Production Of NOvA PVC Extrusions
WBS 2.4
June 5, 2007
Chuck Grozis
Extruder Line (Components)

- Extruder
  - Manufactured by Krauss-Maffei
- NOvA (16 Cell Die)
  - Manufactured by Greiner (Austria)
- Calibrator (Sizing Tool) & Cooling Tank
  - Manufactured by Greiner (Austria)
- Puller
  - Manufactured by Greiner (USA)
- Cut-Off Saw
  - Manufactured by Greiner (USA)
- Roller Table
  - Commercial
Extrutech Extrusion Line Layout
Entire Extruding Line
PVC Powder
Extruder/Hopper
Extruder Control Panel
Extruding Machine - Prototype Die

- **Extruder**
  - Krauss-Maffei (KMD-60) Twin Screw
  - 60mm is the diameter of the barrel on the extruder
- **Extruder PVC output is ~550 lbs/hour**
  - This extruder is currently used for production of the prototype extrusions / IPND.
Extruding Machine - Production Die

• Krauss-Maffei (KMD-90-32) Twin Screw
  – Is being considered for the production run and has a output of ~ 1000 lbs/hr
  – Advantages of larger extruding machine
  – Speed, Residence time of melt is decreased, this prevents sticking and burning, better barrel melt process.
NOvA Extrusion Die (16 Cell)
# Extrutech & NOvA Process Sheet

<table>
<thead>
<tr>
<th>Die Name</th>
<th>Fermi Die</th>
<th>Order Name</th>
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<tbody>
<tr>
<td>Die #</td>
<td>'007</td>
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<tr>
<td>Date</td>
<td>4/19/2007</td>
<td></td>
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<tr>
<td>Shift</td>
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<tr>
<td>Full Material Code</td>
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<tr>
<td>Lot # / Box #</td>
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<tr>
<td>Operator</td>
<td>I.C.</td>
<td></td>
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<tr>
<td>Regrind Type</td>
<td>O-Ring</td>
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</tbody>
</table>

## Fermi Process Sheet

<table>
<thead>
<tr>
<th>Time</th>
<th>Time</th>
<th>Time</th>
<th>Time</th>
<th>Time</th>
<th>Time</th>
<th>Time</th>
<th>Time</th>
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</thead>
</table>

### Heat Zones

- **Screw RPM**
  - Feeder Screw: 37.0
  - Screw Temp: 37.0
  - B1: 37.0
  - B2: 37.5
  - B3: 36.5
  - B4: 36.5
  - Adapter: 35.5
  - D1: 37.5
  - D2: 37.5
  - D3: 37.5
  - D4: 37.5
  - D5: 37.5
  - D6: 37.5
  - D7: 37.5
  - D8: 37.5
  - D9: 37.5
  - D10: 375/366
  - D11: 375

- **Drive**
  - Speed: 230
  - Speed Thrust: 67

- **Melt Pressure**
  - Melt Temp: 3735
  - Extruder Vac: 0.20
  - Regrind Feeder: 0.37
  - Puller Speed: 0.52
  - Puller %: 55.3

- **VAC**
  - 1: 36
  - 2: 72
  - 3: 34

- **Contact Pressure**
  - Back Pressure: 60
  - Chiller: 60
  - 1st Calib. Top: -0.12
  - 1st Calib. Bottom: -0.32
  - 2nd Calib. Top: -0.45
  - 2nd Calib. Bottom: -0.21
  - Tank Gauge 1: -0.19
  - Tank Gauge 2: -0.10
  - Tank Gauge 3: -0.02
  - Tank Gauge 4: -0.06
  - Box #: 17

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**June 5, 2007 CD-2/3a Director's Review Breakout**

C. Grozis
Die Inserts/Web knitting
PVC Exiting Die
PVC Flowing From Die Into Sizer
Sizer “Calibrator”
Extrusion Exiting The Cooling Tank
Extrusion Puller
Extrusion Saw
Extrusion On Roller Table
Packaging Of Extrusions
Production

- Production
  - Two Step Process
    1. Commercial compoudner-mix the PVC Polymer with Titanium Dioxide and processing aids to produce the N-27
    2. Produce rigid (16 cell) PVC extrusions of the NOvA-27 formulation
Extruding Process

• Process
  - The resin (powder form) is inserted into the extruder hopper, where it is heated (~360° Fahrenheit) and pushed thru the die as a melt.
  - After exiting the die the extruded PVC enters the sizer “calibrator”. This tool maintains a vacuum on the outer profile, and keeps the part from collapsing on itself.
  - After exiting the sizing tool, the extrusion enters the cooling tank, ensuring that the extrusion will be at room temperature upon exiting.
  - The extrusion now enters the puller, the pull/push speeds are adjusted here to help maintain the correct extrusion tolerances.
  - The extrusion is pushed into the saw and cut to the specified lengths.
  - The extrusion is now bar coded, goes through the inspection process, and placed on a flat surface.
  - Extrusions placed on “pallets”
  - Proper packaging (covering) of the extrusions now takes place.
  - Extrusions are shipped to Fermi
Extruder Window And Process Variables

- **Extruding Window**
  - Parameters for material to extrude within the window *(process variables)*

- Extruder Heat Zones *(Critical)*
  - Barrel Zones (4)
  - Die Zones (11)

- Screw Temperature *(Critical)*
- Pressures
- Puller Speed
- Screw Speed And Thrust
- Sizing-Vacuum
- Cooling Water Flow
Die Flow - Tuning Process

- **Die Flow Pattern**
  - **Flow** is a function of the resin formulation and heat
  - **Die Flow** is established by tuning a large number of operating parameters
  - **Die Tuning** is cutting metal to achieve final extrusion dimensions. This is done at the die manufacturer (Greiner).
  - **Tuning Process Parameters** for the NOvA extrusions have been established by an extensive research and development effort between Extrutech Plastics Inc. (Manitowoc, Wisconsin) and NOvA
  - **Process Sheet** has been developed from the flow and tuning effort over the past years extrusion runs.