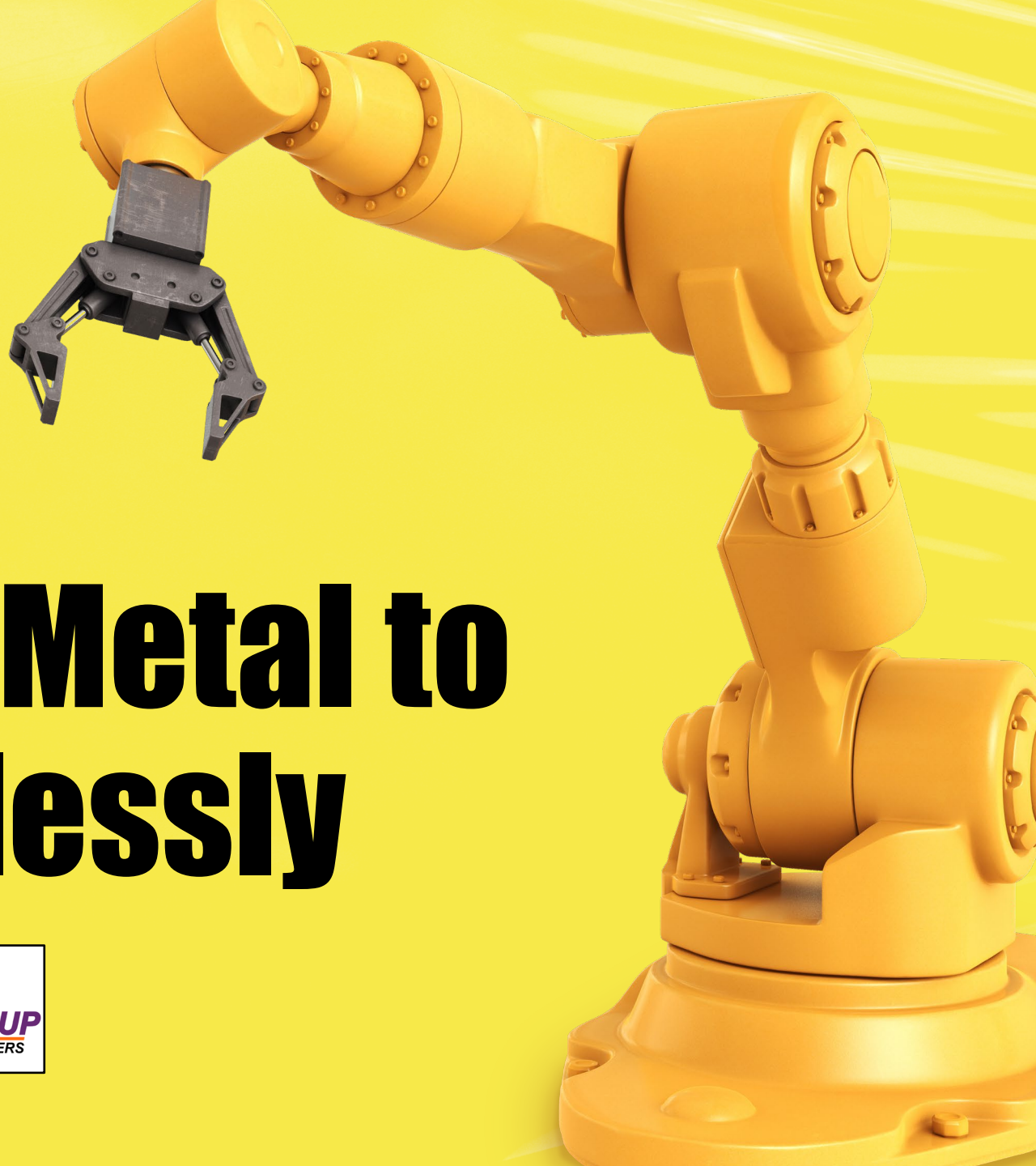


NPE 2024 | **MADE
FOR YOU**
The Plastics Show

Produced by  **PLASTICS**
INDUSTRY ASSOCIATION



Shifting from Metal to Plastic Seamlessly

Paul Gramann, PhD, PE
The Madison Group
www.madisongroup.com



NPE 2024 | MADE The Plastics Show FOR YOU

Produced by  **PLASTICS**
INDUSTRY ASSOCIATION



Paul is a co-founder and currently serves as the President of The Madison Group, a prominent plastics engineering consulting firm. He has over 30 years of experience specializing in plastic material selection, design, material testing, and failure analysis and prevention. He works across several industries including medical, consumer goods, water management, and building products. He also commonly serves as an expert witness for both defense and plaintiff counsels.

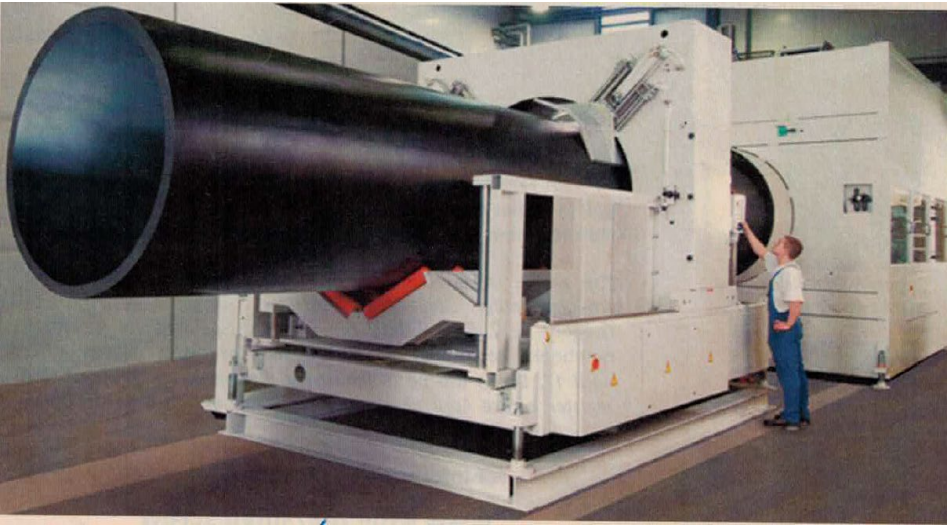
Paul J. Gramann, PhD, PE
President • The Madison Group
Paul@madisongroup.com

This Presentation will Take You Through the Successful Journey of Transitioning a Legacy Metal Part to Plastic.

Why Plastic?



Ref: Plastic News



Ref: Plastic News



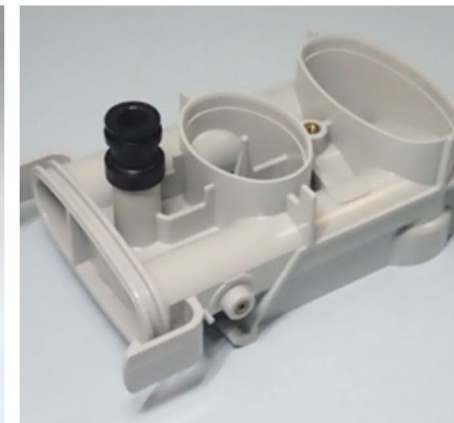
Ref: verywellhealth.com



Benefits of Plastics to Ensure Part Success

Many metal parts still have the potential to be converted to plastic.... given the right engineering.

1. **Design Freedom** – extremely complex shapes
2. **Cost Savings** – holistically plastics will usually win
3. **Lightweight** – plastics are lighter than metal (float)
4. **Corrosion Resistance** – metals corrode, plastics do not
5. **Cosmetic** – transparent, vivid colors
6. **Touch 'n Feel** – soft-touch to high hardness
7. **Manufacturing** – numerous methods to make part
8. **Joining methods** – snap-fits, adhesives, welding
9. **Noise reduction** – lower generation, dampening
10. **Insulation properties** – lower thermal conductivity
11. **Impact properties** – absorb energy without denting



TODAY'S TALK

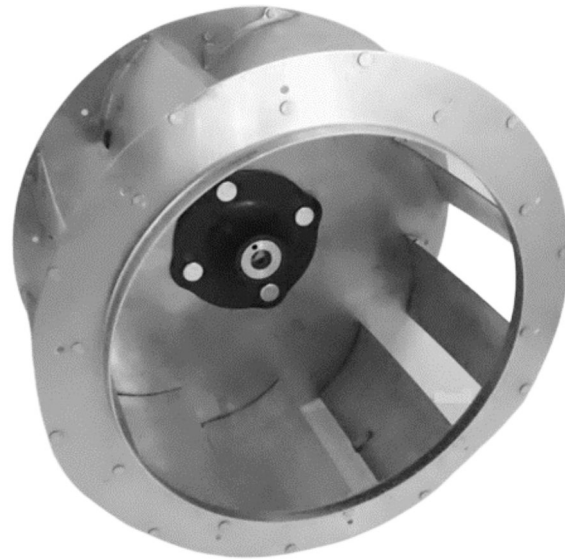
- We know that metals and plastics behave differently.
- The viscoelastic nature of plastics can both enhance and detract from the performance of parts.
- In this presentation, we will explore the advantages and challenges of transitioning from metal to plastic.
- Knowing these challenges allows us to address them by using the proper design, material selection and manufacturing.

Metal to Plastics Journey

You Have This:

Centrifugal Fan:

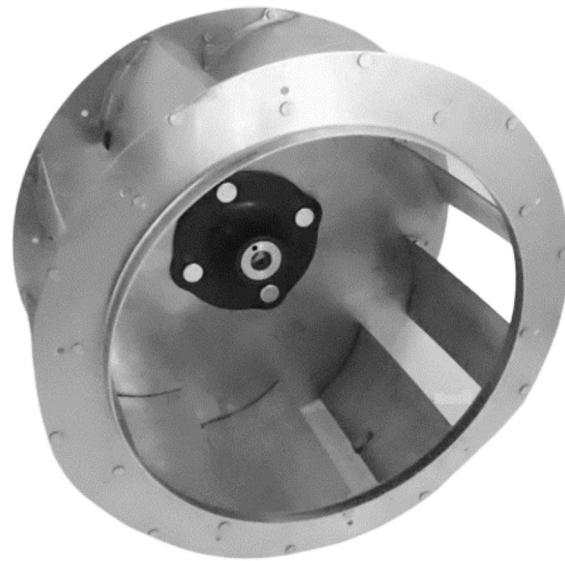
- Aluminum
- 14 parts
- 44 rivets
- Plastic flange
- Metal hub



You Want This:

Centrifugal Fan:

- Aluminum
- 14 parts
- 44 rivets
- Plastic flange
- Metal hub



Centrifugal Fan:

- Polyamide
- 1 part
- No rivets
- Metal hub

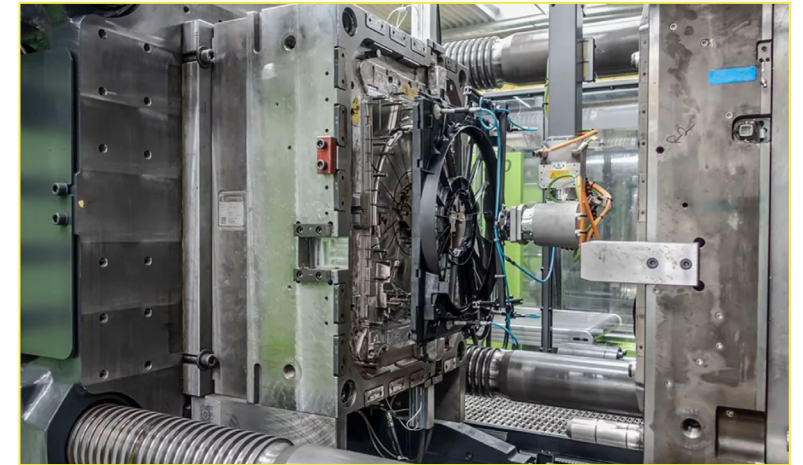
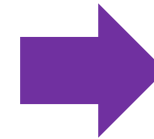


Why Plastic?



Ease of manufacturing – **Labor Savings**

- The plastic part is injection molded in one shot with a metal hub molded-in.
- Total molding time of full plastic assembly is approximately 2 minutes.
- Assembly time of metal fan is ~10x longer.
- Tolerance of plastic part is much tighter.
- Plastic fan blades provide more design freedom.



Why Plastic?



Weight Savings

Material	Specific Gravity
Copper	8.80
Steel	7.85
Aluminum	2.70
Glass	2.60
PVDF (polyvinylidene fluoride)	1.77
PVC-U	1.40
PPSU (polyphenylsulfone)	1.29
Nylon 66	1.16
PMMA (acrylic)	1.15
Polypropylene	0.91

> 2x

Why Plastic?

HOLD ON!



Both parts weigh the same



Why Plastic?

HOLD ON!



Both parts weigh the same

- To achieve required structural properties, wall thickness was increased, and fiber reinforcement utilized.
- It is crucial to know the stresses that the component will endure during both assembly and operation.
- Implement appropriate plastic engineering and design principles to guarantee expected lifetime.
- The motivation for switching to plastic may not be based solely on reduction in weight.

Why Plastic?



Corrosion Resistance

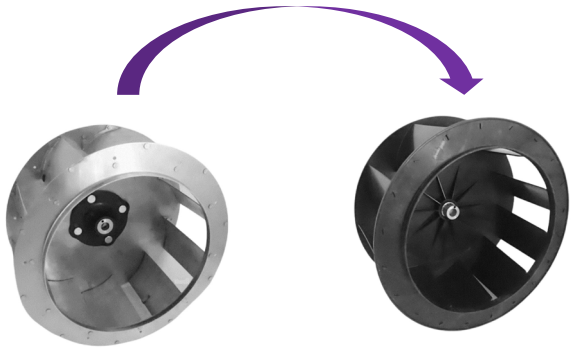
- Plastics do not experience corrosion.



Ref: Fractory

Why Plastic?

HOLD ON!



Plastics can be highly susceptible to chemical attack

Exposure to non-USP grade glycerin

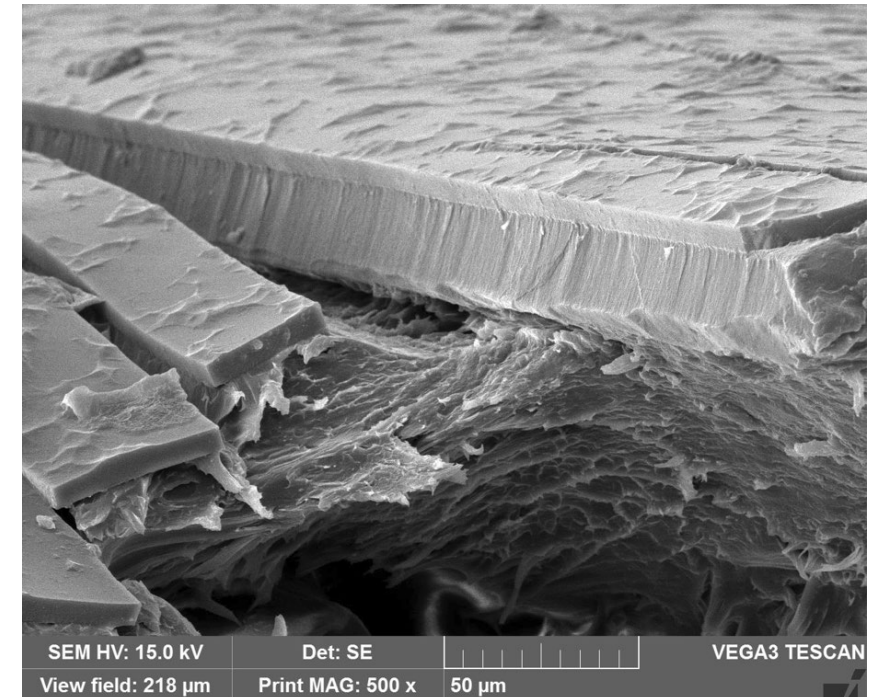


Copper

PVC

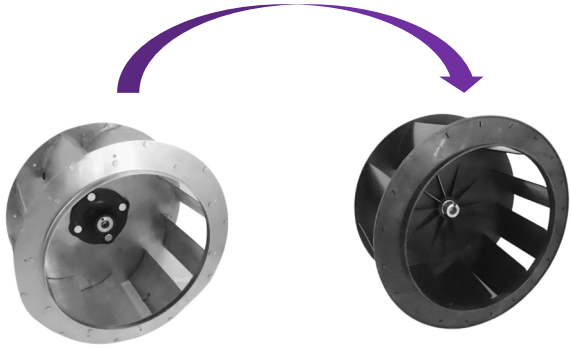
CPVC

Chemical attack of polycarbonate by cooking oil



Why Plastic?

HOLD ON!

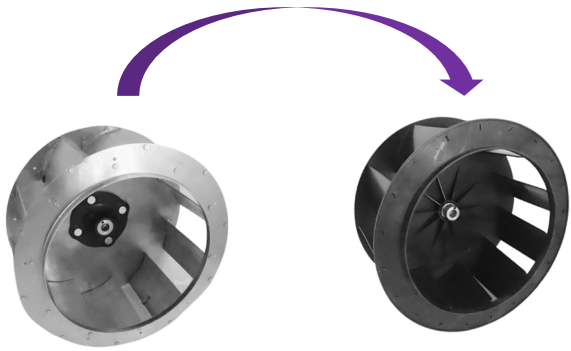


Plastics highly susceptible to environmental stress cracking (ESC)

- ESC is not chemical attack.
- ESC occurs with the combination of stress and a chemical.
- Commonly occurs with chemicals that do not degrade the plastic.
- Dependent on stress level, chemical and plastic.
- Reduce either stress or chemical may eliminate cracking.

Why Plastic?

Failure can be avoided

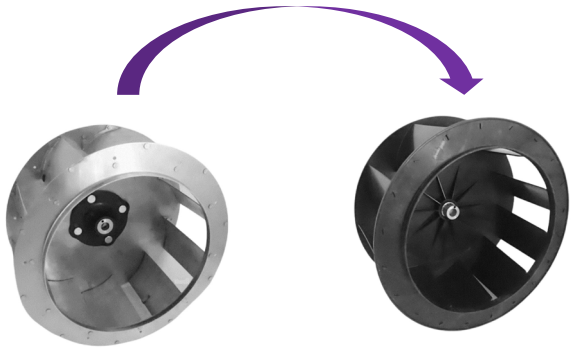


Plastics highly susceptible to environmental stress cracking (ESC)

- Failure from chemical attack or ESC can be avoided with the appropriate engineering.
- Understand stresses and environment.
- Use appropriate molding conditions to keep molded-in stresses low.
- Use design to your advantage to ensure all stresses are low.
- Selection of the correct plastic may be key.

Why Plastic?

Failure can be avoided

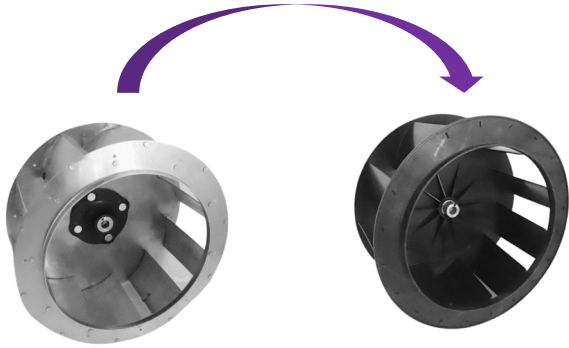


Plastics highly susceptible to environmental stress cracking (ESC)

- Failure from chemical attack or ESC can be avoided with the appropriate engineering.
- Understand stresses and environment.
- Use appropriate molding conditions to keep molded-in stresses low.
- Use design to your advantage to ensure all stresses are low.
- Selection of the correct plastic may be key.

Do the Appropriate Engineering:
Predict & Prevent

Why Plastic?



Exposure to the environment - rain and sunlight

- Many plastics will repel water and UV light.



Ref: Detailed Image

Why Plastic?

HOLD ON!



Exposure to rain and sunlight

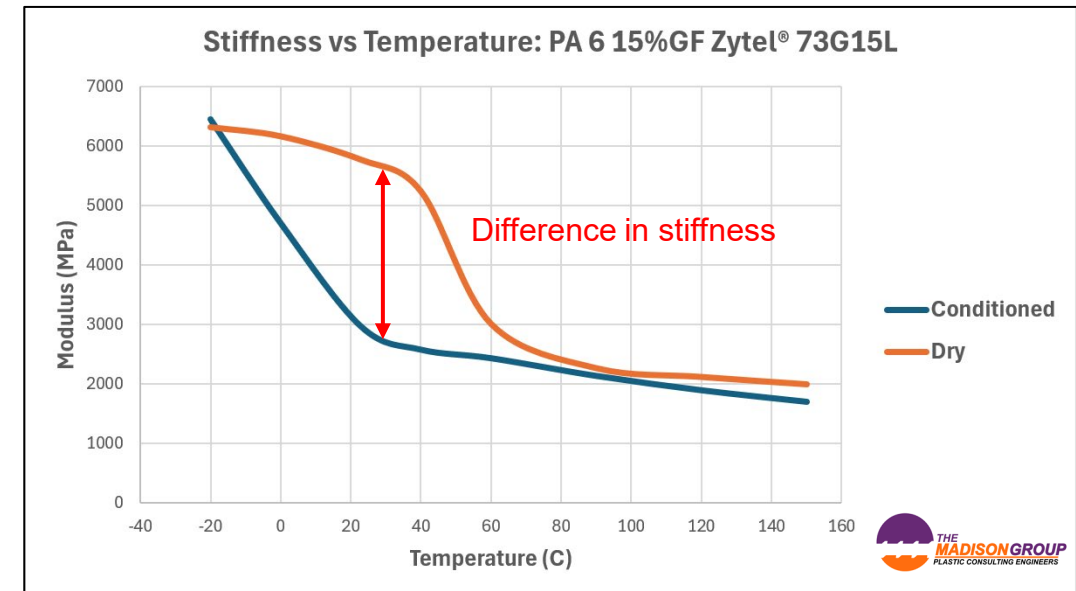
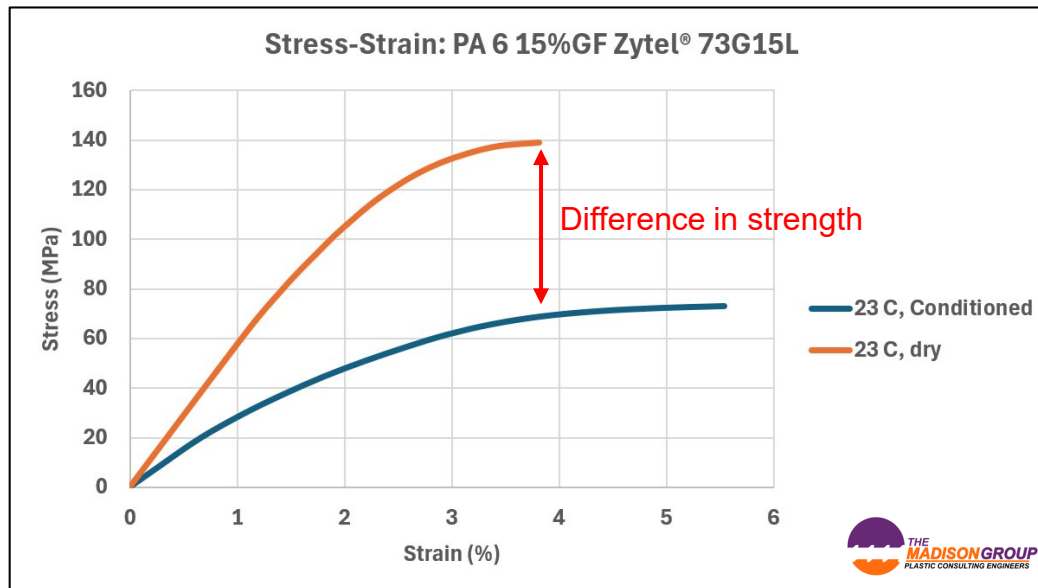
- Some common plastics absorb water like a sponge.
- Moisture acts as a plasticizer – dramatically changes properties.
- Reduces strength and stiffness; but increases toughness.
- The plastic part can change in size.



Demonstration

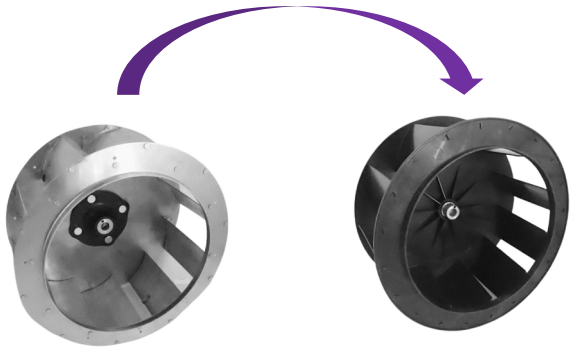
Properties of Nylon 6 change dramatically when exposed to moisture.

Effect of moisture on Nylon 6



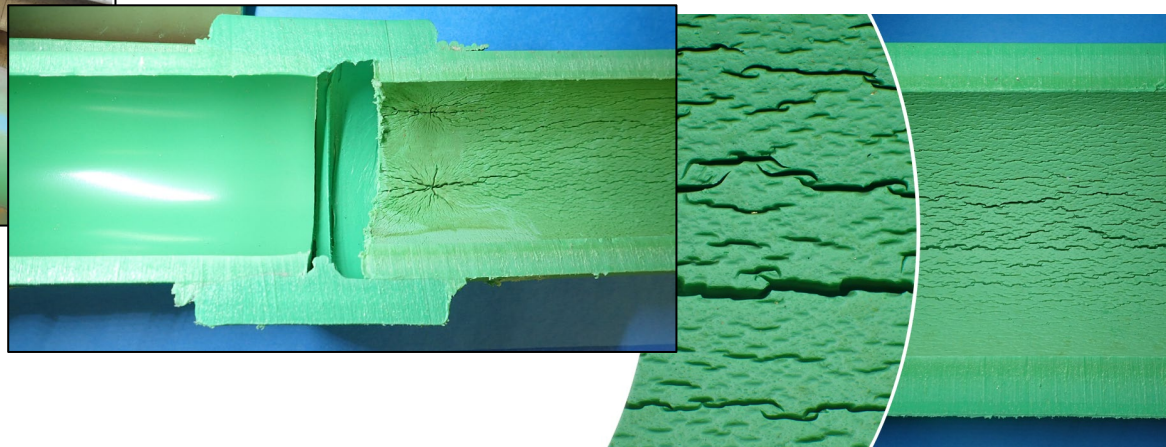
Why Plastic?

HOLD ON!



Some plastics are susceptible to UV and oxidize

- Some of the most chemical resistant plastics are highly susceptible to oxidation (aging).
- UV from the sun or lighting can accelerate oxidation.
- 10X more susceptible in the presence of copper – ubiquitous in the plumbing industry.



- Thermo-oxidation of PP-R pipe
 - Used for transporting hot & cold water.
 - Failures typically start in less than 5 years
 - Catalyzed by metal ions, e.g. copper ions.
 - Both hot and cold water systems are affected

Why Plastic?

Possible Solution



Some plastics are susceptible to UV and oxidize

- Antioxidants and UV blockers can be mixed into plastic to increase lifetime.
- Antioxidants are consumed protecting the plastic – eventually they will be used up.
- There are some applications where certain plastics should not be used.

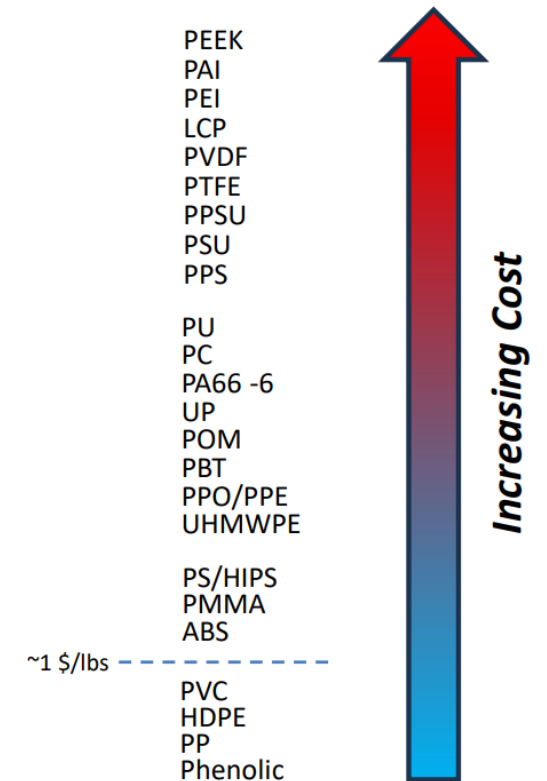


Why Plastic?



Cost

- When all costs are considered, plastics can provide huge benefits.
- Plastic materials are typically, but not necessarily, less expensive.
- Manufacturing with plastics can be significantly less expensive: many parts to one/few parts.
 - Labor costs can be tremendously lower.
- End of life can be more difficult with plastics.



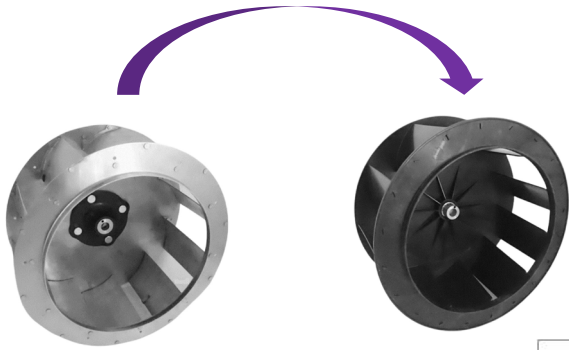
Why Plastic?



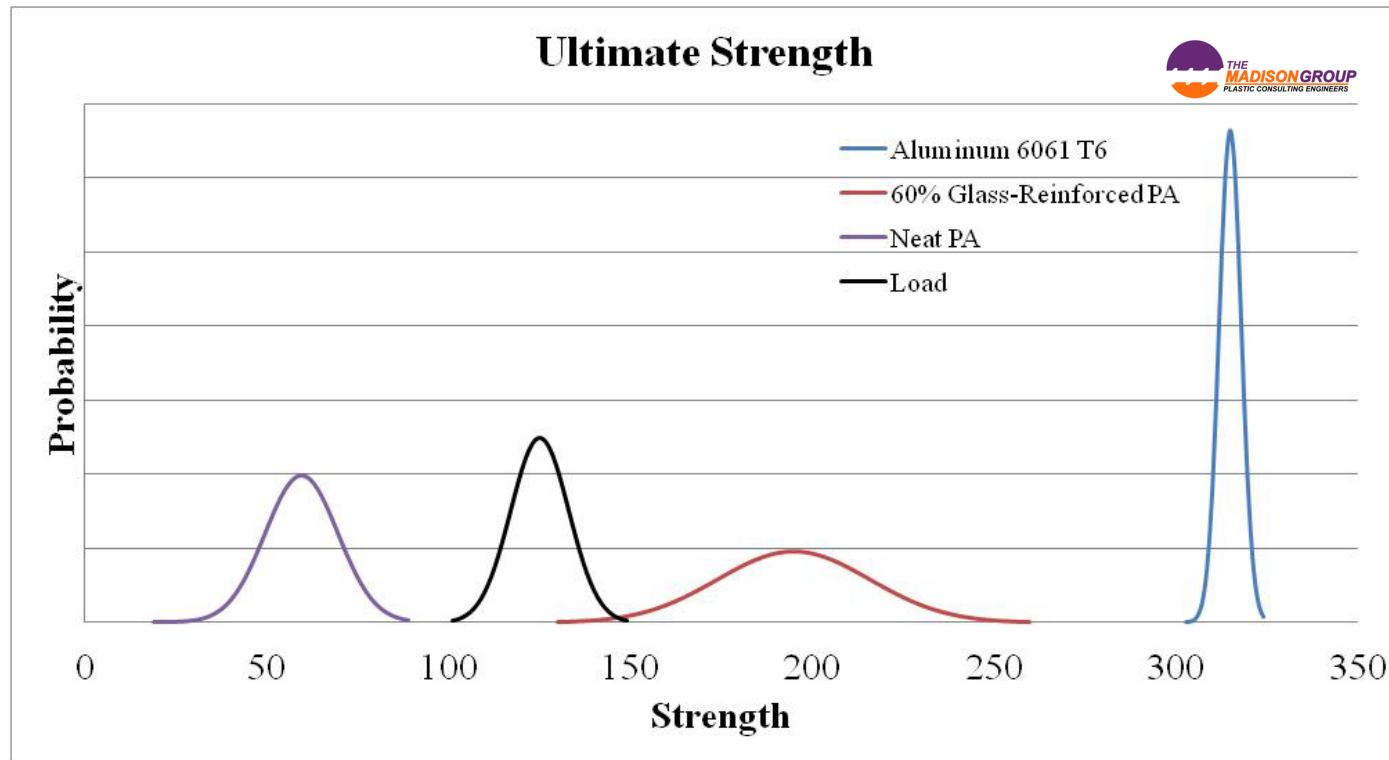
Properties of plastics vs metal

Material	Modulus	Ultimate Tensile Strength
6061 T6 Aluminum	68.9 GPa	310 MPa
60% Long-Glass Fiber PA6	21.4 GPa	262 MPa

Why Plastic?

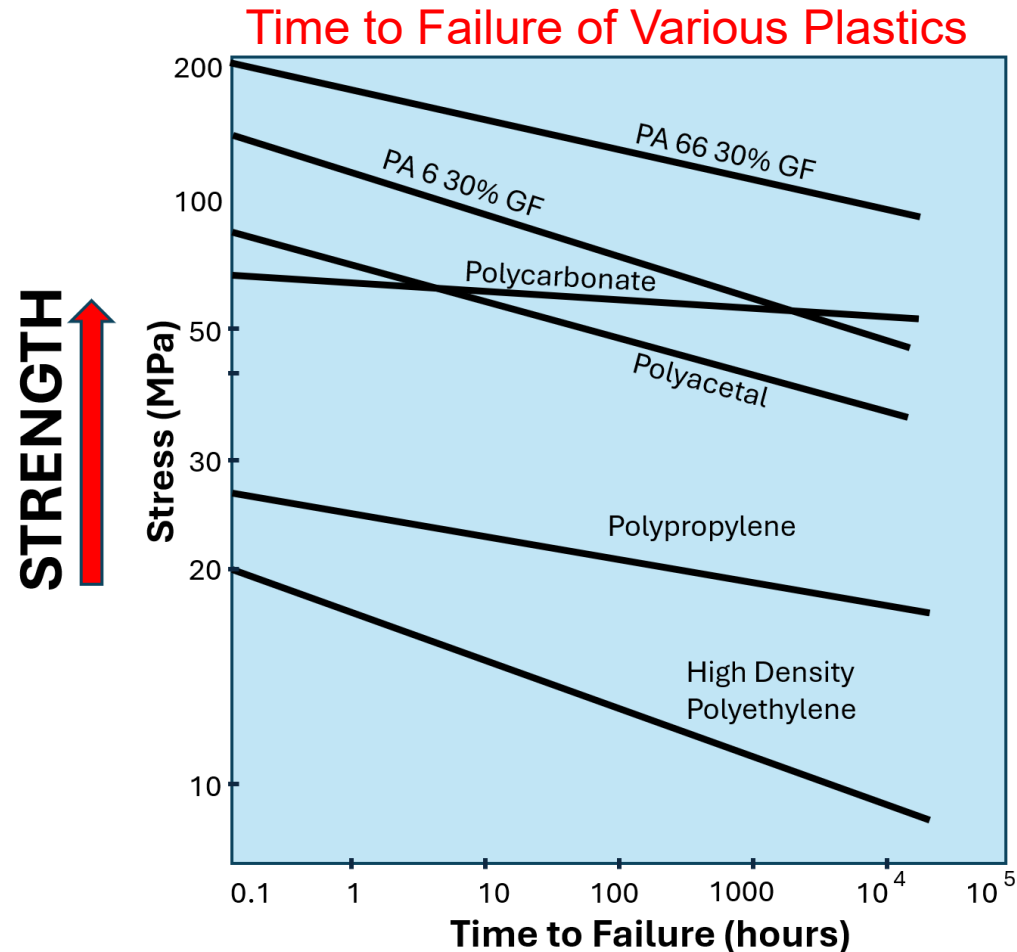
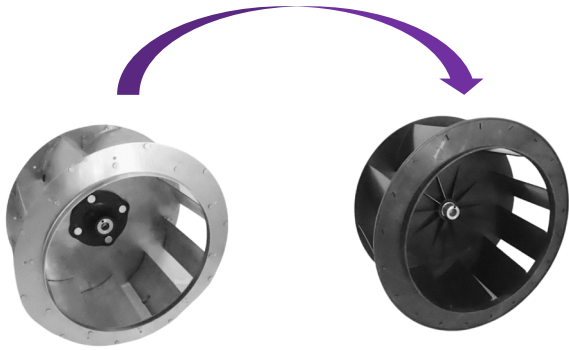


Properties of plastics vs metal



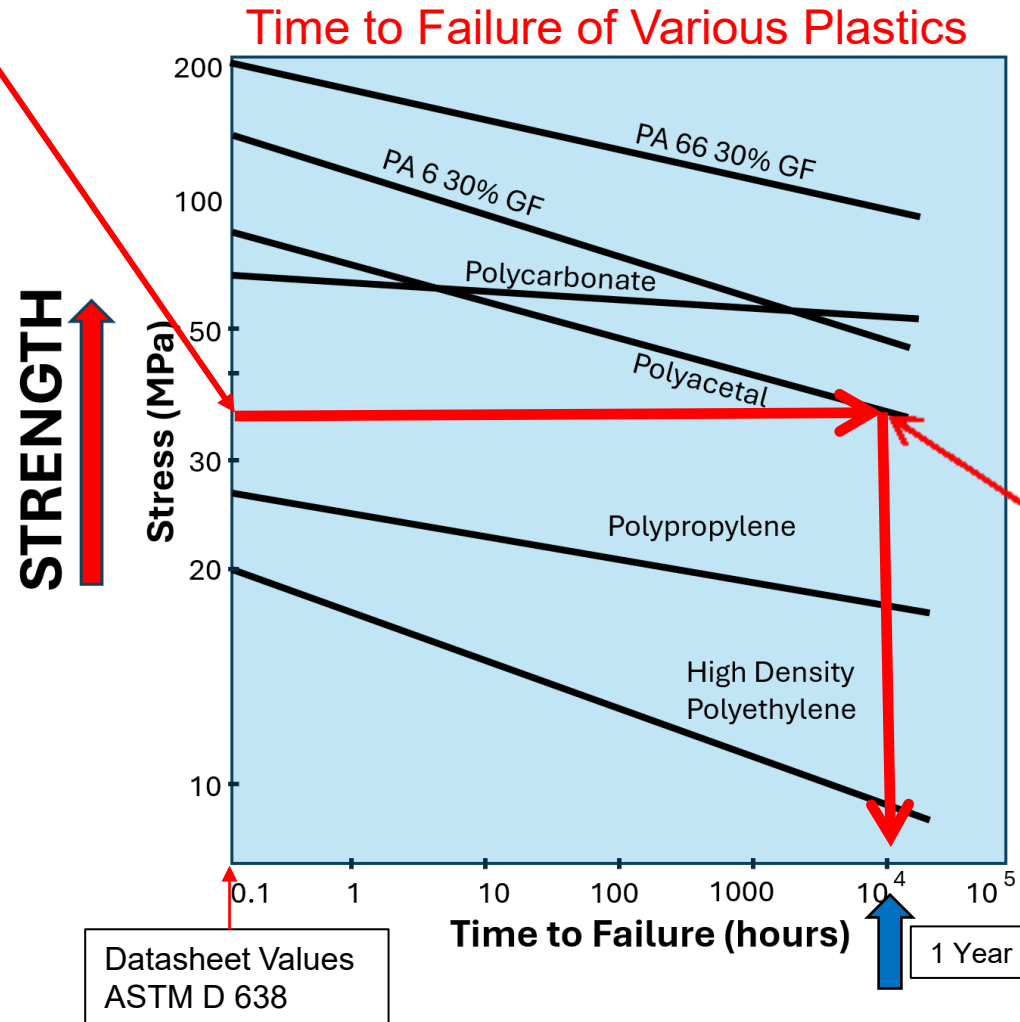
Why Plastic?

Do not forget plastic properties change with time.



Why Plastic?

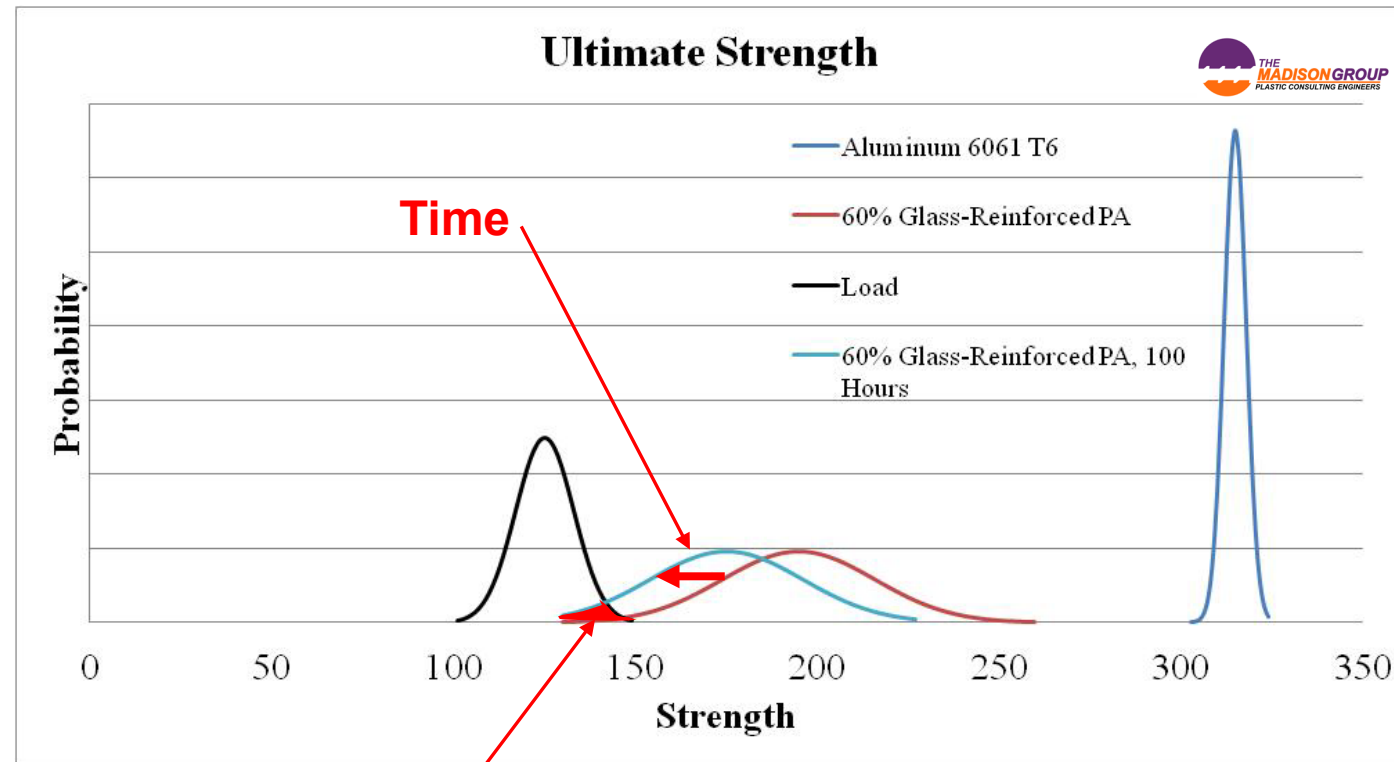
Do not forget plastic properties change with time.



Why Plastic?



Properties of plastics vs metal



Why Plastic?

With appropriate engineering, the challenges associated with converting a metal part to plastic can be overcome.



Thank you! Questions?

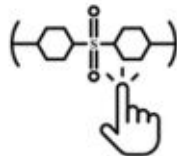


Paul Gramann, PhD, PE
paul@madisongroup.com
www.madisongroup.com

The Madison Group is the recognized leader in plastics engineering. Over the course of three decades The Madison Group has focused on polymeric materials. We understand how these materials behave, how to properly design with them, how they are processed, and the numerous manufacturing steps required to produce a successful product. Our capabilities include:



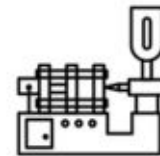
Design Review



Material Support



Product Testing



Manufacturing
Support



Failure Analysis



Customized
Training