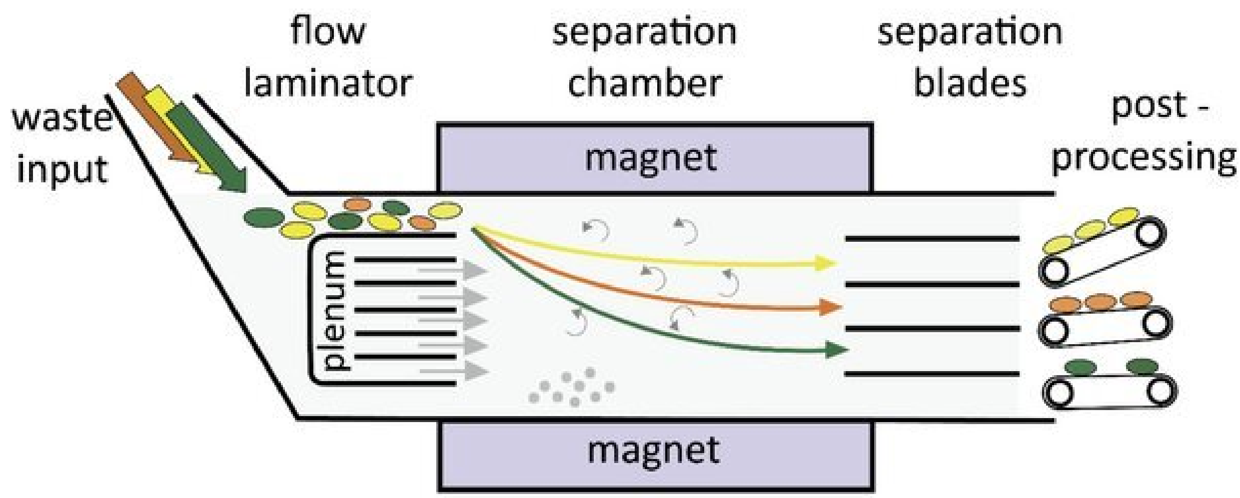
Improving plastic waste separation with magnetic fields

November 24 2021



Schematic of the separation process. Credit: Eindhoven University of Technology

In 2018, 61.8 million metric tons of plastic waste was produced in the European Union with only 9.4 million metric ton recycled. This constitutes a huge amount of plastic waste, which rapidly needs to be addressed. One solution is to turn to magnetic density separation, which can separate plastic materials using magnetic fields, but this technique is not always effective. Rik Dellaert studied flows of plastic particle mixtures in wind tunnels to assess the effect of turbulence on the separation process. He'll defend his Ph.D. thesis on November 26th at the department of Applied Physics.

Plastic is a versatile material that is used for a wide range of applications in society. It is used in food packaging to increase shelf life and also used in a variety of health products such as those to manage the spread of diseases such as COVID-19.

However, many plastics are single use plastics, which presents issues with regards to recycling and separating these materials from other waste streams. New techniques are needed to improve plastic waste recycling.

Ferrofluid

One technique is magnetic density separation, which has recently been developed by Umincorp. Magnetic density separation uses a ferrofluid that generates a vertical mass density gradient when in the presence of a magnetic field. In other words, as you move from the top of the fluid to the bottom, the apparent mass density of the fluid increases.

When plastic particles are added to this ferrofluid, the various particles move to a height in the fluid where the apparent mass density of the ferrofluid is about the same as the mass density of the plastic particles. Separated plastic can then be reused in higher-value products, and this significantly increases the economic feasibility of recycling.

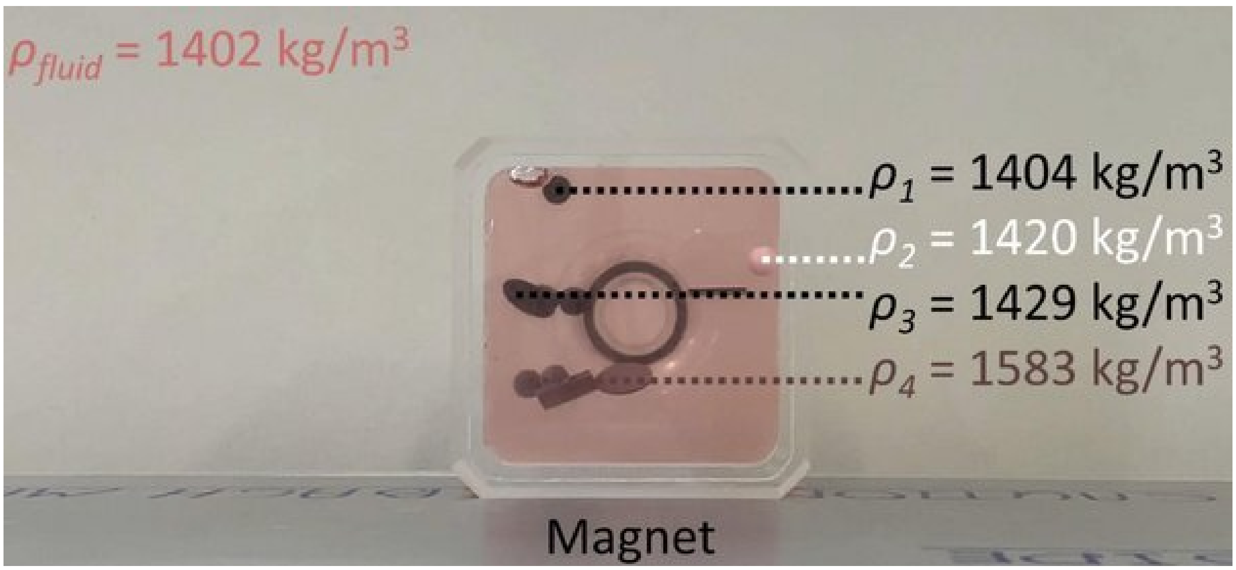
The separation process is occurring inside the magnetic density separator where, at the end of the machine, horizontal plates remove the fluid/particle mixtures at different heights. The different mixtures contain different mass densities of plastic particles and the particles are then separated from the ferrofluid by a centrifuge resulting in plastic particles with a specific mass density range, which can be used as an indicator of the type of plastic in this mass density range.

Challenges

This novel magnetic density separation technique comes with its own set of challenges. Turbulence inside the separation process reduces the separation efficiency due to increased mixing and should therefore be suppressed as much as possible. Secondly, particle collisions can delay the separation process.

Magnetic density separator at the factory hall. Credit: Eindhoven University of Technology

For his Ph.D. research, Rik Dellaert set out to explore solutions to these challenges. First, he used two wind tunnels to measure and analyze the turbulence in the flow. Second, he used a fluid tank to track collisions between particles in a ferrofluid with a vertical mass density gradient in a magnetic field.



Height differences of plastic particles inside a ferrofluid. Credit: Eindhoven University of Technology

Outcomes

From his research, a key recommendation by Dellaert is that a "laminator" should be used at the entrance of the flow that consists of a collection of parallel square ducts to suppress turbulence. This "laminator" should have relatively small ducts and thin walls while maintaining a specific flow velocity.

To explore the particle collisions that take place during the separation process, a numerical model was developed by Dellaert's colleague Sina Tajfirooz. This model was successfully validated using experimental data from Dellaert's experiments, which provided critical insight on the underlying processes in the magnetic density separator. These insights can be used to improve productivity and efficiency.

More information: Turbulence and particle behavior in a magnetic density separation application studied with LDV, PIV & PTV, research.tue.nl/en/publication … c-density-separation

Provided by Eindhoven University of Technology