ASSIGNMENT 3 (DSL-732)

MATERIAL SELECTION

1. Body of electric switch/plug

For selecting the proper material for the body of an electric switch, we have to make a list of properties that we would want in our product. The product should prevent user from getting any shock while operating the switches. Also, the switches are regularly used in a rough and tough way, so should be durable. as follows

- Good electrical insulator
- Strong
- Hard
- Resists wear and scratches
- good water resistance
- easily available in large quantities
- can be manufactured in various sizes and large numbers
- opaque
- recyclable (if possible)

Working in the CED Edupack

Material universe – All polymers

Plotting graphs with properties-

Stage 1: x = electrical resistivity (3.3e18 to 3e19) , y=thermal conductivity (0.1 to 0.4)

Stage 2: x = tensile strength (34 to 63) , y = Maximum service temperature (210 to 230)

Stage 3: x = elongation % (1 to 2), y = Thermal expansion coefficient (110 to 130)

Stage 4: x= recycle (true or false), y = Co2 footprint, primary production (3 to 3.5 kg)

Stage 5: x = Density (1250 to 1300 kg/m3), y = Price (120 to 130 INR/kg)

Stage 6: x= category- composition details (polymer and natural) -woodflour percentage (60-80%), y = Compressive strength (35 to 69 Mpa)

After the 6 stages, there are only 2 materials that passed from 828 materials.

The materials are as follows:

a) PF (Woodflour filled, molding)
b) UF (Alpha cellulose fibre)

Now detail study of the properties of both the materials is done to analyze the suitable material for switches.

Properties	Phenol Formaldehyde (PF)	Urea Formaldehyde Resin (UF)
Common names	Bakelite, Durez, Fiberite	Beetle, polopas
Density(kg/m^3)	1.37e3 – 1.46e3	1.47e3 – 1.52e3
Price(inr/kg)	136 - 150	142 - 156
Composition	P(40-70%) N(30-60%)	P(40-70%) N(30-60%)
Compressive strength (MPa)	172 -214	172 - 310
Tensile strength (MPa)	34.5 – 62.1	41 - 89.6
Elongation (% strain)	0.7 – 0.8 brittle	0.5 – 1 very brittle
Maximum service temperature (deg C)	142 – 158 good	70 – 84 low
Thermal conductivity (W/mdegC)	0.167 – 0.335	0.0837 – 0.419
Thermal expansion coeff	54 – 81	39.6 – 64.8
Electrical resistivity (ohm.cm)	3.3e15 – 3e16	5e16 – 5e17
Transparency	Opaque	Opaque
Durability - flammability	Slow burning	Self -extinguishing
Durability - water	excellent	acceptable
Co2 footprint, production (kg/kg)	2.42 -2.67	1.91 -2.12
Material processing – polymer molding (MJ/kg)	Compression molding - 16 to 17.7	14 -15.5
Material processing Co2 footprint – polymer molding(kg/kg)	1.2 to 1.32	1.05 – 1.16
Recyclable	No	No
Downcycle	yes	yes
Current usage	Adhesives, electrical laminates	Industrial laminating, decorative laminating, coatings, adhesives

Though PF is the commonly used material (bakelite) for switches, UF can be a good alternative where water resistance is not necessary and maximum service temperatures are low, but is comparatively higher in price than PF.

2. A coffee mug

A coffee mug is mostly used for hot liquids with temperatures above 100 deg C. So, the product material should be able to sustain in this temperature. Also, the cup is in contact with our hands, so it should also have some level of thermal insulation, to prevent burns and also to keep the liquid hot for a longer time. It should not break easily and should be stable. It should be moldable and should not have toxins. A coffee mug should have the following properties

- Low thermal conductivity
- Reusability

- Easy to clean(non-staining)
- Non-harmful to health
- high hardness,
- high melting points,
- low thermal expansion,
- good chemical resistance
- smooth in texture – glossy finish

Working in the CED Edupack

Material universe – ceramics and glasses

Plotting graphs with properties-

The commonly known materials that are used for making coffee mugs are ceramic, glass, borosil, plastics, and alloys such as steel. So, individual properties of these materials were studied.

Stage 1: x = Density (2200 – 2300 kg/m^3), y = Maximum operating temperature (200 – 500 deg C)
Stage 2: x = Thermal conductivity (1 – 2 W/m.°C), y = Thermal expansion coefficient (2 to 5 µstrain/°C)
Stage 3: x = Elongation (0-0.05 % strain), y = Flammability
On selecting (non-flammable), the list of materials is shortened to 131/326

Stage 4: x = Specific heat capacity (750-800 J/kg.°C), y = Recycle
On selecting the materials which are recyclable, the list is further shortened to 33/326

Now by selecting the area under 300 deg C of Maximum operating temperature in stage 1 and Thermal expansion coefficient above 3, the list is narrowed down to 5 materials.

Stage 5: Water (salt) vs. Water (fresh), selecting the excellent scenario in both the cases, narrows down the list to 3 materials which are –

- Borosilicate - 3320
- Borosilicate - 7740
- Borosilicate - KG33

Now looking at them
Typical usage – Borosilicate – KG33 is eliminated as its used only for laboratory ware.
Composite materials - Borosilicate – 3320 is eliminated as it has Uranium, which is toxic for using with food

So, the material from the ceramic family, that can be used for making coffee cup is **Borosilicate - 7740**

3. Mobile phone cover

As mobile phones are used a lot, they are more prone to wear tear and staining. Also, the main purpose of mobile phone covers is to prevent damage to the phone, so it should be unbreakable and shock absorber. The aesthetics are also important, so it should be available in multiple colours and should be customizable. So, the material properties of mobile phone covers should be:

- Shock absorber
- Bad conductor of heat
- Available in colours/customizable in shape
- Resists wear and scaratches
- Recyclable (if possible)
- Water resistant

Working in the CED Edupack

Material universe – All bulk materials

Plotting graphs with properties-

Stage 1: x = Minimum service temperature (-20 to 0 °C), y = Maximum service temperature (45 to 100 °C)

Setting the limits –
Price =150 to 250 INR/kg
Base = Polymer
Flammability = Non-flammable
Recyclable material

This results in two options of materials –

- PVDC – copolymer, barrier film resin, unplasticized
- PVDC – copolymer, injection

Both these materials have very similar properties, and both can be used for making phone covers.