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Making a Blue Tank
Additives

- **Process Stabilizers (Phosphates)**
  - Protects during melt mixing and rotomolding

- **Long Term Stabilizers (Phenolic)**
  - Protection during the process and for the lifetime of the part.

- **UV Stabilizers (Hals)**
  - Protection against sunlight (UV)

- **Fillers**
  - Reduce material cost and add strength to the rotomolded part
Material Production Options
Powder

Feeder
- Color
- Additives

Extruder
- Single Screw
- Twin Screw

Waterbath

Cutting Equipment*
Pulverizing Mill*
Turbo mixer*

Note: Additional material handling will be required after the making of the pellets to the Mill and then the Mixer.

MicroPellets

Feeder
- Color
- Additives

Extruder Design
- Single Screw
- Twin Screw
  - Melt Pump

Polymer Filtration
Gala Under Water Pelletizer

Note: MicroPellet system can also produce normal size pellets.
Melt temperature
Melt pressure
Melt filtration
Process control
Extruding MicroPellets

Consistency !!!!
Methods for Adding Color
Colors

The two basic methods of coloring “material” for the rotational molding process are dry blending and color compounding. Both systems have their advantages and disadvantages, and some molders specify one system above the other or even use both methods depending on the end application.
One big disadvantage of this method is pigment migration. It is particularly relevant with high loadings of pigment. Clearly this may have influence on any food contact approval or toy manufacture, mold surfaces can be stained and covered with contamination can occur if the mold is being used for different colors. Part failures are possible.
Compounding

Color compounds are made by hot melting the color pigment into the base polymer via an extruder creating MicroPellets or standard pellets. The standard colored pellets are then ground where they are reduced to powder.

This type of coloring gives the best possible dispersion, and uses the lowest amount of pigment. For these reasons the properties of the base polymer are retained and may even be improved. In some cases it is also possible to achieve brighter colors, and more opaque colors, since greater loading levels are achievable without loss in properties.

It is also clear that as the pigment is encapsulated within the base polymer, no amount of rotation and tumbling during the rotomolding process, will remove the pigment. Hence moldings using this method are consistent, with no pigment migration to the surface.
Comparison

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Dry blends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expensive</td>
<td>Very dirty process</td>
</tr>
<tr>
<td>No deterioration to PE properties</td>
<td>Cheap and make just in time</td>
</tr>
<tr>
<td>Low levels of pigment added</td>
<td>Need to hold pigment stock</td>
</tr>
<tr>
<td>Cost</td>
<td>Pigment wipe off</td>
</tr>
<tr>
<td>Color repetitive</td>
<td>During molding</td>
</tr>
<tr>
<td>Potential for long delivery times</td>
<td>After molding (toys)</td>
</tr>
<tr>
<td>Good color hold and no wipe off</td>
<td>Typically use ‘powder form’</td>
</tr>
<tr>
<td>Enhanced UV stability</td>
<td>Poor technical performance</td>
</tr>
<tr>
<td>Not messy, no mixing</td>
<td>Quality of the pigment supplied</td>
</tr>
<tr>
<td>No real issues of “moldability”</td>
<td>“Unreliable” color</td>
</tr>
<tr>
<td>Better control on uniform wall thickness</td>
<td>Pigment swirl or bad flow issues</td>
</tr>
<tr>
<td>Able to generate textures, gloss or matt better</td>
<td>Labor intensive process</td>
</tr>
<tr>
<td>Can improve release action</td>
<td></td>
</tr>
</tbody>
</table>

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Grinding the Pellets
Grinding the Pellets

The standard industry norm of supplied polyethylene powder is based on a “500µm” maximum with most of the particles being at 290 to 300µm. This is achieved by the use of a mill which is basically a combination of a cutting system and a series of sieves. The aim of the process is to generate a consistent powder to a set specification where variables, which can affect the molding process, are controlled. The main variables are the size of the powder, the particle size distribution, the bulking behavior of the powder, the shape of the particles, and the flowability or pourability of the powder.
Grinding the Pellets

Normal specification:
- particle size distribution
- pourability
- bulk density
- particle shape (!)

Flowchart:
- Granules
  - Grinding head
  - Cyclone
    - Dust collect
  - Sieves
    - Powder collect
    - Package

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Grinding the Pellets

The operation of size reduction is not seen as “grinding” or “milling” but more like “high speed cutting”. In general terms, the granules are fed into a chamber, where there are two sets of “plates”. One of these is typically rotating and the other fixed. They have a series of teeth or cutting edges, and are situated such that the gap between them gets closer at certain regions. So, as the granule moves through the plates it is cut and reduced in size. The reduced in size granules, i.e. powder, is released at the edge of the plates. Released powder is then fed on an air current to a series of sieves which sorts and select the particles of a certain size. Those particles which are “oversize” are returned to the cutting plates where they go through the system again.
Grinding Powder

Clearly this process is one which generates a lot of heat – as the temperature rises within the cutting environment, the polyethylene particles will soften. This in turn makes any cutting “cleaner” and more “sharp” rather than tear or shear when the polymer is “cold”. However, this temperature must be controlled, because if the polymer softens too much then the mill will “block” where the molten particles stick and adhere to each other forming a large molten mass, and hence no new granules will be able to enter the grinding chamber. Thus the skill of the mill operator is to run in that very narrow window between where the particles are torn or shredded, and where the mill blocks due to the particles sticking and adhering together.
Test Equipment

- **Bulk density test**
  - Powder allowed to flow into cup.
  - Remove excess powder. Weigh.
  - Bulk density = \( \frac{\text{powder weight}}{\text{volume}} \)
  - ASTM D1895

- **Dry flow test**
  - Standard weight of powder placed in funnel. Time taken to flow through standard orifice measured.
  - ISO 6186
  - ASTM D1895

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- **Bulk density cup**
  - Capacity 100 cc

- **Dry flow funnel**
  - Dimensions: 93 mm to 105 mm
Powder Shape

- Hairy particles can stop even flow of powder in process.
- Bridging can occur where hairy particles can not flow into narrow spaces, as they lock together and melt.
- If particles are too hairy they adhere together and create voids. These voids are seen on sharp corners or radii.
- Physical properties (such as impact, tensile strength and elongation) can be weakened with bubbles, bridging and voids.
- Increased process conditions may overcome bubbles but will result in thermal degradation.
- Fibrous particles can combine into “fluffy balls” rolling about on the inner surface of the powder, resulting in irregular shaped “eggs” or lumps.
Grinding Unit
Disadvantages

• The extra grinding stage of reducing a granule to a processable form is a cost
• Quality control of powder is important as powder variables can alter process requirements
• Each grade or polyethylene type requires specific conditions
• Powder transfer can be dangerous, build up can cause dust explosions and fire
• Extra stabilization may be required in the polymer as an extra process step is being incorporated, hence resulting as a more expensive polymer
• Extra equipment purchase is necessary
• Grinding units, mills, must be regularly checked as blunt cutters will alter powder made
Powder Characteristics
Disadvantages

• Risk of contamination
• If there is a change in the PSD curve, the melting characteristics of the powder will be different
• Powder which is hairy will mold differently than a “smoother” powder
• It is very easy for a molding to be under cooked or over cooked if quality procedures are not maintained
• Hairy particles can form clumps which do not melt in a uniform way
• Pigment swirling may be an issue with dry blend colors
• Powder flow into some designs, sharp corners, etc may be an issue
• Powder by its very nature may mean that packing into a certain mold design may be a problem
• Powder needs space in a mold in order to “tumble” and distribute itself
Powder/MicroPellet Comparison

Apparent Density and Dry Flow

Density = 34
Flow = 27 seconds

Density = 53
Flow = 11 seconds

Dowlex 2631 UE RX
MI 7, Density 0.935
PE Process variables

• Main variables are
  - oven temperature and residence time
  - amount of polymer in mold
  - type of polymer in mold
  - rotation speeds of the mold
  - nature of cooling medium and time
  - temperature of demolding

• Secondary variables are
  - polymer shape (MicroPellets or powder)
  - polymer melt flow (MWD)
  - density of the polymer
  - mold material and thickness
  - mold shape
  - position of the mold on arm
  - release agent
  - oven efficiency and type
  - cooling operation efficiency and type
Controlling the Process

• **K-Paq** measures the mold temperature and the internal air pressure in real time.
• The data is transmitted out of the oven and cooler bays to a control station where the data is then recorded for in-line analysis.
Temperature graphing

- Material starts to melt
- Melting complete
- Material starts to sinter, bubbles start to disappear
- Optimum process (PIAT)
- Solidification
Cooking Comparison

Dowlex 2631 UE RX-102
MI 7, Density 0.935

Temperature vs. Time graph showing the cooking comparison between Powder and MicroPellets.
Cooking Comparison
Gala’s Experience

• 8 years of work in the rotational molding industry.
• Numerous projects conducted.
• Various companies around the world.
Case Study from 2006

Material preparation

5 Tons of Material purchased

- All material came from the same batch
- 4 tons of material was made into MicroPellets
- 1 ton of material was ground into powder.
MicroPellets produced for the Tank Trials
MicroPellet form compared to Powder
Material Used

• Marlex HMN ® TR-942 / HMN TR-942G
• HDPE
  – Density 0.943 g/cm³
  – Melt Index 2.0 g/10 min.
Trial 1

• 1450 gallon/5480 liters
  – 1 powder tank and 7 MicroPellet tanks
  – Independent arm Ferry machine
  – 4 to 1+ ratio rotation
  – 260 lbs/117 kgs shot size
  – Cycle time, 44 minutes at 500F/260C
  – Rotolog used to measure temperature
    • PIAT
    • Mold
    • Oven
Powder Tank under natural light

MicroPellet Tank under natural light
Trial 1
Results
## Tank Wall Thickness Comparison

**Micro Pellet Test Data Sheet**

### Run 1

<table>
<thead>
<tr>
<th>Tank Wall Thickness Comparison</th>
<th>24&quot;</th>
<th>16&quot;</th>
<th>8&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>.30</td>
<td>.31</td>
<td>.30</td>
</tr>
</tbody>
</table>

### Run 2

<table>
<thead>
<tr>
<th>Tank Wall Thickness Comparison</th>
<th>24&quot;</th>
<th>16&quot;</th>
<th>8&quot;</th>
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<tbody>
<tr>
<td>Thickness</td>
<td>.31</td>
<td>.31</td>
<td>.31</td>
</tr>
</tbody>
</table>

**Notes:**
- **Resin Weight:** 260 lbs
- **Resin Type:** VTF 8000 10 8x4
- **Cook Time:** 44 min
- **Cook Temperature (F):** 500°
Trial 2

- 3900 gallon/14760 liter
  - 1 powder tank and 4 MicroPellet tanks
  - Oven built by Tank Manufacturer
  - 4 to 1+ ratio rotation
  - 800 lbs/360 kgs shot size
  - Cycle time, 510F/266C oven temp.
  - Rotolog used to measure temperature
    - PIAT
    - Oven
Processing time

• Used the Rotolog to determine the peak internal air temperature.

• Oven shuts down at PIAT of 375F/191C
  – Powder tank took 70 minutes to reach PIAT
  – MicroPellet tank reached PIAT in 64.5 minutes.
Trial 2
Results

NOMINAL
U.S. GAL.
- 4000
Trial 3

- 12250 gallon/46370 liter
  - 1 powder tank and 1 MicroPellet tank
  - Oven built by Tank Manufacturer
  - 4 to 1+ ratio rotation
  - 3800 lbs/1720 kgs shot size
  - Rotolog used to measure temperature
  - PIAT
  - Oven
- Same time needed for both parts
- Powder: 3800 lbs / 1720 kgs
- Micros: 4000 lbs / 1814 kgs

Trial 3
Trial 3
Results
Slimline tank

– 1100 liter tank
– Reduced shot from 62.6 kgs to 55 kgs
– Reduced cook time from 24 minutes to 18 minutes

Wall Thickness/Shot Reduction
Area that is difficult for powder to flow into and lay-down.
Benefits of using MicroPellets

• Cleaner – virtually no dust
• Compounding (eg. Coloring) and MicroPelletizing can be achieved in a single step
• Micropellets have a better packing density than powder.
• Improved flow characteristics: Fills hard to reach areas in complex molds. Enables more uniform inner layers.
• Consistent lay-down and cook times.
Benefits of using MicroPellets

- Enhanced part detail definition (threads, logos, lettering)
- Better impact results are typically reported.
- Segregation of Powder in the container
- Possibility of improved process conditions:
  - Lower temperatures
  - Reduced cycle times
  - Slower rotation speeds
  - Faster mold charging
- Uniform wall thickness, giving potential of shot weight reduction.
Thank You

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