MEC-E1070 Selection of Engineering Materials

Task 5: Materials and the Environment + Processes

Instructions: Check the following questions and exercises. Read chapter 15 of 4th edition of the course textbook about Materials and the environment, as well as chapters 13 and 14 about processes and process selection.

Criterion: A good report on this task demonstrates a good understanding of:

- how the complexity of auditing the environmental impact of a product is amenable to simplifications that can be evaluated already in the design phase (Task 5.1)
- how materials selection is constrained by production processes and vice versa (Task 5.2)

Task 5.1: Auditing the environmental impact:

Task 5.1.1: Estimate the amount of energy in different polymers. Which polymer embodies the least energy during its manufacture, when a Young's modulus value of at least 0.8 GPa is required? Solve the task with the level 2 map.

Task 5.1.2: Draw up a map with which you can compare different materials with, regard to beam strength (in bending) versus CO_2 emissions. Which material possesses the smallest carbon footprint compared to strength? Also, draw up this map for beam strength versus CO_2 emissions when recycled material is used. Briefly discuss the differences between these maps.

Task 5.1.3: The blades of a wind turbine are quite heavy, massive structures. It requires specialized forms of transport to load and carry these structures to their destination. Evaluate the energy consumption and CO_2 emissions of wind turbine blades of the same size but made from different materials (Glass-reinforced plastic (GRP), Carbon-fiber-reinforced polymers (CFRP), and aluminum), when transported 2600 km from Rotterdam, Netherlands to Oulu, Finland with a semi-trailer truck as shown in Figure 1.

Material	Length	Max. height/ width	Mass
GRP	30 m	3 m	**2400 kg**
CFRP	30 m	3 m	**2430 kg**
Al	30 m	3 m	**4320 kg**

***Hint**: The **eco audit tool** in GRANTA software is designed to do these kinds of calculations.*

Figure 1 A semi-truck loading the wind turbine blade to transfer.

Prof. Dr.-Ing. Junhe Lian junhe.lian@aalto.fi Tel.: +358 50 477 0765
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Task 5.1.4: Evaluate the environmental impact of a GRP wind turbine blade. How does the end-of-life of the material affect the overall life-cycle expenses of the turbine blade? There is no recycling use of GRP and CFRP, but aluminum can be easily recycled. Does the situation change significantly if the turbine blade is made from aluminum and recycled in the end instead of going to landfill?

Task 5.2: Selection of processes

From **task 0_1** you have chosen a material group and given **three examples** of materials representative of that group with corresponding examples of what they are used for.

Task 5.2.1: Look up the datasheets for the example materials in the GRANTA software, find the link to the "ProcessUniverse", and explore the available information. Do this for all three example materials (or closely related materials) that you chose at Level 2 and Level 3.

Task 5.2.2: Choose three **joining processes**, three **shaping processes**, and three **surface treatment processes**. Make a table with these nine processes and the three example materials, indicating the suitability of each of those processes for each of those materials. Discuss your entries in this table. Briefly discuss the processes you chose, and what their advantages and disadvantages are, concerning materials, shapes, availability, cost, waste, and energy use. (For your report, just having the table is enough, but be familiar with the processes you have chosen, you will discuss them in the flipped classroom.) Reflect on the simplifications that the GRANTA software imposes at Level 2 and Level 3, on both materials and processes and how such simplifications help or hinder at different stages of the design process. Summarize your thoughts about that in the report.

Task 5.2.3: Now choose **one of the use cases** you considered for **task 0_1**. Explain how such products are made. (No need to go into large details, approximately 200-300 words with one or two illustrations is good.)

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