The Home Energy Resources Unit (HERU) – Conversion of household waste into heating fuel

Driving energy and resource efficiency through chemical engineering

Introduction

Meeting European environmental legislation is becoming more challenging due to the limitations of many existing processes. Domestic and industrial waste disposal is particularly challenging. Recycling, is restricted to certain materials and relies on effective sorting mechanisms and, hence, consumer behaviour.

A novel system dubbed the Home Energy Resources Unit (HERU), aims to address this by providing a waste-to-energy system suitable for domestic use.¹ The system enables most items currently collected for disposal to be used as an energy source that might power a home boiler, thereby moving away from the linear approach to consumerism (buy, use, dispose) to a circular one, where ‘wastes’, emissions and energy leakage are minimised in material loops. The HERU enables the almost-complete utilisation of waste materials including paper, plastics, and organic waste, diverting many materials from landfill. Materials which cannot be used, such as glass and tin cans, could still be retained for recycling.

The process uses heat treatment to break materials down at temperatures up to 300°C and produces an average of 2.6 times the amount of energy used to run the HERU itself.

¹ http://bit.ly/2Sfc94u

Some waste is inevitable, and cannot be prevented or re-used. In this case, recovery is the ideal approach. This can be recovery of the materials, such as through composting or recycling, or recovery of the energy such as with the HERU. Final disposal of the waste is always a last resort.
Using heat pipe technology within the pyrolysis reactor

The HERU system, (Figure 1), uses pyrolysis to thermochemically convert any feedstock into three energy vector phases; namely biochar (solid), bio-oil (liquid), and syngas (gas). The gas and liquid phases can then be fully combusted to release their energy content, which is then used to heat water.

Pyrolysis as a chemical engineering process has been around for a long time and was intended to be used for many applications, but it was largely unsuccessful because of the production of harmful gases, such as dioxins. The HERU utilises heat pipe technology which enables uniform temperature distribution within the reactor, preventing the formation of such harmful compounds.

A heat pipe is a passive thermal transfer device that can transport large amounts of heat over relatively long distances isothermally. No moving parts are required in a heat pipe. The main structure of a heat pipe consists of an evacuated tube that is partially filled with a working fluid that exists in both liquid and vapour phases. The heat pipe within the HERU operates by having an evaporator located at the bottom of the heat pipe and a condenser located at the top (Figure 2). When a high temperature is applied at the evaporator section, the working fluid in the liquid phase evaporates and flows with high velocity towards the cooler end of the pipe (the condenser). As soon as the vapour reaches the condenser section, it condenses and gives up its heat. The liquid working fluid returns to the evaporator part of the pipe by the influence of gravity.

The operating temperature of the HERU never exceeds 300°C, allowing this system to be used within households and still maintain high energy recovery. The waste feedstock for this system does not require any pre-treatment steps which might create behavioural barriers for consumers. It converts these materials into a high-quality fuel that can be used as a composting agent in the garden or in water filtration. The suitability as a water filter of biochar produced in the HERU is currently the subject of research at Brunel University London, UK.

Figure 1. Home Energy Resource Unit (HERU)

The HERU system enables mixed waste to be all used at once with no pre-treatment, offering flexible, simple and safe use for domestic purposes. Efficient waste-to-energy processes can help meet domestic and industrial environmental targets. Therefore, the HERU system can produce energy (hot water) from most domestic materials at low CO₂ emissions and a high COP. The HERU could be in the market in less than two years’ by 2021. It is currently being tested at various locations in the UK and its results are being monitored and analysed. With appropriate waste sorting, the HERU system could divert the majority of household waste, which has a variety of wider benefits:

- Compact, user-friendly technology
- Reduced need for waste collections
- Generates heat at a place where it can be used (in the home)
- Domestic energy generation can reduce energy bills for the consumer

At a higher level, home waste-to-fuel appliances may be a disruptive technology. Wide adoption of this technology has the potential to reduce demand for inefficient and expensive waste infrastructure, generate carbon savings and help address fuel poverty.

Lessons for chemical engineers

- Materials that are considered as ‘waste’ are actually valuable resources that can be used in processes such as HERU to heat water.
- Efficient waste-to-energy processes can help meet domestic and industrial environmental targets.
- Similar waste-to-energy units can be custom built to industries that produce high volumes of waste, improving their efficiency with the least environmental impact.
- The heat pipe technology allows for uniform heat flux throughout the reactor, resulting in complete thermo-chemical conversion via pyrolysis.
This case study was produced by Institution of Chemical Engineers Energy Centre in partnership with HERU (www.myheru.com) and Brunel University London (Profs. Hussam Jouhara and Stefaan Simons). For more information on the work of the Energy Centre, visit http://www.icheme.org/energycentre or contact energycentre@icheme.org