EMEC Recycling course Exam 16-10-02

1a. Give five parts or substances that, in your opinion, should be removed from car wrecks during dismantling prior to shredding. Give the reason of removal for each part (e.g. environmental hazard, easy material recovery, etc.) in some detail. List the parts to be removed in order of importance with respect to arguments of your choice.

1b. Draw a detailed flowsheet for the processing of end-of-life vehicles (ELV). The flowsheet should include decontamination, partial dismantling of the car wrecks, collection of the automotive shredder residue and detailed process steps for the recovery of both steel and non-ferrous metals. Indicate the main components of the products obtained in each separation step.

1c. Give an estimate for the necessary capacity of the applied processing steps in question b) (e.g. shredding, non-ferrous metal separation, etc.) and the required amount of ELV's (900 kg/ELV), if the minimum capacity of heavy media separation is 30 t/h in order to be feasible.

The average composition of current ELV's is:

Material	Composition [wt-%]
Steel	68
Aluminium	5
Other non-ferrous metals	3
Polymers	10
Other materials	14
Total	100

The average size distribution of the non-ferrous mix after shredding is:

size fraction [mm]	percentage [wt-%]
0 - 12	20
12-30	22
30-70	30
70-120	19
>120	9
total	100

2a. The aluminium alloy 226 has at 0°C a density of 2.75 [t/m³].
The coefficient of linear-thermal expansion is 20 x 10^{-6} [K^{-1}].
The volume increases from solid to liquid state by 6.5 %. The volume between 660 °C and 1000 °C increases linearily by 3 % .
What is the density of the liquid alloy at 800 °C?

2b. A holding furnace of elliptical cross-section has the following inside measures:

Horizontal diameter	2.8 m
Vertical diameter	1.9 m
Furnace length	3.2 m.

The furnace can be filled up with the above mentioned liquid alloy with 800 °C to a bath depth of 40 % of the vertical diameter. Using the calculated density what is the holding capacity of this furnace in tons of liquid metal? If you do not have the accurate formula for the calculation of the area of an ellipse, make an acceptable assessment.

3. Car scrap from a shredder from which the fluff fraction has been removed contains 70% of steel, 10 mass% of aluminum, 5 mass% of heavy non-ferrous and 15% of non-metals. The scrap has about 5% in the 0-8 mm fraction, 30% in the 8-20 mm fraction and the remainder in the +20 mm fraction. The composition of all fractions is similar.

Please provide a flow sheet of a process that is able to separate the scrap into its four components. If the scrap is produced at 40 tons/hour, what is the approximate size/width of the separators involved?

4a. Describe the working principle of three different detection principles and their applications in recycling technology.

4b. What are the critical performance parameters of a sensor for application in an automatic sorting system? In what units are they expressed? Give a short description.

4c. Mention three different design options for an automatic particle sorter. Give a brief comment on the following aspects: particle size, capacity, detection, number of fractions, data processing.

4d. A plant manager wishes to operate his new colour-sorter for plastic flakes at a throughput of 2 tonnes/hr. Sensor width is 1 meter, flakes have density 1100 kg/m^3, flake sizes are 20*20*4 mm, and falling velocity before the camera is 1.5 m/s. He asks you, the engineer, an advice ("do it" or "don't"). Give him the advice and support it with calculations and arguments including the aspects "average area coverage" and "segmentation". Discuss the quality of the sorted fractions to be expected. 300 pps /per meter bandwith.

5a. Explain how sustainable development of the car can be achieved and discuss the environmental conflicts in e.g. car design when realising this.

5b. The recycling of end-of-life vehicles involves a network of interconnected recycling processes (dismantling, shredding, mechanical separation, melting, etc.) and material streams. The performance of each of these processes is of direct influence on the final material recovery.

5b1. Explain clearly (give some examples) the role of product design, liberation, and process efficiency in relation to the optimisation of e.g. final metal recovery. Discuss the crucial role of the quality of intermediate recycling products in closing of the material cycle.

5b2. Discuss in view of this a possible approach for Design for Recycling.

5c1. Mention and describe in detail the three different steps in e.g. the Eco Indicator '99 method and ...

5c2. ... explain why the outcome of the Eco Indicator method has to be used with care (discuss at least three shortcomings of this method).
