Design for Manufacturing: Plastic Injection Molding

July 5, 2018

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MHUB
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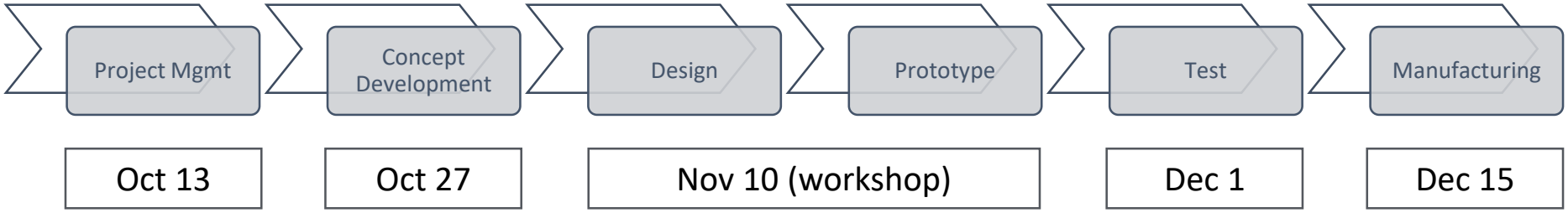
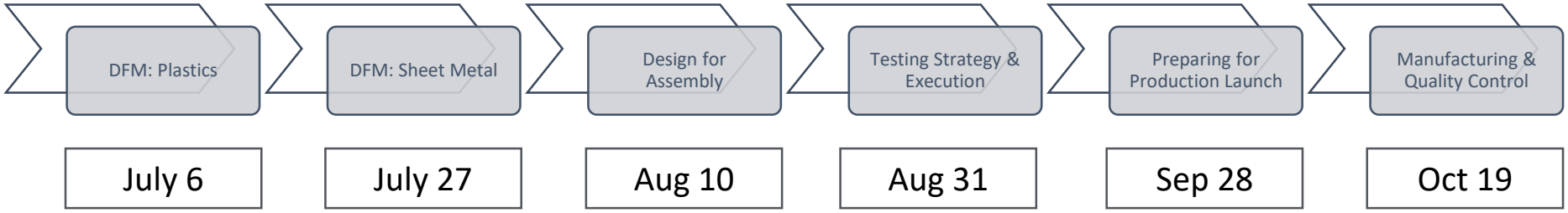
mHUB Programming: Product Development

- 2017 Introductory Classes:



- 2018 Advanced/Deeper Dive Classes:



Jim Shaw: Graphical Resume

Rolling Meadows, IL

Wheeling, IL

Lake Zurich, IL

mHUB

2002-2007 Missile Defense

2007-2011 Commercial Products

2011-2013 Automotive Suspensions

2013-now CAD/CAE Training

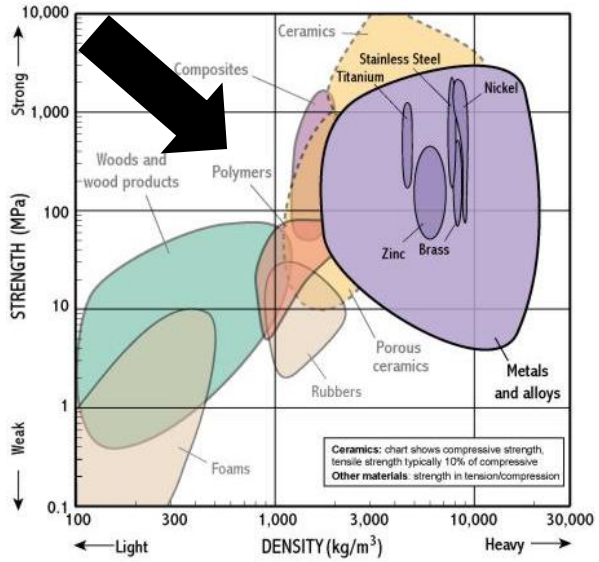
Design For Manufacturing: Plastic Injection Molding

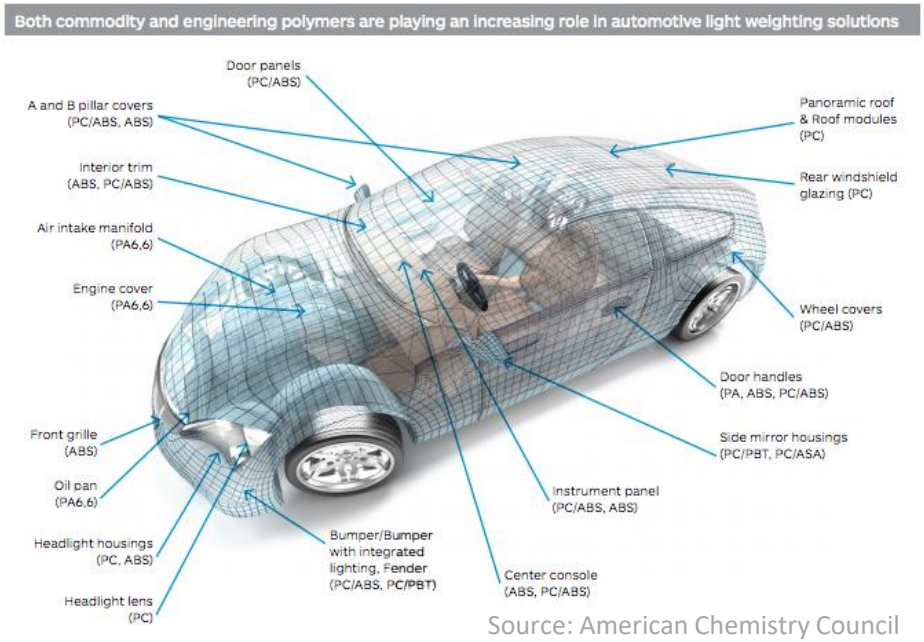
Today's Agenda

- Why Plastic?
- Why Plastic Injection Molding?
- Overall Design Approach
- Additional Resources: Specific Design Details
- Insight from the Expert – Mike Walter (Met2plastics, LLC)

Design For Manufacturing: Plastic Injection Molding

- Why Plastic:
  - Versatile Material Properties
  - Can be as strong as metal
  - Can be as light and cheap as wood
  - Can be reinforced with carbon/glass for extremely high strength/weight ratio

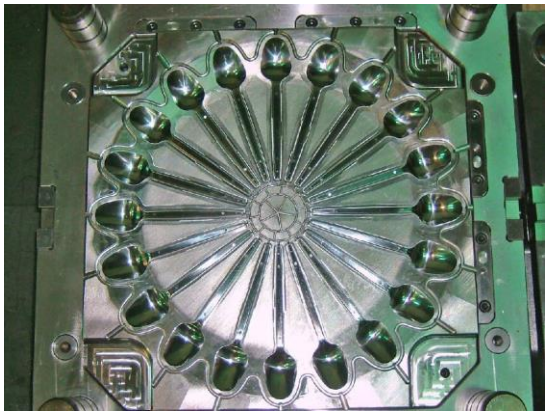




Source: American Chemistry Council

Design For Manufacturing: Plastic Injection Molding

- Plastic Injection Molding
  - Highly Automated
  - Medium-High Tooling Cost
  - Very Low Part Cost
  - Very High Volume



Design For Manufacturing: Plastic Injection Molding

- Plastic Injection Molding Process (in 45 sec)

Source: Youtube (Bill Hammack, University of Illinois)

Design For Manufacturing: Plastic Injection Molding

Design Approach for Plastic Injection Molded Component

1. Establish Functional and Performance Requirements
2. Preliminary Design of Component
3. Develop Final Design
4. Evaluate Design through Prototype & Material Testing
5. Develop Production & Distribution System

Design For Manufacturing: Plastic Injection Molding

Establish Functional and Performance Requirements

1. Overall shape/size
   - Function, Aesthetic/Marketing, Shipping, Strength/Weight
2. Establish Structural Requirements
   - Loads (Gravity, Pressure, Dynamic/Drop), Temperature (Indoor/Outdoor, Space/Solar), Liquid/Moisture Exposure
3. Establish Non-Structural Requirements
   - Corrosion, Weather, Fire Resistance, Cost Target, Production & Marketing Requirements

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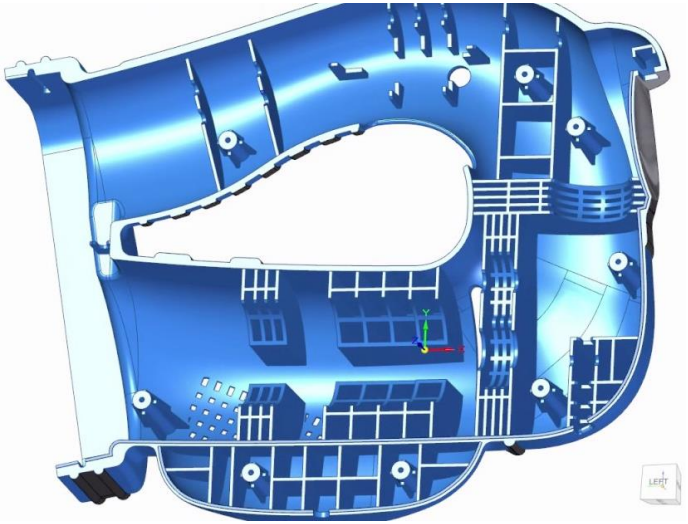
Preliminary Design



1. Select Feasible Material
   - Strength, weight, cost; Trade-off Matrix
2. Narrow down Processes/Suppliers
   - Leverage other experts knowledge
3. Establish Design Details
   - Nominal wall thickness, rib size & locations, review economics
   - Decide on materials/methods for connections, coatings, etc.

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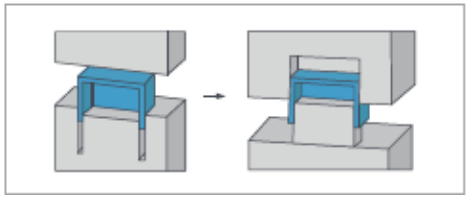
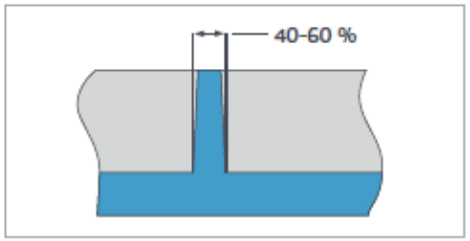
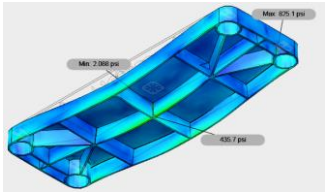
Develop Final Design

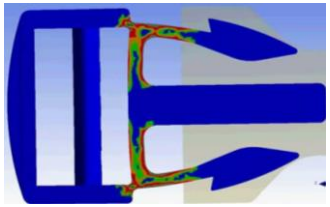
1. Re-check economics
   - Estimated part cost, build volumes & processes
2. Re-check Functional/Performance
   - Leverage the use of Engineering Simulation Software
3. Optimize Design Geometry
   - Overall Material Thickness, Rib Sizes, Fillet Radii, fine tune material properties (consider additives)
   - Consider Flanges (for stiffness), Inserts, Edge Conditions, Assembly considerations

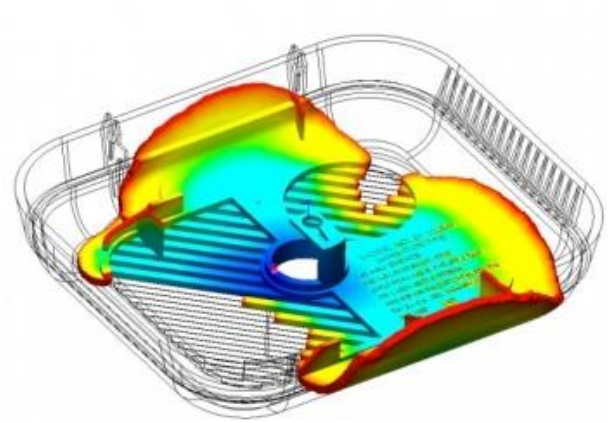


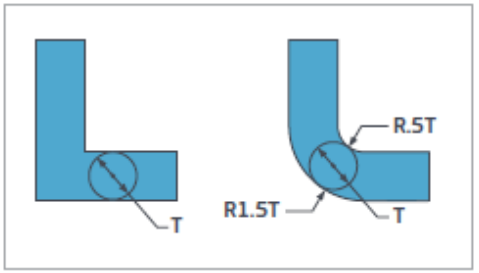


To prevent sink, the thickness of the rib should be about half of the thickness of the wall.









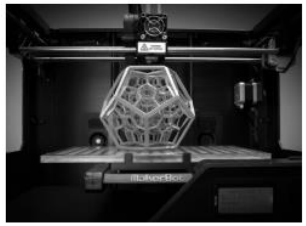
Sharp corners have high-stress concentration and plastic flow is hindered. Rounded corners have reduced-stress concentrations and plastic flow is enhanced.

Source: Protomold

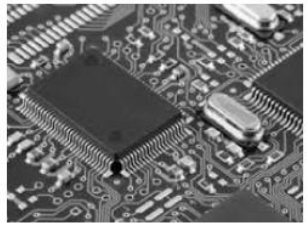
Design For Manufacturing: Plastic Injection Molding

Evaluate Design through Prototype & Material Testing

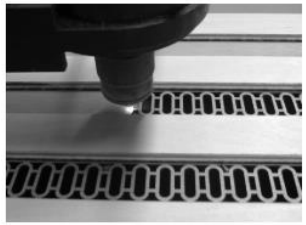
1. Establish Prototyping Method
2. Develop Test Program
3. Redesign as needed


3D Printer Lab

Cold Metals Lab


Electronics Lab


Hot Metals Lab


Laser Cutting Lab


Plastics Lab

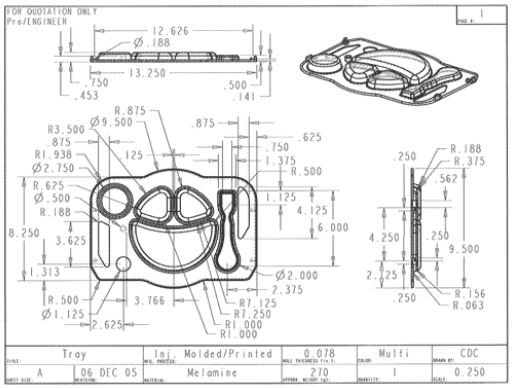

Software

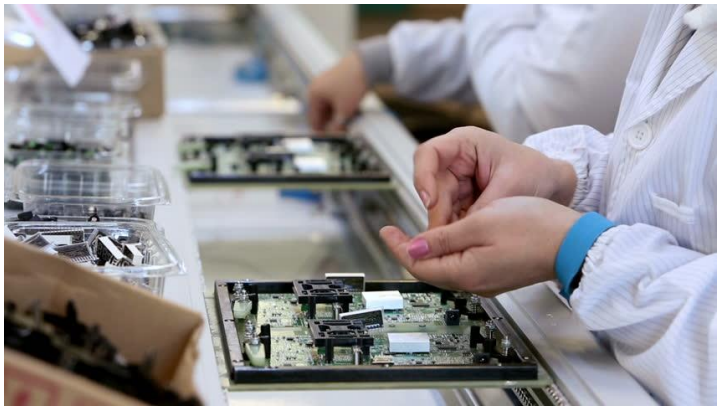

Testing Lab

Design For Manufacturing: Plastic Injection Molding

Develop Production & Distribution System

1. Create Detailed Part Drawings
   - Fully document all dimensions & tolerances in CAD
2. Mold Design
   - Compromise Part Design as needed, to facilitate high quality and low part cost
3. Production Process Design
   1. Determine level of Automation and “Value Add” processes to be done by supplier
   2. Establish preliminary build quantities and inventory levels





DEDIENNE MULTIPLASTURGY® GROUP

MET2PLASTIC
metal to plastic solutions

4 KEY QUESTIONS TO ASK WHEN SELECTING A PLASTIC PROCESSOR



MHUB

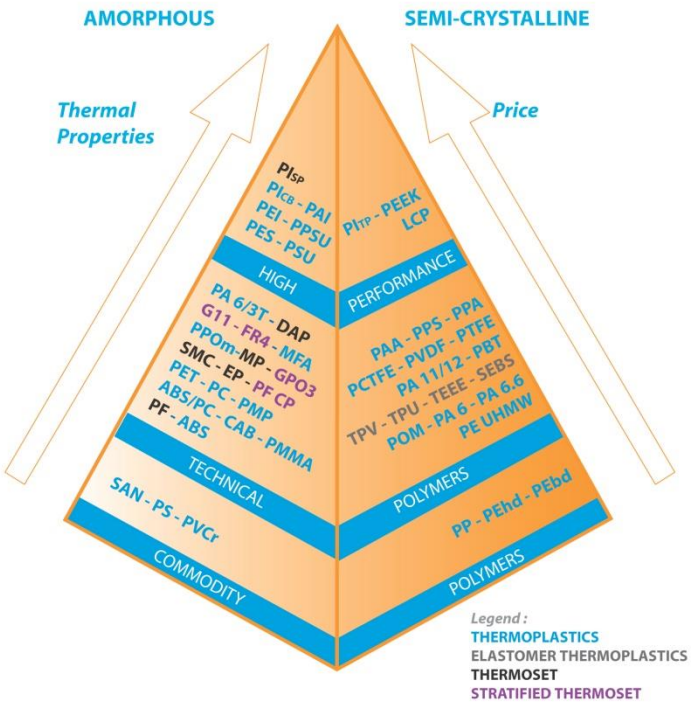
July 6, 2018

met2plastic.com

MATERIALS

1. What type of plastic should I use?

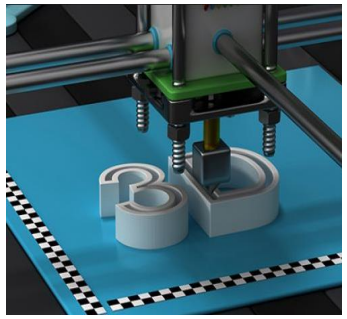
- Don’t specify “Plastic” – there are thousands of grades!
    - Thermoplastic vs. Thermoset;
    - Amorphous vs. Semi-Crystalline
- Specify based on requirements
    - Mechanical (impact strength, stiffness, tensile strength, etc);
    - Chemical resistance
    - Thermal
    - Flammability / Smoke & Toxicity
    - Dimensional
    - Cosmetic requirements
- Other considerations
    - Cost (<$1 / lb to >$100 / lb)
    - Material availability
    - BPA-free requirements

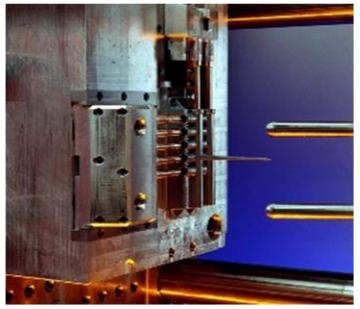


PROCESSES

2. Which process should I use to produce my part?

- 3D Printing
- Milling / Turning
- Thermoforming / Vacuum Forming
- Injection Molding
- Blow Molding
- Rotational Molding
- Compression Molding





PROCESSES

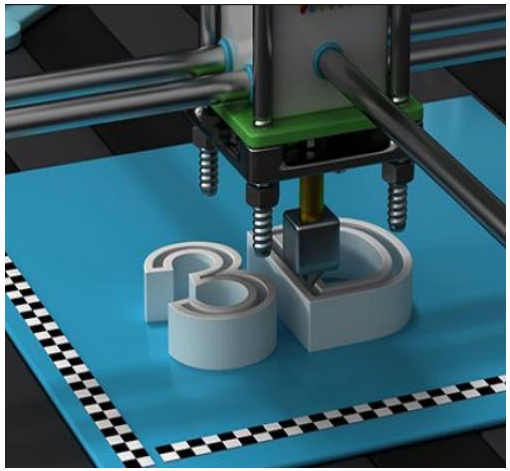
3-D Printing

Benefits

- No capital investment
- “Unlimited” design flexibility
- Suitable for low volume production requirements
- Fast turnaround for low volumes

Drawbacks

- Limited materials to select from
- Dimensional tolerances can be an issue
- Surface finish capability / finishing requirements
- High part costs
- Slow throughput for higher volumes



PROCESSES

Milling / Turning

Benefits

- Little to no tooling / capital investment required
- Suitable for low quantity runs
- Able to maintain tight dimensional tolerances

Drawbacks

- Limitations in material selection / color selection
- Surface finish limitations
- Higher part costs due to longer cycle times

PROCESSES

Thermoforming / Vacuum Forming

Benefits

- Low tooling / capital startup costs
- Low setup / startup costs
- Ability to mold from thin-walled sheet stock
- Suitable for large components

Drawbacks

- Limited design flexibility (2 ½ dimensional)
- Typically requires secondary machining operations
- Not good for deep draw parts
- Higher part cost

PROCESSES

Injection Molding

Benefits

- Low production costs at higher volumes;
- Faster cycles
- Wide variety of materials to select from;
- Materials can be customized;
- Custom color options;
- Can mold intricate detail;
- Capability to combine multiple parts into a single part

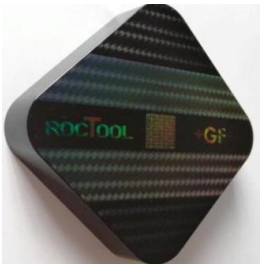
Drawbacks

- High tooling / capital startup costs
- High setup costs
- Limitations with part design
    - Undercuts
    - Warp potential (semi-crystalline materials, glass filled materials)
    - Dimensional variance
    - Sink marks
    - Draft requirements

PROCESSES

Injection Molding Sub Processes

- **Gas-Assist Molding**
  - Tubular structures
- **Structural Foam Molding**
  - Heavy-walled, non-cosmetic parts (unless parts are painted)
- **Two-Shot Molding**
  - e.g., rigid component with soft-touch grip
- Heat and Cool Molding (RocTool)
  - Cosmetic finishes, improved material flow
- Hybrid Molding
  - Combining continuous fiber composites with injection molding
- RIM (Reaction Injection Molding)
  - Thermoset materials



3. How do I select the right supplier?

Most plastic processors are specialists in particular areas, and tend to be more competitive in those areas. Look for:

1. Industries served (Automotive, Aerospace, Medical, Pharma, Packaging, Consumer Goods, etc)
2. Product Mix (Low Volume/High Mix, High Volume/Low Mix)
3. Equipment size / part size capability (micro-molder, large part molder, etc)
4. Age of equipment
5. Materials expertise
    - Commodity Materials, Engineering Materials, High Performance Plastics (HPP's), Composite Materials, etc.
6. Value-add capabilities
    - Engineering, Tooling, Moldflow
    - Assembly, Painting, Decorating, Testing
    - Inventory Management
7. Quality system certifications applicable to your industry

Molder size is important. Make sure you won't get lost in the customer crowd!

TOOLING

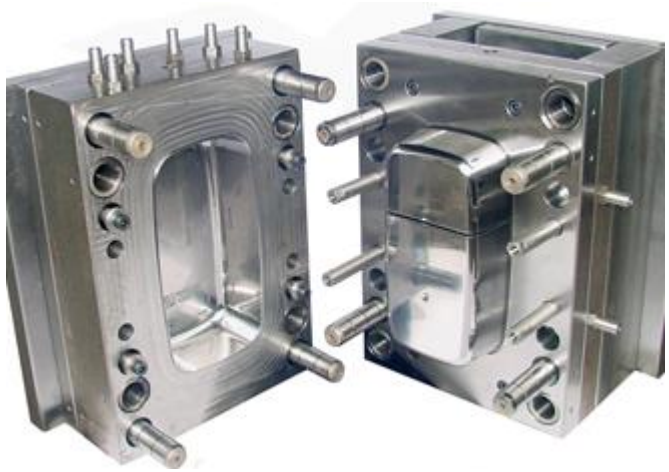
4. If injection molding, how do I specify tooling?

Think about:

- Required life of tool
- Required output / capacity
- Minimum tool life required
    - 10k shots? 100k shots? 1M shots?

Then determine:

- # of cavities
- Tooling material (aluminum, prehard Steel, hardened steel, etc)
- Gate type (edge gate, subgate, sprue gate, etc)
- Runner type (hot runner, cold runner)
- Part ejection / allowable ejector mark locations
- Demolding undercuts (hand-loads, lifters, mechanical slides, hydraulic slides)
- Location of mold manufacturer (U.S. / Canada, Asia, Europe)
    - If Asia, remember that the mold cost is just a portion of the total cost!
    - Asia tooling requires infrastructure to manage the toolbuild and tooling modifications



GET YOUR MOLDER INVOLVED IN THE EARLY STAGES!

PART DESIGN

Common mistakes to avoid when preparing your part for production

1. **Not considering design constraints of the production process when developing your prototypes**
    - Just because a part can be 3-D printed or machined doesn't mean that it can be mass produced
2. **Overtolerancing your parts**
    - Do you really need +/-.001 tolerances, or will +/-.010" be sufficient
    - Why pay for something you don't need?
3. **Specifying only one material**
    - If possible, specify material from at least two suppliers
4. **Not allowing for cosmetic defects**
    - "No Flash" is often not achievable -- Provide realistic flash allowances
    - SPI AQ-103 is a good reference for cosmetic specification development (available from ANSI)
    - If you can't have any defects, make sure your part is designed to support defect free molding

PART DESIGN

Common mistakes to avoid when preparing your part for production

5. **Not factoring in for draft**
    - Build draft into your part models.
    - Specify “Plus Draft” or “Minus Draft” on dimensions
6. **Adding insufficient draft**
    - Draft requirements are dependent on a number of factors:
        - Material shrink
        - Material stiffness / lubricity
        - Length of draw
        - Texture
7. **Designing walls that are too thick or too thin (for traditional injection molding)**
8. **Designing parts with inconsistent wall thicknesses**
    - Think like the material!
    - Material chooses path of least resistance

ABOUT MET2PLASTIC, LLC

- Providing **Metal to Plastic Solutions**
- **Located in** Elk Grove Village, IL
- **Division of Dedienne Multiplasturgy® Group**
- Specializing in **Injection Molding** of critical parts and **metal replacement components**
- **Experience with high-temperature** and **composite materials**
- AS9100, ISO 9001, & ISO 13485 Certified

MET2PLASTIC INDUSTRY FOCUS

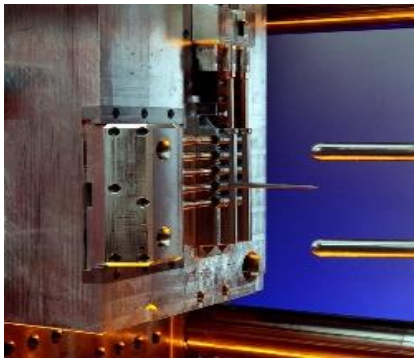
Medical

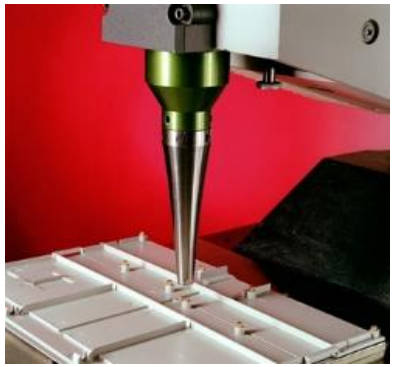
Aerospace

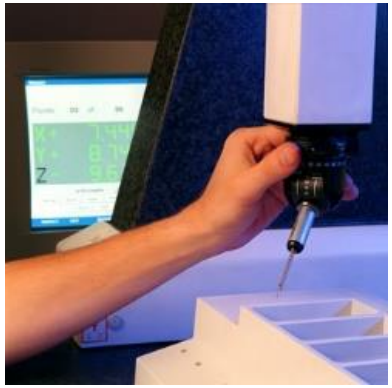
Industrial / Business Equipment

MET2PLASTIC – PRODUCTION CAPABILITIES

- **40 to 720 ton Capacity**
- **Part Sizes: <1g to 6.5 lbs.**
- **Modern Equipment**
  - Average press age of 7 years
  - SPC Equipped
- **Specialty Processing Capabilities**
  - High Temperature Materials
  - Gas Assist Molding
  - Structural Foam Molding
  - Utilize Scientific Molding to develop robust processes
- **Value add capabilities**
  - Sonic Welding / Heat Staking
  - Assembly
  - Solvent Bonding
  - Machining
  - Testing



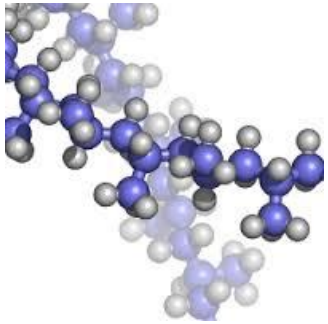




MET2PLASTIC - MATERIALS EXPERIENCE

High Temperature Resins

- PEEK
- PEI (Ultem)
- PPS (Ryton, Fortron)
- PPSU (Radel)
- PSU (Udel)



Engineered Resins

- Acetal (Celcon, Delrin)
- Nylon (Zytel)
- PBT Polyester (Valox)
- Polycarbonate (Lexan)
- PPO (Noryl)
- TPE (Santoprene)

Commodity Resins

- ABS
- Acrylic
- HDPE
- LDPE
- Polypropylene
- Polystyrene
- PVC

WE THANK YOU
FOR YOUR ATTENTION

Design For Manufacturing: Plastic Injection Molding

Thank You!

1. Next Class
    1. Design for Manufacturing Sheet Metal: July 27

2. Please Remember
    1. Sign-in Sheet
    2. Follow up Survey