The ENERGY Forum

PORT PLASTICS

PROCESSING POLYMERS
SAME RESIN, DIFFERENT DATA

WHY THE DIFFERENCE IN MECHANICAL PROPERTIES OF POLYMERS?

MANUFACTURING MOLDING-PROCESS TRADEOFFS

Figure 1 shows a brief overview of the tradeoffs between each of the following processes: Injection, Extrusion, and Compression Molding. You will notice that the lowest stress during process pertains to Compression Molding, which very useful with the correct tooling, required material stability, and tight tolerance machining.

THREE COMMON CONVERSION PROCESSES

INJECTION MOLDING

- Begin with a lower viscosity material so that it can flow easily into a mold.
- Forcing the polymer through a small opening so directionality of fibers develops.
- The polymer cooled quickly to get the material out of the mold fast, resulting in a shape that stores increased internal stress and less dimensional stability of the final shape.

EXTRUSION MOLDING

- Begin with a higher viscosity material.
- Similar to IM, slowly force the polymer through an opening so some directionality develops.
- Cooling of the polymer occurs quite slowly, while resulting in reduced internal stress and providing improved dimensional stability of the final shape.

COMPRESSION MOLDING

- Begin with a free flow powder loaded in a mold and apply pressure and proper heat.
- Zero directionality occurs resulting in a very dimensionally stable material.
- This process, which is slightly slower, yields lower internal stress as compared to IM & EM.

THE SAME RESIN: WHY ARE THE MECHANICAL PROPERTIES SO DIFFERENT?

See Figure 2. Review the three columns on the far right of the chart as compared to the Victrex Resin processed via Injection Molding.

The three filled PEEK samples, shown above, display nominal values which differ by process; hence, it is important to understand which process will provide the correct properties needed for your application.

FIGURE 1

Extrusion Molding	Compression Molding	Injection Molding
Some stresses in fiber filled materials	Lowest stress (i.e. best stability)	Highest stress levels (i.e. poor stability)
Average mechanical strength	Lowest mechanical strength	Highest mechanical strength
Slight Anisotropic (small directionality)	Isotropic properties (zero directionality)	Very Anisotropic (high directionality)
Thinner cross sections available	Larger cross-sections available	Limited cross-sections as sinks & voids are common
Longer lengths (48") for all geometries	Specialty formulations easier to evaluate	High tooling cost
Larger MTO minimums	Lower MTO minimums	Only feasible for large volume runs (> 10,000 pcs)
Best process option when strength and stiffness are critical	Best process option when machining to very tight tolerances	Best process option for very high volume, small parts

FIGURE 2

Mechanical Property Comparison – PEEK CA30 Extruded vs. Victrex Resin Data				
Mechanical Property	**Test Method**	**Victrex PEEK 450 CA30**	**PEEK CA30**	**PEEK CM CA30**
Samples Converted via		***Injection Mold***	***Extrusion***	***Compression Molded***
Specific Gravity @ 73°F	ASTM D 792	1.41	1.41	1.42
Ultimate Tensile Strength @ 73°F, psi	ASTM D 638	32,480	19,000	16,000
Tensile Modulus @ 73°F, psi	ASTM D 638	1,885,000	1,100,000	1,400,000
Elongation, at break @ 73°F, %	ASTM D 638	1.8	5	3
Flexural Strength @ 73°F, psi	ASTM D 790	51,475	25,750	23,000
Flexural Modulus of Elasticity @ 73°F, psi	ASTM D 790	2,929,000	1,250,000	1,000,000
Compressive Strength @ 73°F, psi	ASTM D 695	34,800	29,000	28,000
Hardness, Rockwell @ 73°F	ASTM D 785	M107, R124	M102	M108
Izod Impact (notched) @ 73°F, ft-lb/in. of notch	ASTM D 256	1.65	1.03	1.4
Water Absorption Immersion, 24 Hours, % by wt.	ASTM D 570	0.06	0.06	0.15
Water Absorption Immersion, Saturation, % by wt.	ASTM D 570	-	0.3	0.5

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HOW DOES PLASTIC DATA AFFECT YOUR MATERIAL SPECIFICATIONS?

CONSIDER THE DATA THAT YOU ARE USING:

- How were the test samples generated?
- Determine which process will be used to achieve the correct test values needed.
- Resin suppliers always provide data based on injection molded samples.
- Most shape converters take the "easy way out" and provide Resin data.

TEST MATERIALS IN A QUALITY LABORATORY FAMILIAR WITH THE INDUSTRY
MATERIAL PROPERTY DATA IS GENERATED FROM THE ACTUAL STOCK SHAPE

WHEN WRITING MATERIAL SPECIFICATIONS:

- Consider writing around machinable shape data.
- Consider the final shape and associate the process required.
- Determine whether or not you are dealing in small or large production needs.
- Consider asking for batch data on the shape being produced.

Perhaps this overview will enhance your understanding of the impact that each polymer process yields using the same basic polymer compound shown here – PEEK with 30% carbon fiber.

CONTACT PORT PLASTICS FOR ALL YOUR NEEDS IN TERMS OF POLYMERS FOR THE ENERGY MARKET.
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