Aalto University
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Task 0: Pre-assignment

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Task 0_0:

Check GRANTA EduPack software and learn the user interface, watch tutorial videos and follow the exercises by yourself (In GRANTA EduPack 2023 R2 go to → Help/Video Tutorials → "GRANTA EduPack overview", and "Select" videos).

Task 0_1:

You will be given the following material groups to study and choose one as you wish: -

Composites	Plastics
Foams	Non-technical ceramics
Metals	Technical ceramics
Elastomers	Natural materials

Explain the description of the given material group (what it is, what are the typical material in the group, etc.) - Give three examples of specific materials representative of this group and corresponding examples of what they are used for.

Plastics

Plastics are long chain polymeric molecules. Modern plastics have been improved and are now used in many areas. Nowadays plastics have solid stability and durability. Typical behavior for plastics is their ability to be molded. This may not be true for all plastics (especially at ambient temperatures). Usual elements found in plastics are carbon, silicon, hydrogen, nitrogen, and others. These elements are usually extracted from oil or coal. [1]

Typical Materials in this group:

Polyethylene (PE)

Typical uses

Oil container, street bollards, milk bottles, toys, beer crate, food packaging, shrink wrap, squeeze tubes, disposable clothing, plastic bags, paper coatings, cable insulation, artificial joints, and as fibers - low cost ropes and packing tape reinforcement.

Methyl methacrylate (PMMA)

Typical uses

Lenses of all types, cockpit canopies and aircraft windows, signs, domestic baths, packaging, containers, electrical components, drafting equipment, tool handles, safety spectacles, lighting, automotive tail lights, chairs, contact lenses, windows, advertising signs, static dissipation products, compact disks.

Polyether ether ketone (PEEK)

Typical uses

Electrical connectors, hot water meters, F1 engine components, valve and bearing components, wire and cable coatings, film and filament for specialized applications, pump wear rings, electrical housing, bushings, bearings.

Task 0_2:

From the GRANTA EduPack-database, find the following material properties:

Fracture toughness

= measure of resistance of a material to crack propagation.

It can be measured by loading a sample containing an introduced crack of a specific (2c) length. The fracture toughness is proportional to the tensile stress σ that is measured when the crack propagates.

We define toughness as the material's ability to absorb energy before fracture.

Transparency

= transparency is usually determined by optical methods. Before analyzing a sample, it should be prepared as a thin film.

Transparency of a material is represented by four ratings:

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

Specific heat capacity

=The energy required to raise the temperature of a unit mass of material by one degree of temperature – J/kg.°C (same as J/kg.K).

Cp depends on temperature change and phase change. For more exact calculations it is better to use a model that respects the temperature influence in certain temperature intervals.

Specific heat capacity is measured using calorimetry. Many liquids are specific by having a much higher specific heat capacity. Most common example would be water.

Thermal conductivity

=Thermal conductivity (λ) is a measure of how well a material transfers heat.

Measured by recording the steady state heat flux J (W/m^2) flowing through a material of thickness W, under the influence of a fixed temperature gradient ΔT.

Thermal conductivity varies with temperature. Values quoted in the database represent room temperature performance (around 23°C) and may not represent the performance at other temperatures.

For a given temperature difference, materials with a high thermal conductivity will conduct more heat than materials with lower conductivity. Likewise, materials with high conductivity will require a smaller temperature gradient to conduct a given amount of heat.

Electrical conductivity

= A measure of the ease that an electric charge moves through a material.

Electrical conductivity is defined as:

Electrical conductivity = 1 / Electrical resistivity

Factors that should be considered when selecting materials are that electrical conductivity and resistivity are very sensitive to impurities, heat treatment and mechanical worked state, especially at very low temperatures. This sensitivity is decreased above room temperature.

Flammability

= Flammability rating on a four-point scale. These are the approximate correspondences to LOI and UL-94 at 1.6 mm thickness.

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

UL94 ratings are for plastics only. There are very few UL V-1 rated materials. LOI of 50 is an arbitrary cut-off point above which materials are rated 'non-flammable'.

Maximum service temperature (T_{max})

Highest temperature at which material can be used for an extended period without significant problems, such as oxidation, chemical change, excessive creep, loss of strength, or other primary property for which the material is normally used.

There is no universal test for T_{max}. It is frequently reported on the basis of manufacturer recommendation.

CO2 footprint

= The CO2-equivalent mass of greenhouse gases (kg CO2e), in kg, produced and released into the atmosphere as a consequence of production one kg of the material.

Data are approximate, but still useful in comparing and selecting materials based on CO2e emissions. When comparing materials, differences of less than 20% are not usually significant.

Thermal expansion coefficient

=The fraction a material expands per degree of temperature.

Most materials expand when they are heated. The linear thermal expansion coefficient α is the thermal strain per degree C or F.

Thermal expansion coefficient can be measured by exposing the material of known length to specific temperature gradient. After the material heats up we can measure the dilated length and calculate the coefficient.

Toxicity

= The database ranks toxicity on a four-point scale: non-toxic, slightly toxic, toxic, and very toxic. More pertinent, often, is information about whether a material can be used in contact with skin or food, for children's toys, or for storing medical supplies.

The four toxicity categories, from one to four are:

- Toxicity category I is highly toxic and severely irritating,
- Toxicity category II is moderately toxic and moderately irritating,
- Toxicity category III is slightly toxic and slightly irritating,
- Toxicity category IV is practically non-toxic and not an irritant.

Examples

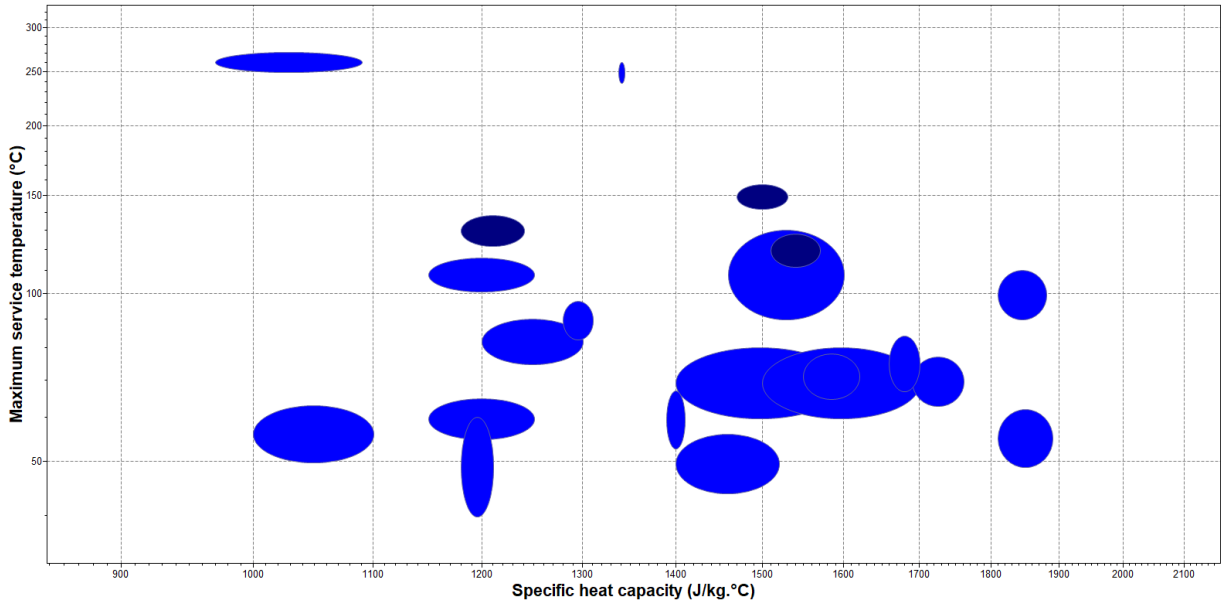

Figure 1 - Specific heat capacity - Maximum service temperature chart at level 2

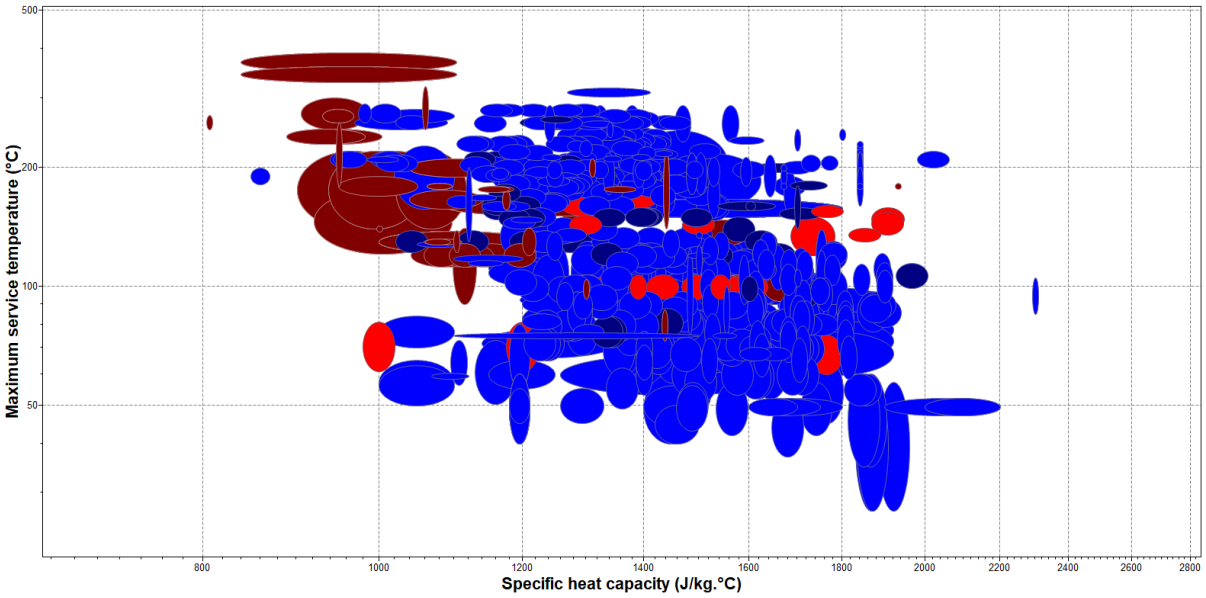

Figure 2 - Specific heat capacity – Maximum service temperature chart at level 3

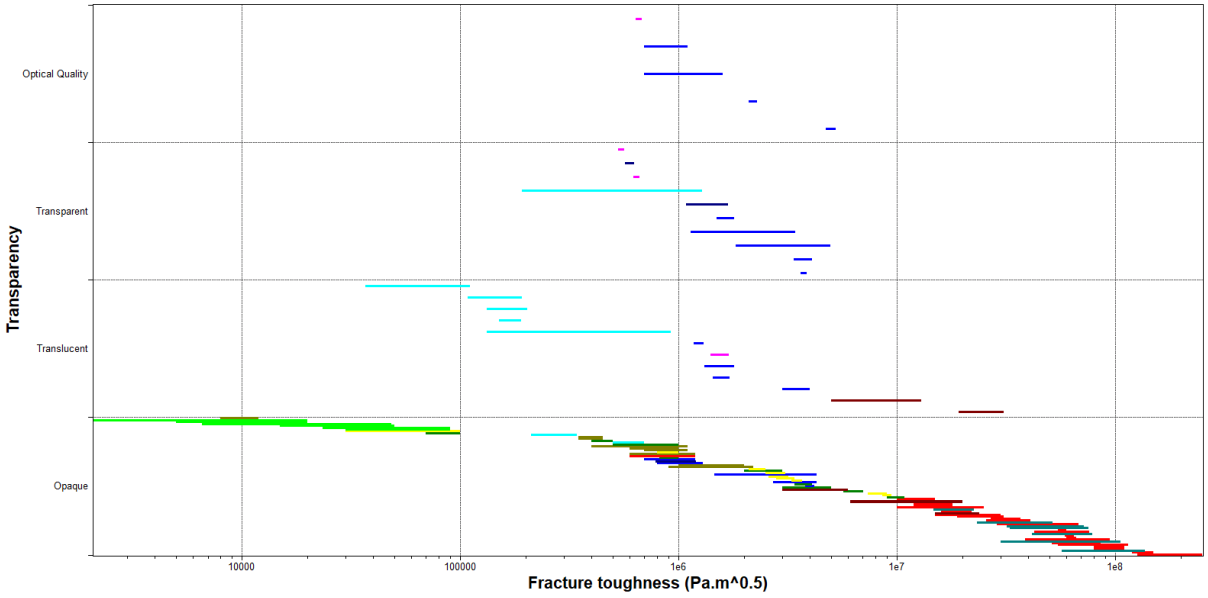

Figure 3 - Transparency - Fracture toughness chart at level 2

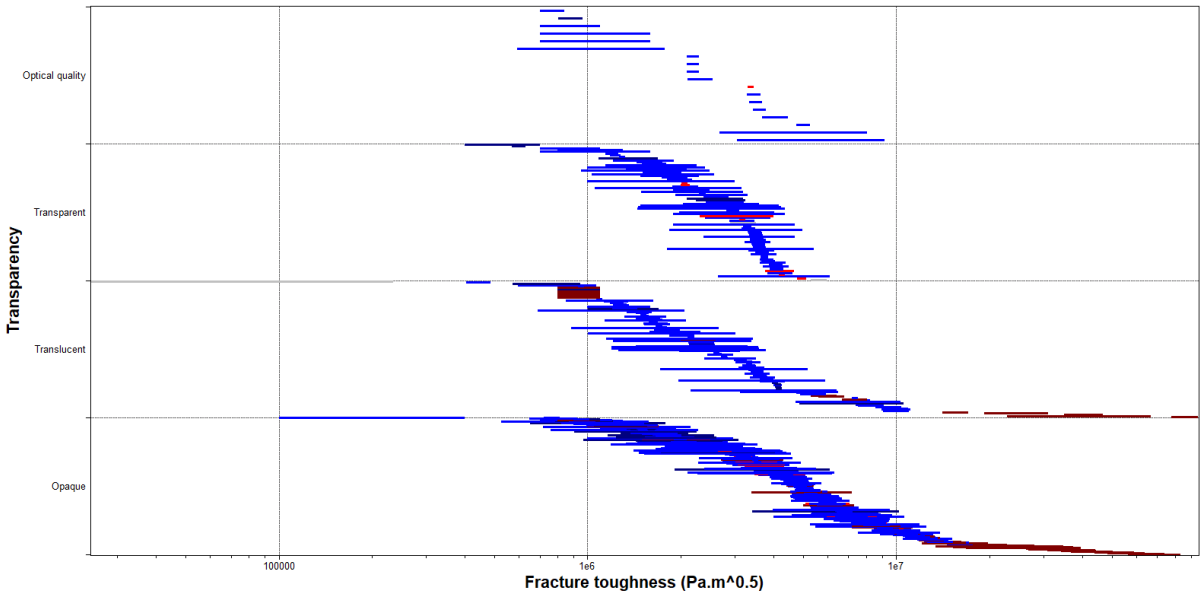

Figure 4 - Transparency - Fracture toughness chart at level 3

Discussion:

The Level 3 database is much more comprehensive thus the specific property values are different for the whole group.

Task 0_3:

Find translations of the material properties in the list in Task 0_2 in at least two languages that are not English. Use your native language if that is not English, and at least one additional language you consider important in technology/engineering.

Original	Czech Translation	German Translation
Fracture toughness	Lomová houževnatost	Bruchzähigkeit
Transparency	Průhlednost	Transparenz
Specific heat capacity	Specifická tepelná kapacita	Spezifische Wärmekapazität
Thermal conductivity	Teplotní vodivost	Wärmeleitfähigkeit
Electrical conductivity	Elektrická vodivost	Elektrische Leitfähigkeit
Flammability	Hořlavost	Entflammbarkeit
Maximum operation temperature	Maximální provozní teplota	Maximale Betriebstemperatur
CO_2 footprint	CO2 stopa	CO2 Fußabdruck
Coefficient of thermal expansion	Koeficient teplotní roztažnosti	Der Wärmeausdehnungskoeffizient
Toxicity	Toxicita	Toxizität

[1] Aamer Ali Shah, Fariha Hasan, Abdul Hameed, Safia Ahmed, Biological degradation of plastics: A comprehensive review, Biotechnology Advances, Volume 26, Issue 3, 2008, Pages 246-265, ISSN 0734-9750, https://doi.org/10.1016/j.biotechadv.2007.12.005. (https://www.sciencedirect.com/science/article/pii/S0734975008000141)