

B3 How does waste separation work? – Separating materials by density and magnetism

1 Separation of a mixture of solids consisting of sand and iron

1.6 Questions

Can silica sand and iron be separated based on their densities?

Answer:

The density of silica sand is 2.85 g/cm^3 , and the density of iron is approx. 7.8 g/cm^3 . It is not possible to separate them in water by means of sedimentation. It may be possible to separate them by means of flotation. In a salt solution with a density of greater than 3 g/cm^3 , the sand would float on top.

Another separation method would be a cyclone separator.

2 Can we separate a mixture consisting of sand, plastic, water, and salt?

2.6 Questions

a) What other properties of materials do you think could be used for product separation?

Answer: In addition to density and magnetism, there are other properties that make materials distinguishable for separation. They include melting temperature, boiling point, combustibility, electrical charge, conductivity, and many more. The difficulty is not usually in finding characteristics that some materials have and others do not, but rather in developing a technical method that makes use of these differences.

b) Why it is so difficult to separate non-ferrous metals such as aluminum, copper, brass, tin, and zinc from ferrous metals on one hand and from glass, paper, and plastics on the other?

Answer: Paper and cardboard have a density of approx. 0.8 g/cm^3 , plastics of approx. $0.8 - 1.5 \text{ g/cm}^3$, glass of approx. $2.2 - 2.6 \text{ g/cm}^3$, aluminum of 2.7 g/cm^3 , iron and steel of approx. 7.8 g/cm^3 , copper of approx. 8.9 g/cm^3 , brass of approx. 8.7 g/cm^3 , tin of approx. 7.3 g/cm^3 , and zinc of 7.1 g/cm^3 . From this you can see that paper, cardboard, and plastics can be separated from the other materials quite well due to their different density. However, it is not possible to separate glass and aluminum by density. It would also be very difficult to separate metals by density. Therefore, as in our experiment, it is necessary to use a sequence of different methods. In modern automated waste sorting systems, the dry waste is presorted using wind sifting (lighter materials are blown off) and then using optical methods (spectral reflection) so that only the metal mixture remains. Depending on how much effort is put into the sorting mechanism, plastics and glass can be separated according to categories using spectral sorting. The metals can then be separated using magnet and eddy current separators.

- c) What suggestions can you come up with for how you could separate solid materials (e.g., salts) that are dissolved in water from the water?

Answer: There are two methods that have proven themselves on a large scale: reverse osmosis and distillation.

Reverse osmosis is covered in experiment “B4 We produce drinking water – Methods of purifying water.” The way it works is by pressing salt water under high pressure through a membrane, which keeps the salt ions back.

In the distillation method, the salt water is heated until the water content vaporizes. The vapor then contacts a cool surface and condenses. All of the salt remains behind and the resulting water is pure.

3 Principle of the separation of aluminum from other non-ferrous metals

3.6 Questions

- a) Check the garbage at home or at school. How much do the proportions of components in the garbage differ? Write down the proportions.

Answer: Normally, students will find that the garbage at school has a relatively high proportion of plastic and paper. At home, the mixture will be more varied; depending on the household's eating habits and lifestyle, the proportion of metal and glass may be higher or lower.

If you have Internet access:

Note: On the media portal of the Siemens Stiftung, you will find a link list in the media package for “Experimento | 10+: B3 How does waste separation work?” that refers to additional information.

- b) How is the principle of eddy current separation used in waste separation and in metal recycling? Search online for your answer.

Answer: For links for searching, see the link list for the experiment.

- c) In what other areas is the generation of eddy currents used in industry and technology?

Answer: Conventional electricity meters or braking in trucks, buses, and trains.

- d) Recovering raw materials from garbage is particularly useful if they can be separated in an energy-efficient manner and if the materials in question require a high level of energy for production. What examples for this concept can you find online?

Answer: Recycling of paper and cardboard is worthwhile in ecological and economic terms. Currently in Germany, for example, up to 80% of paper is recycled. The same holds true for glass, with up to 83% currently recycled in Germany. Recycling of aluminum is extremely worthwhile in terms of energy; up to 86% is recycled in Germany. Even up to 95% of tinplate from cans is recycled. The recycling of clean industrial plastic

waste separated by category or, for example, from pure PET bottles is uncontroversial. In contrast, the recycling of plastic from mixed household packaging waste is controversial. Today, experts consider this type of recycling dubious in ecological and economic terms, and they recommend thermal recycling (burning to produce electricity).

- e) A very interesting recycling process is the recycling of raw materials from Tetra Pak packaging materials. What are the material components of Tetra Pak packaging? How would you design a separating method?

Answer: Tetra Pak packaging consists of up to three materials: the outer layer is made from cardboard (75%) for mechanical stability and for protection from impact, the middle layer is made from thin aluminum foil (4%), and the inner waterproof layer is made from polyethylene (PE, 21%). The paper content can be separated easily by finely shredding the packaging and soaking it in water (paper fibers soaked in water become somewhat heavier). The lighter snippets of combined aluminum/PE float to the top and can be skimmed off. The PE and aluminum can be separated through melting. However, due to the low aluminum content, the high cost of this process makes it uneconomical on an industrial scale.

- f) What options do industrial plants, such as car factories, have for avoiding unnecessary waste?

Answer: Today, metal car parts are easily recycled fully automatically for the most part. The recycling of plastic parts, however, is usually still very expensive and therefore uneconomical. However, if carmakers would use fewer types of plastic and not in combination, but use homogeneous plastics, it would be possible to recycle according to categories and it would also be economical. In principle, the metals of trucks, buses, trains, streetcars, etc. are also recycled today. However, since the quantities of these vehicles are relatively low compared to cars and the lifecycles are much longer, recycling concepts have not yet been developed for these plastics.