Coffee Maker Housing

1.)

Primary Functions

- Provide a protective barrier separating the internal electrical components from outside disturbances
    - Insulation to keep heat in
    - Water resistant to keep moisture out
- Support 12 cups of water and internal components

Secondary Functions

- Provide smooth, easily cleaned surface

Hard Constraints

- Low density
- Low cost
- Elastic to allow for snap fit joints
- Impact resistant
- Strength
- Can handle constant heating and cooling cycles
- High melting point
    - regular home coffee is around 54°C -60°C
    - MacDonalds can be up to 88°C
    - Our material melting point must be substantially higher than both of these
- Manufacturable for our intended method: Injection Molding

Soft Constraints

- Aesthetically appealing

Objective

- To find an ideal ratio between strength and elasticity while minimizing material cost and density and maximizing impact resistance and melting point

2.)

The primary function of the external coffee maker housing is to provide a protective barrier separating the internal electrical components from outside disturbances. Simply, the housing must keep external moisture out while keeping heat in. A variety of materials can be used, but many are eliminated because of their density, thermal properties, susceptibility to corrosion, or cost. Though our material needs to have a certain degree of strength (rigid enough to support the weight of 12 cups of water as well as the internal components) and impact resistance, it needs to be elastic to allow for cantilever snap fit joints and resistance to the temperatures fluctuations created by the heating element.

Most metals, while strong, are too dense, making our coffee maker too heavy. Weight of the coffee maker is a major factor because it affects its mobility, therefore limiting the target customer base. Also, the raw material costs and difficulty to manufacture make most metals too expensive. Our snap fit design would be eliminated as well with the choice of a metal because of their lack of elasticity. Also, while generally aesthetically appealing, a secondary function, most metals are not as heat and corrosion resistant as we would like. Overall, metals did not seem like a viable option, so we placed our emphasis on thermoplastics.

When looking at thermoplastics many were still too brittle, many were not cost effective, and many did not have the temperature resistance we were looking for. Though polystyrene had a modulus of elasticity (around 2.8 GPa) that we were looking for it had a low impact resistance. Heat stabilized nylon and polyetherimide had a too large elastic modulus, between 3.5 and 4.5 GPa, while high density polyethylene (HDPE) had too low an elastic modulus of 1.1 GPa. Polybutylene and acrylic provided some of the material properties we were looking for but were not cost effective. Based on the material properties desired, we looked closer at molded ABS plastic, polypropylene, and polycarbonate.

The combination of high elasticity, low density, acceptable melting points, and low cost made ABS plastic, polypropylene, and polycarbonate our main material options. We believe Molded ABS plastic is the way to go. The modulus of elasticity (2.4 GPa), melting point (over 150°C) and cost (1.80$/lb) provide a relatively cost effective option with a good mix of strength, elasticity, impact resistance, and heat resistance. Polycarbonate has the mix of elasticity and strength we are looking for (2.3 GPa), as well as a high melting point (250°C), but is quite expensive at 2.90$/lb, making it our second option. Polypropylene, though more cost effective (0.8$/lb) with a decently high melting point (160°C), lacks a little in strength (1.4 GPa) and impact resistance. Plainly, though a very cheap option, we think it may be too soft for our application, making it our third option. A further explanation of our material selection can be seen in the right side of the table on the following page.

3.) Based on the material properties required for our coffee maker housing design, we believe Molded ABS plastic is the best option. The modulus of elasticity (2.4 GPa), melting point (over 150°C) and cost (1.80$/lb) provide a relatively cost effective option with a good mix of strength, elasticity, impact resistance, and heat resistance. Creep was also considered in this selection due to the variety of thermal conditions the material is subjected to. The glass temperature, T_g, is more important than the melting temperature, for how creep will affect the polymer's rigidity. For Molded ABS plastic the T_g is 107˚ C to 115˚ C. These temperatures are well above the operating temperature of the coffee maker and for all practical purposes the material no longer creeps. In addition, ABS plastic seems to be a great option for our intended method of manufacture, injection molding. ABS is relatively easy plastic to deal with and is easy on the injection molding equipment, both the mold itself and the ejectors. ABS also does a good job of filling voids in think sections without sinking. A further explanation of our material selection can be seen in the table on the following page. Because of the method of our manufacture, injection molding, the shape of the part doesn't really increase the difficulty of manufacture. The carafe handle is already an asymmetrical design, so the actual assembly of the carafe should be simple.

Plastic Comparison Sheet

			Mechanical Properties			Moldability Characteristics					
Resin Generic Name	Some brand names	Relative Cost	Strength	Impact Resistance	High Temp. Strength	Warp and Dimensional Accuracy, Molded	Fills Small features	Voids in thick sections	Sink in Thick Sections	Flash	High Temp. hard on Mold & Ejectors
Acetal	Delrin, Celcon	Medium	Medium	Medium	Medium-Low	Fair	Fair	Poor	Good	Good	Fair
Nylon 6/6	Zytel	Medium	Medium	High	Low	Fair	Excellent	Good	Fair	Poor	Fair
Nylon 6/6, glass filled	Zytel	Medium	High	Medium	High	Fair	Good	Excellent	Good	Fair	Fair
Polypropylene	Maxxam, Profax	Low	Low	High	Low	Fair	Excellent	Poor	Poor	Poor	Good
High Density Polyethylene (HDPE)	Dow HDPE, Chevron HDPE	Low	Low	High	Low	Fair	Excellent	Fair	Poor	Poor	Good
Polycarbonate	Lexan, Makrolon	Medium	Medium	High	Medium-High	Good	Fair	Fair to Good	Fair to Good	Good	Good
Acrylonitrile Butadiene Styrene (ABS)	Lustran, Cycolac	Low	Medium-Low	High	Low	Good	Fair	Good	Fair	Good	Good
Polycarbonate / ABS Alloy	Cycoloy, Bayblend	Medium	Medium	High	Medium	Good-Excellent	Fair	Good	Fair	Good	Good
Polyetherimide	Ultem	High	High	Medium	High	Good-Excellent	Fair	Fair	Good	Good	Poor
Polyetherimide, fiber reinforced	Ultem	High	Very High	Medium	High	Good	Fair	Fair	Good	Excellent	Poor
Polybutylene Terephthalate	Valox, Crastin	Med-High	Medium	High	Low	Fair	Fair	Unknown	Fair	Fair	Good
Polystyrene	Styron	Low	Medium-Low	Low	Low	Good	Good	Unknown	Fair	Fair	Good
Thermoplastic Elastomer	Isoplast, Santoprene	Low-Med	Low	High	Medium	Fair	Excellent	Excellent	Good	Poor	Excellent
Acrylic	Plexiglass, Acrylite	Medium-High	Medium	Low	Low	Good	Fair	Excellent	Good	Good	Good