and/or material degradation. [2]
- Wall thicknesses can be controlled by modifying rotation speed of the machine axes. [3]
- Heat insulation of a certain mold areas reduces its part thickness while applying extra heat to other areas produces a greater wall thickness.

Typical nominal wall thicknesses for rotomolded PE parts are shown below. [1]

Thickness	mm	inches
Minimum	1.52	0.060
Optimal	3.18	0.125
Maximum	12.70	0.500
thickness known	50.80	2.000*

* for crosslinked PE.

3.2 Rounded edges

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

Recommended radii values on rotomolded PE parts edges are shown below. [1]

Radius	Outer	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

- Sharp corners should be avoided to reduce bridging of powdered material. [2]
- Corner angles in rotomolded PE parts should not have less than 45°. [1]

Recommended corners angles for rotomolded PE parts are shown below. [2]

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

3.4 Minimum wall separation (double wall molding)

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

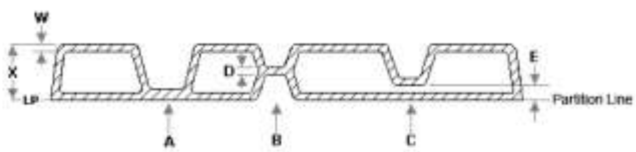

Figure 1. Design details of the flat or double wall rotomolded part.

3.5 Reinforcements

- Reinforcement must be designed as corrugations instead of solid ribs. [2]
- Corrugations must have a slight wall draft angle in order to enhance part demolding. [2]
- Hollow rib width (M in Figure 2) must be at least five times larger than wall thickness (W), (X≥5W), and height (N) must be at least four times wall thickness. [1, 3]
- Clearance between ribs (O in Figure 2) must not be less than three times wall thickness (O≥3W), although a gap of five times wall thickness is even better. [1]
- A commonly used feature to provide extra stiffness to the part is the so-called *kiss-off* [3], shown as A and B in Figure 1.
- *Kiss-offs* combined wall thickness (D in Figure 1) must be 1.75 times wall thickness (D=1.75W). [1]
- Gap (E in Figure 1) of pseudo-reinforcements (C) must be at least three times wall thickness (E≥3W), although a clearance of five times wall thickness is even better. [1]

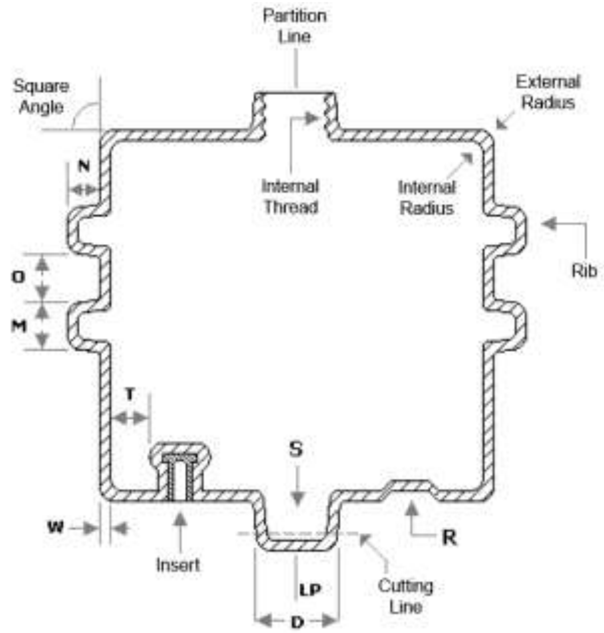

Figure 2. Design details of a hollow rotomolded part.

3.6 Demolding draft angles

- Surface drafting must be performed specially in mold core (inner surface), due to the fact that material will shrink when cooled down and will stick to core [1, 2]. The cavity (usually part external surfaces) does not usually need wall drafting, since shrunk material pulls away from it. [1, 2]

Demolding draft angles recommended for rotomolded PE parts are shown below [1, 3].

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

An extra degree will be needed in texturized surfaces molds. [3]

3.7 Threads

- Rounded and thick profiles must be used in both inner and external threads. [1, 2, 3]
- Acute draft angles on the thread tip and base must be avoided. [2]

- It is possible to weld injected molded inserts in holes during rotomolding. [1]
- Flow-inducing substances are often sprayed in the thread area since they improve material penetration and help obtain a better thread quality [3].

3.8 Metallic inserts

- Use high conductivity materials. [2]
- Use textured surfaces (with protuberances) to improve adhesion to the plastic. [2]
- The insert should be designed in such form that it remains anchored to plastic. [2]
- Make sure that there is an adequate space between the insert and any other surface, in order to prevent powdered material bridging. The distance between part surface and part containing the insert should be at least four times wall thickness [2]. See T in Figure 2.
- Provide a secure placement to the insert inside the mold.[2]
- Avoid inserts with excessive spacing or too wide that might hinder part release due to shrinkage forces. [2]
- Be careful using inserts in PE parts as they will produce residual stresses that will reduce stress cracking resistance. [3]

3.9 Venting

- Ventilation points are generally installed in sections that will be removed during part finishing. [2]
- If the previous action is not possible, it will be necessary to weld a ventilation hole in a later operation.[2]
- Ventilation ducts must be made of low thermal conductivity material (example: stainless steel or Teflon™).[2]
- Ducts should be filled with glass wool without compacting in order to prevent leakage of powdered material during molding operation. [2]
- Duct's external openings should be designed to prevent water infiltration to mold cavity during cooling. [2]
- Recommended duct size is approximately between 10 and 15 mm of diameter per cubic meter of mold volume. [2]

3.10 Undercuts

- Undercuts are feasible when shrinkage or material flexibility allows to release the molded part. [3]
- Generous demolding draft angles in external undercuts will help loosen material from the mold. [3]
- Inner undercuts are not allowed since material shrinkage will interfere with part ejection. [3]
- Undercut indentations and partition line should be placed on the same plane to the first one and in parallel direction to the second one [1] (see Figure 2, where R is an undercut).
- Undercuts are frequently designed so that they may be removed with material shrinkage if undercut is too deep; an additional removable core should be used for proper demolding. [1]

3.11 Holes

- They cannot be molded as such feature in rotomolding process. A subsequent mechanization is needed after molding using normal cutting tools or using bolts on shield that do not adhere to resin. [1, 3]
- A boss (projected blind hole) may be manufactured by molding a cylinder whose tip is cut at the end, which leaves an opening [1]. See S in Figure 2.
- The diameter of holes should be at least five times nominal wall thickness (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 that produce the articulated union in part. [1]
- Tolerances in section 3.13 should be considered for articulations.

3.13 Uniformity and tolerances

- Larger draft angles in both inner and external corners will result in higher wall thickness uniformity. [3]
- Allowed PE shrinkage is typically 3 to 4%, with tolerances between 1 and 2%. This shrinkage should be taken into account particularly in partition line area(s) or mold part couplings where it is impossible to control shrinkage. [3, 4]
- Thickness variations can be modified by adjusting mold thermal conductivity, by sections, as desired. [2]
- Wall uniformity tolerances are normally ± 20%, and ± 10% when producing higher precision parts. [1, 2]
- Flatness tolerances are between 2 and 5%. These are the best result that can be obtained in rotomolding due to its unilateral cooling process. [3]

3.13.1 Minimizing part bending or curving

- Avoid non-uniform wall thickness. [2]
- Make sure that part does not release prematurely (mold liberation is very effective). [2]
- Reinforcements (hollow ribs) can sometimes be used to counteract bending tendency. [2]
- Avoid large flat sections as possible. Use domed curved contoured gridded pattern and other designs elements instead. [2, 3]
- The use of curved surfaces is highly recommended to hinder part bending. [3]

3.13.2 Other uniformity considerations

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

Dimensional tolerance values used in PE rotomolded parts are shown below:

Tolerance	Linear Dimensions*	Base /width of undercuts	Hole diameter
Industrial	0.020	0.015	0.010
Possible	0.010	0.008	0.008
Precision	0.005	0.004	0.004

* Linear Dimensions: height, width and depth along a wall.
Plus 0.250 cm is allowed for parting liner variation.

3.14 Miscellaneous

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

- Special substances can be used in the molds that stick to the PE during the molding process. [3]
- A graphic or image may be used after molding with very effective decoration methods developed for such purposes. [3].

4 References

1. Jordan I. Rotheiser' "Design for Rotomolding"' Revista de <u>Tecnología del Plástico</u>' N° 139. October 2003.
2. "Linear Polyethylene. Product Terminology Training Seminar. Sclairtech"' DuPont Canada' 1992.
3. R.J. Crawford "Rotational Molding. The Basics for Designers" <u>Rotation Magazine</u>'

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