



Production Of NOvA PVC Extrusions WBS 2.4

June 5, 2007

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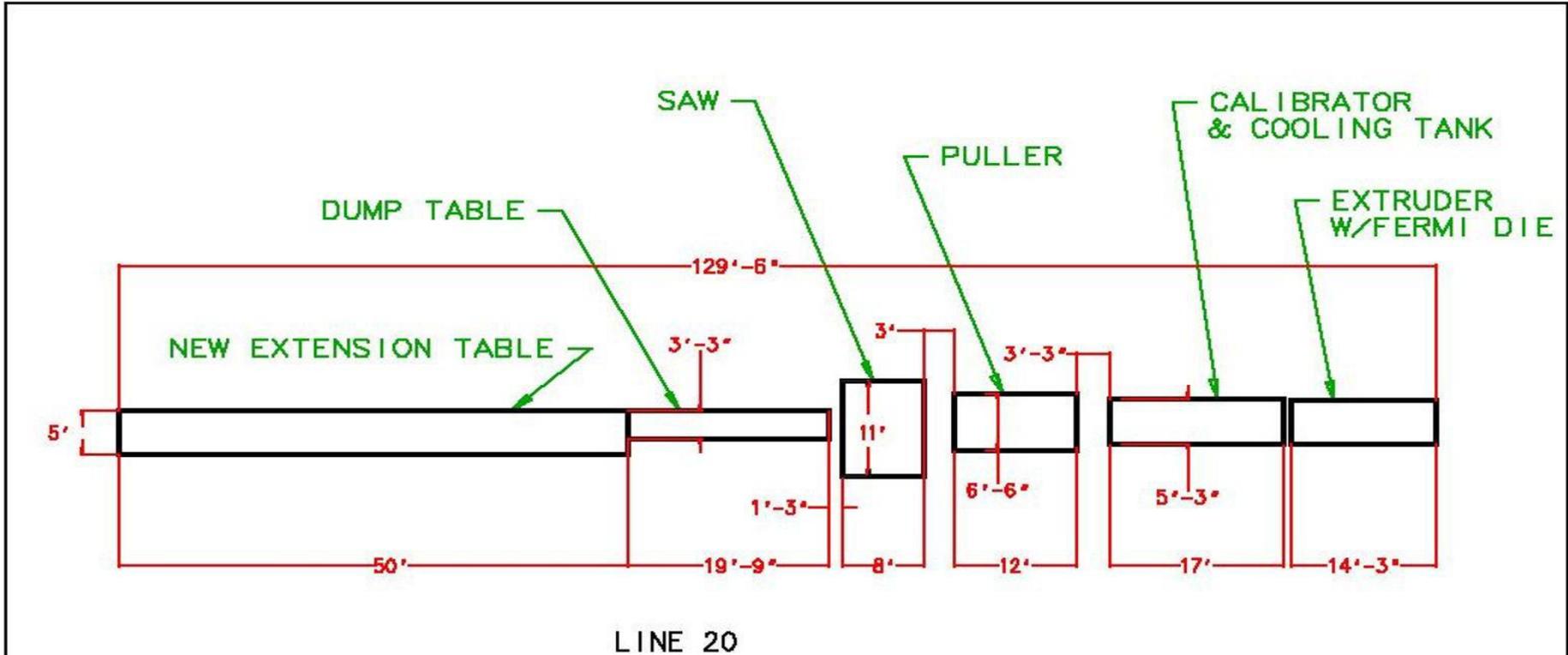


Extruder Line (Components)

- 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



REV	DATE	BY	DESCRIPTION
4			
3			
2	4-20-06		

- UNLESS OTHERWISE SPECIFIED
1. FINISH ALL SURFACES EXPOSED
 2. TOLERANCES
 3. PLACE DIMENSIONS ON DIMENSION LINES
 4. DIMENSIONS ON NON-DIMENSIONAL LINES

 EXTRUTECH PLASTICS, INC. "The Best Extruder of Clean Polypropylene Parts" 1002 West Carter Street - New Haven, CT 06528		
DATE: 4-20-06	SCALE: 1/2"	DRAWN BY:
EXTRUDER LINE LAYOUT		DRAWING NUMBER:



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

		Fermi Process Sheet							
Die Name	Fermi Die								
Die #	*007				Order Name				
Date	4/19/2007				Shift	1st			
Full Material Code	Nova 27				Line #	20			
Lot # / Box #	020412-07-NC				Screen Pack	*-----			
Operator	I.G.				Breaker Plate	O-Ring			
Regrind Type									
	Time	Time	Time	Time	Time	Time	Time	Time	
	9:41 AM	11:06 AM							
Heat Zones	Set/ Actual	Set/ Actual	Set/ Actual	Set/ Actual	Set/ Actual	Set/ Actual	Set/ Actual	Set/ Actual	
Screw RPM	37.0	37.0							
Feeder Screw	95.0	95.0							
Screw Temp	320	320							
B1	380	380							
B2	375	375							
B3	365	365							
B4	365	365							
Adapter	355	355							
D1	375	375							
D2	375	375							
D3	375	375							
D4	375	375							
D5	375	375							
D6	380	380							
D7	380	380							
D8	380	380							
D9	375	375							
D10	375/366	375/364							
D11	375	375							
Drive	230	-249							
Screw Thrust	67	65							
Melt Pressure	3135	3128							
Melt Temp	379	380							
Extruder Vac	-0.20	-0.20							
Regrd Feeder									
Puller Speed	0.47	0.52							
Puller %	52.9	55.3							
VAC 1	76	76							
VAC 2	72	72							
VAC 3	34	34							
Contact Pressure	60	60							
Back Pressure	4	4							
Chiller	60	60							
1st Calib. Top	-0.42	-0.42							
1st Calib. Bottom	-0.32	-0.32							
2nd Calib Top	-0.45	-0.46							
2nd Calib Bottom	-0.21	-0.22							
Tank Gage 1	-0.080	-0.170							
Tank Gage 2	-0.100	-0.140							
Tank Gage 3	-0.020	-0.040							
Tank Gage 4	-0.070	-0.030							
Box #	11	7							

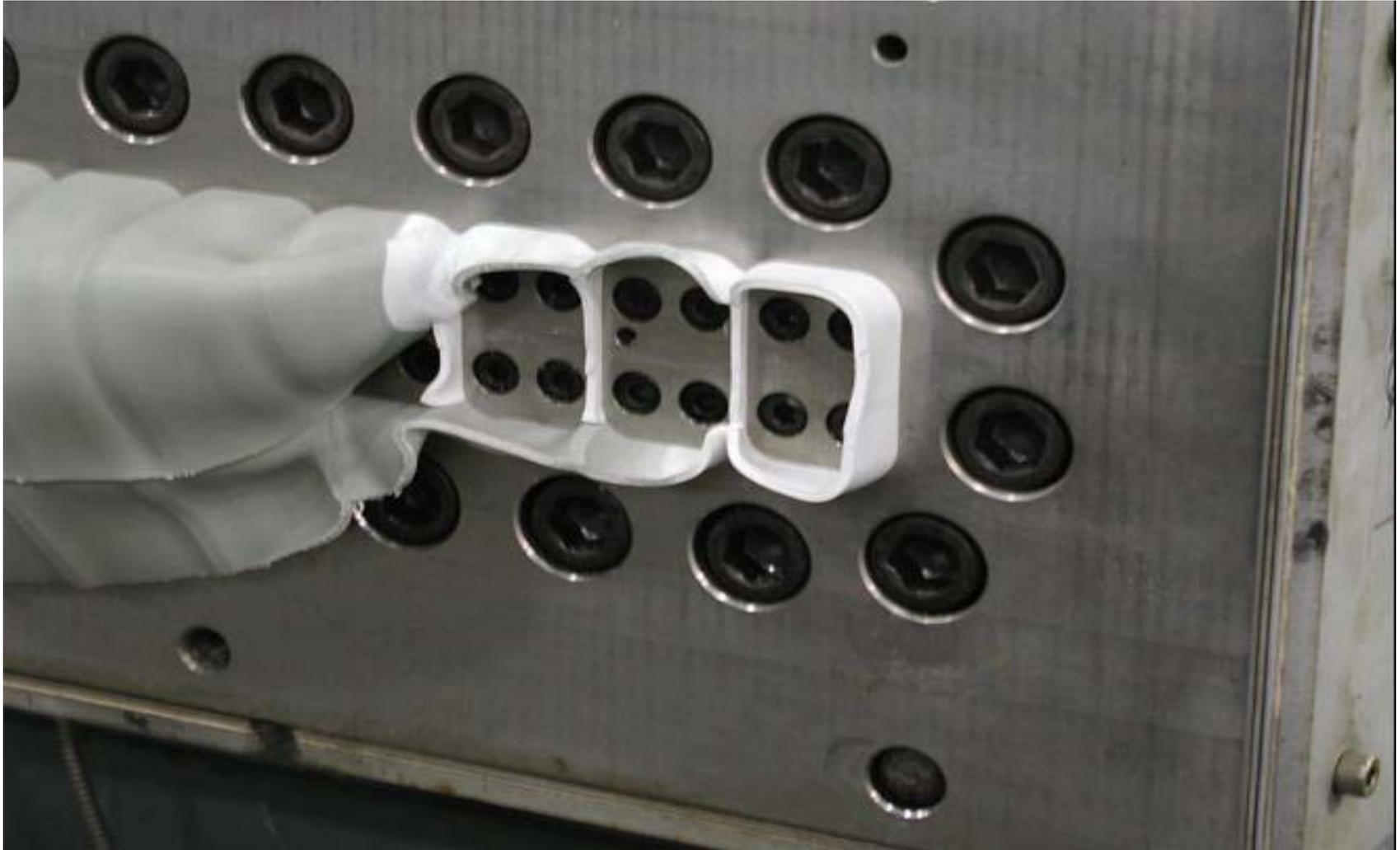


Die Inserts/Web knitting





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 compounder-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 ($\sim 360^\circ$ 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.