MEC E1070 Task 0 Ollimatti Särkelä 897284

Task 0_1

For my material group I chose elastomers. Elastomers are a subset of polymers, being mostly thermoset polymers (rubber). Thermoplastic elastomers (TPE) also exist, but they are far less common. The name elastomer comes from elastic polymer, which suggests that elastomers generally have capability for great elastic deformation.

Thermoset elastomers include materials such as nitrile rubber (NBR), butyl rubber (IIR) and various types of polyurethane (PUR). Nitrile rubbers are likely most well known to laymen from their use in nitrile gloves. NBR has various uses in the automotive and aeronautical industries as seals and hoses since it is resistant to chemicals such as oil and fuel.

Butyl rubber originally gained popularity from its use in inner tubes of pneumatic tires, which remains as its main use to this day. IIR is used in various other high-pressure applications as well.

PUR or polyurethane rubber is “the strongest rubber” according to Granta EduPack. It has high strength and abrasion resistance. It is used for things such as gears, bearings, wheels, tires and fabric coating.

The less common thermoplastic elastomers have a mix of thermoplastic and elastomeric properties. Their properties suit extrusion and injection molding well, as thermoplastics can be melted and reformed unlike thermosets.

Task 0_2

Fracture toughness

Symbol: K_{1c} Unit: $MPa\, m^{1/2}$ or $\frac{MN}{m^{1/2}}$

Fracture toughness measures the resistance of a material to the propagation of a crack. It is measured by deliberately propagating a crack in a material and recording the tensile stress or bending load at the time of propagation.

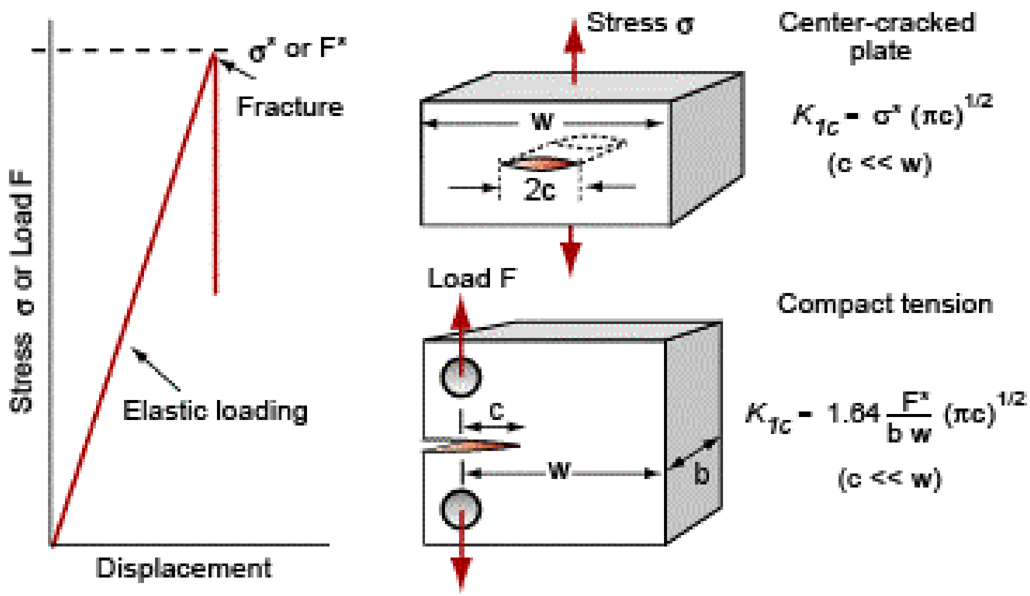

Figure 1. Measuring fracture toughness

Flammability

Flammability is rated on a four-point scale. Most polymers, including elastomers, are flammable to varying degrees. The limiting oxygen index measures the required oxygen concentration in % to maintain steady burning. Fresh air has about 21% oxygen in it. A material with an LOI lower than this will burn freely in air.

Flammability rating	LOI % (limiting oxygen index)	UL-94 rating (1.6 mm nominal thickness)
Highly flammable	< 20	Unclassified or HB
Slow-burning	20–25	HB
Self-extinguishing	26–49	V-2, V-1, V-0, 5VA and 5VB
Non-flammable	> 50	Exceeds all UL94 ratings

Figure 2. Flammability rating

LOI 50 % is a arbitrary cut off point after which materials are considered non-flammable. UL94 ratings are for plastics only and is measured by igniting a strip of polymer 1.6 mm thick and examining its burning.

Transparency

Transparency ratings are not set in stone, as a thin film of a translucent material may be considered transparent.

Opaque	Completely non-transparent, no light passes through
Translucent	Diffuse light is transmitted through the material with the result that images cannot be clearly distinguished
Transparent	Very good transparency though may be inherently tinted
Optical quality	Outstanding transparency, suitable for use in such applications as lenses for spectacles

Figure 3. Transparency rating

Maximum operating temperature (Tmax)

Maximum operating temperature is the maximum temperature at which a material can be used for an extended period of time without significant problems, such as oxidation, chemical change or excessive deflection. There is no universal test for Tmax, and it is frequently reported based on manufacturer recommendation. For polymers the important temperature is the glass transition temperature T_g, as crossing this breaks their desired properties.

Specific heat capacity

Symbol: C Unit: $\frac{J}{kg\,K}$

Specific heat capacity measures the energy required to raise the temperature of a unit mass of material by one degree of temperature. Specific heat capacity is measured via calorimetry.

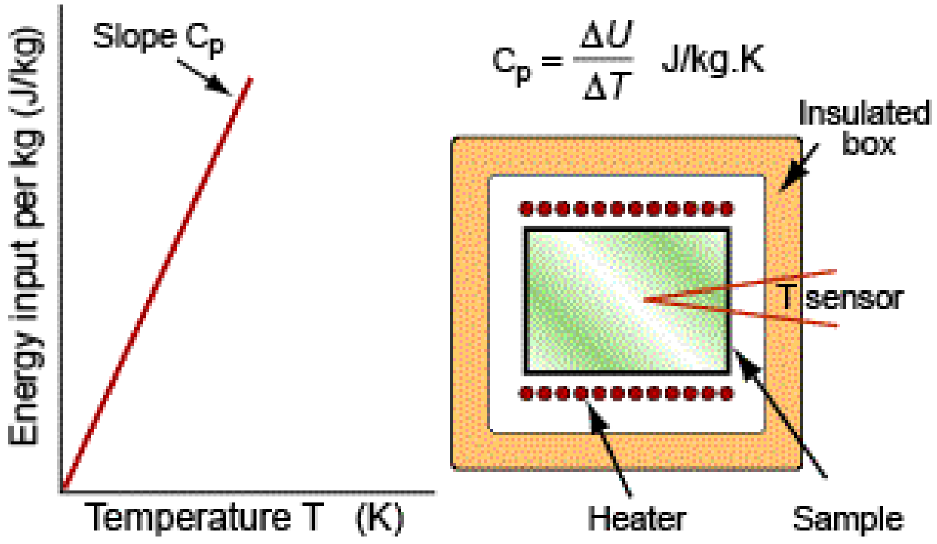

Figure 4. Calorimeter principle. Electrical energy is pumped into a sample of material of known mass, and the rise in temperature is measured.

CO_2 footprint

Materials have different carbon dioxide footprints for different parts of their lifecycle. Granta EduPack lists at least production footprints for virgin and typical grade materials, polymer molding CO_2 footprint, grinding CO_2 footprint and combustion CO_2. These are given as CO_2-equivalent mass of greenhouse gases in kilograms for producing/molding/grinding etc. one kg of the material.

Thermal conductivity

Symbol: $\lambda, k\ or\ \kappa$ Unit: $\frac{W}{m\,K}$

Thermal conductivity is a measure of a material's ability to conduct heat. It is measured by recording the heat flux flowing through the material from a surface at a higher temperature to a lower one.

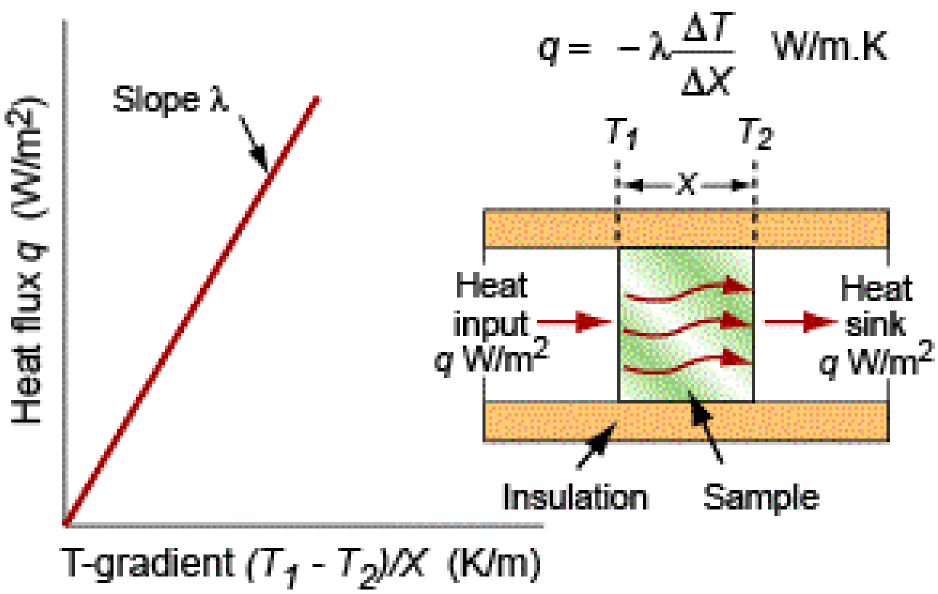

Figure 5. Measuring thermal conductivity. q is the heat flux.

Coefficient of thermal expansion

Symbol: α Unit: $\frac{1}{K}$ $or \frac{"microstrain"}{°C}$ $or\ 10^{-6}K^{-1}$

It is defined by $\alpha = \frac{1}{L}\frac{dL}{dT}$, where L is a linear dimension of the body. It is measured by measuring the change in dimensions of a test sample with a change in temperature.

Ceramics	0.1–15 microstrain per degree C
Metals	5–35 microstrain per degree C
Filled polymers	1–75 microstrain per degree C
Unfilled polymers	50–400 microstrain per degree C
Elastomers	100–700 microstrain per degree C

Figure 6. Typical values of α for different classes of materials

Electrical conductivity

Symbol: $\sigma, \kappa\ or\ \gamma$ Unit: $\frac{S}{m}$

Electrical conductivity is the reciprocal of electrical resistivity, which measures the electrical resistance of a material. One must not confuse conductivity and resistivity with conductance and resistance. Conductivity increases as the purity of the material increases. The resistivity of a metallic conductor decreases as temperature is lowered (and thus conductivity increases). This leads to the fact that superconductors function only in very low temperatures.

Toxicity

Toxicity is ranked on a four-point scale in Granta EduPack: non-toxic, slightly toxic, toxic and very toxic. There are many ways to measure toxicity, as there are many different types of toxins. Acute toxicity looks at the lethality of a toxin following different types of exposure.

Method of administration	Category 1	Category 2	Category 3	Category 4	Category 5
Oral: LD_{50} measured in mg/kg of bodyweight	7	50	300	2 000	5 000
Dermal: LD_{50} measured in mg/kg of bodyweight	50	200	1 000	2 000	5 000
Gas Inhalation: LC_{50} measured in ppmV	100	500	2 500	20 000	Undefined
Vapour Inhalation: LC_{50} measured in mg/L	0.5	2.0	10	20	Undefined
Dust and Mist Inhalation: LC_{50} measured in mg/L	0.05	0.5	1.0	5.0	Undefined

Figure 7. Acute toxicity. Category 1 requires the least amount of exposure to be lethal and category 5 requires the most exposure to be lethal.

Now comparing for values found in levels two and three. Values are for butyl rubber (IIR). Level 3 had the option for unreinforced or 30-50% carbon IIR, unreinforced was chosen since it matched level 2.

Property	Level 2 value	Level 3 value
Fracture toughness	0.037-0.111 MPa m^0.5	0.037 – 0.111 MPa m^0.5
Specific heat capacity	1.85-1.95J/kg°C	1.85-1.95J/kg°C
Thermal conductivity	0.08-0.13 W/m°C	0.08-0.13 W/m°C
Coefficient of thermal expansion	170-200 microstrain/°C	170-200 microstrain/°C

I presume I misunderstood this part of the task. I don’t see how this is useful exercise.

Task 0_3

English	Suomi	Deutsch
fracture toughness	murtumislujuus	bruchzähigkeit
flammability	syttyvyys	entflammbarkeit
transparency	läpinäkyvyys	transparenz
maximum operating temperature	suurin toimintalämpötila	maximum betriebstemperatur
specific heat capacity	ominaislämpökapasiteetti	spezifische wärmekapazität
CO_2 footprint	hiilijalanjälki	CO_2-bilanz
thermal conductivity	lämmönjohtavuus	wärmeleitfähigkeit
coefficient of thermal expansion	lämpölaajenemiskerroin	längenausdehnungskoeffizient
electrical conductivity	sähkönjohtavuus	elektrische leitfähigkeit
toxicity	myrkyllisyys	toxizität