Questions EMEC Recycling course December 2004

Course notes: Solids processing for recycling and waste treatment, September 2004
1 December 2004
14h00 – 17h00

---

1. Calculate the operating costs per tonne of steel with the following data:
   - Shredder output 50 t/h at 2000 kW rated power
   - Working hours 2000 h/y
   - Front loader 125 €/h
   - Personnel (2 persons) 40 €/h
   - Energy 7 €ct/kW
   - Maintenance 40.000 €/y
   - Recoverable steel in car scrap input: 70%
2. For what feed materials shredders with a vertical rotor are typically applied? What is the economic advantage for the produced scrap?
3. What are the main forces that effect size reduction in shredders?
4. What is "damp shredding"? List advantages and disadvantages.
5. Why on the European continent usually dry shredding is applied?
6. What is a cutting drum? Imagine a cutting drum of diameter D and with waste bags of diameter d. (m is bag mass, V the linear velocity of the bag).
   a. Give the force balance on a bag that just abandons its circular path (at an angle α from the vertical) for a parabolic one, when the weight of the bag is just balanced by centrifugal force mV^2/R. Illustrate with a sketch.
   b. On this point, express the linear velocity of the bag (V) in terms of radius R and revolutions per minute N.
   c. Now express N as function of D, d and α.
   d. At the critical speed N_{crit} the bags start "centrifuging" and there is no cutting action anymore. When the optimum speed N_{opt} is $0.7*N_{crit}$, give the expression for N_{opt} as function of D and d.
   e. What are approximate typical sizes of D and d in industrial practice?
7. What is a rising current separator? Describe its functioning and give a sketch.
8. The dimensionless Reynolds number is defined by $Re=\rho dv/\eta$ (liquid density*particle diameter*velocity / liquid viscosity). What does Re mean, and explain why Re is relevant in the assessment of the rising current separator for a given sample.
9. The drag force on a falling particle is given by $F_d=C_d A\ 0.5\rho v^2$. Give an expression for the stationary settling velocity of a particle in standing water. Is C_d constant for all particle sizes? (See also Question 8).
10. When the water velocity in the rising current separator is 1 m/s, what is the cut size for crushed bricks of $\rho_b=2000\ kg/m^3$?
11. What is the fundamental reason why in the recycling of shredded consumer goods sharp separation with a rising current separator is impossible?
12. Give sketches of three different air sifters and give a clear explanation. Also list some typical applications for each type.

EMEC 2004 Magnetic and eddy current separation

You may choose question 1 or 2

1.

The need for electric power is about 100 billion kWh per year in the Netherlands. Mention three options for recycling the organic fraction of household waste and guestimate the impact of each strategy in terms of the electric power consumption of the Netherlands. (For incineration assume an increase in calorific value of the waste from 9 to 14 GJ/ton by removing the organic material, and an efficiency of 20% in converting this energy to electricity).

2.

A plant that processes household waste produces a fraction that is rich in organics by screening at 50 mm. An overbelt multipole magnet with a pole width of 100 mm is used to collect the steel from the organic fraction. The magnet is positioned above the conveyor belt carrying the organic fraction so that it is just able to pick up free flat pieces of solid steel that are close to the surface of the conveyor belt. If it is not intended to pick up batteries with 20 mass% of steel that occasionally happen to float on top of a piece of waste, how high above the belt can the material be loaded?

Note: the field strength of the magnet and its gradient vary with the position z with respect to the bottom surface of the magnet block as:

$$e^{\pi z / w}$$

where w is the pole width of the magnet.