

Pyrolysis of plastic waste for fuel production

FINAL REPORT



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Executive summary

The project “Plast to fuel” (P2F) is aiming at solving urgent issues related to economics and environment within a viable and high added value business model. Nowadays in Iceland, plastic waste quantity is increasing and the recycling rate is achieved only by costly exportation of the most valuable fractions. The ultimate goal is to be able to treat all sorts of plastic waste into high quality fuel for transportation fleet, vessel fleet and energy production. The company ReSource International is developing a process based on pyrolysis of polymers present in plastic waste fractions. Development of the process, including new catalysts to improve the pyrolysis, will be supported by the knowledge and know-how of the Innovation Center of Iceland. In addition of the technical novelty the project proposes to develop a new recycling market and an overall development of the waste management field by increasing recyclable fractions. During the one year project duration it was possible to setup a laboratory or bench-scale processing unit that is used to test different plastics as feedstocks. It was also possible to design the future pilot-scale processing plant. Results of the project are promising for future development of a reliable and industrial scale production of liquid fuel from plastic waste.

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Introduction

The project “Plast to fuel” (P2F) aims to solve urgent issues related to economics and environment within a viable and high value business model. In addition of solving local waste management issues, producing fuel and increasing value from residual, the technology developed in the form of an integrated process presents a great value for export. It will therefore be possible to bring growth opportunity for the Icelandic engineering and waste management companies.

The project P2F proposes the development and design of a process to transform all sorts of plastic waste into crude oil and refined fuel fractions. The ultimate goal is to be able to treat all sorts of plastic waste into high quality fuel for transportation, vessel fleet and energy production. The process consists of a pre-treatment of plastic waste fraction and a thermal and catalytic cracking of the plastic which offer the opportunity to recycle even degraded and dirty plastic fractions into high valuable products. The core process is based on the so-called pyrolysis which is the thermal degradation of the plastic and rubber polymer chain.

Goal and objectives

The ultimate goal is to be able to treat all sorts of plastic waste into high quality fuel for transportation fleet, vessel fleet and energy production. The company ReSource International aims to develop a process based on pyrolysis of polymers present in plastic waste fractions.

The project offers a new solution for plastics recycling in Iceland as today no other option is available for recycling except export. Furthermore the technological development does not focus only on already established feedstock for pyrolysis such as clean and source separated plastics but wishes to extend the range of feedstock to specific waste fractions present in Iceland and of low value today. The Icelandic economic sectors on focus will be agriculture, fishery and household waste with their related plastic and rubber waste fractions.

The principal objectives are to deliver:

1. A waste processing system that prepares waste prior to pyrolysis. Many of the components for this chain already exist in Iceland but have not been put together. Thus it will be possible to have access additional sources of plastic waste which have been considered of no-interest and use it for high value output products such as fuel.
2. Innovative design of the core process (i.e. pyrolysis) for continuous treatment of plastic waste with high energy efficiency. Improvement will be brought on components of the pyrolysis system in order to increase reliability within a reasonable cost. For example catalysts which improve the pyrolysis reaction will be developed and tested during the project
3. A reliable pyrolysis process combined with post-treatment of the products to obtain high quality liquid fuel. The fuel will be produced according to vessel fleet and transportation vehicles standards.
4. A comprehensive partner network in the Icelandic waste management field to support common solutions and the creation and development of a new market for pyrolysis oils.

WP1: Laboratory scale process

Design and building

In order to develop knowledge and offer a simple testing platform, the first WP was focusing on building a laboratory scale also called bench scale processing unit. The processing unit is working in batch mode which means that the plastic feedstock is put up all at once before the process starts. No additional material are put in the system during operation.

Each batch takes approximately 4-5 hours. The main parameters monitored are temperature within the reactor, the first and second condenser and the gas flow within the safety bubbler. The temperature within the reactor is crucial for good results and is controlled with a PID controller with a probe installed in the top part of the reactor. A schematic of the system is presented in the diagram below.

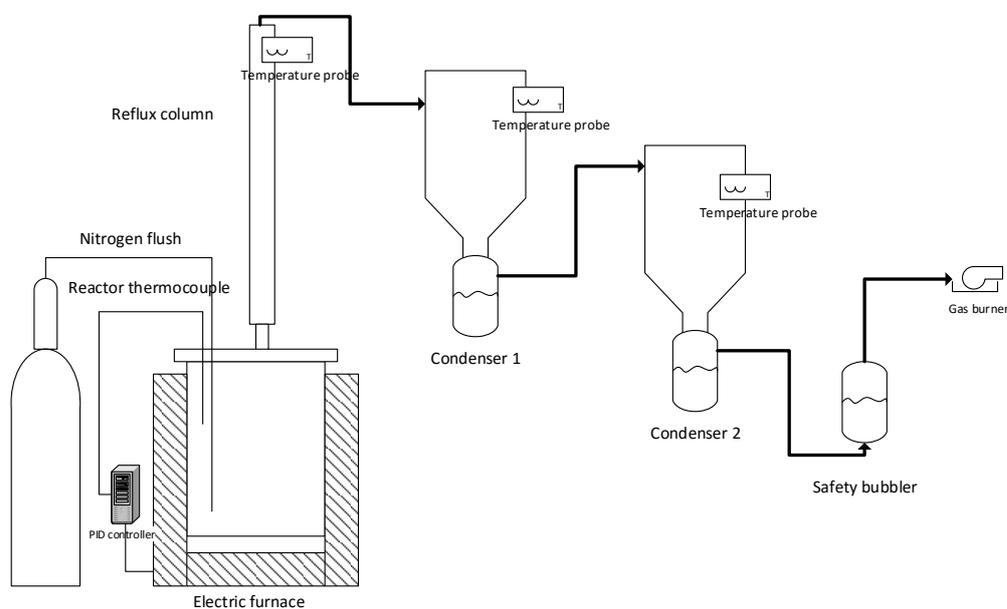


Figure 1 - Schematic view of the pyrolysis laboratory scale processing unit

Test on plastic waste

A series of tests have been conducted using clean plastic waste of Polyethylene (PE) and Polypropylene (PP).



Figure 2- Heating elements for the reactor

ReSource International will continue to run this processing unit for gathering more data on the parameters sensitivity. Also it is planned to use catalyzers within the plastic waste in order to see how efficient they could be in term of oil quality and reduction of the processing temperature (energy saving).

WP2: Up-scaling to pilot-scale

For confidentiality reasons only a part of the project results are presented here. Technical details on the performance of the pilot scale are not necessarily given here.

Visit of PM Endurvinnslan

In order to offer high quality process it was determined in the initial design phase that materials used as feedstock in the pilot-scale should be well prepared.

Preparation of the material relies on several steps:

1. Separation of plastic types
2. Cleaning and drying
3. Mechanical shredding
4. Storage in silo

In Iceland one company involved in plastic recycling used to run operation with machinery similar that could suits preparation of plastic waste prior to pyrolysis. The company went bankrupt in 2014 and the machinery was for sale. It was therefore decided to visit the closed plant to assess suitability of the machinery for the project. Some pictures with explanation are presented below.



Figure 3 - Big size storage silo for shredded plastic



Figure 4 - Feeding system for plastic extruder unit



Figure 5 - Feeding system for plastic extruder unit (bis)



Figure 6 - Plastic extruder unit

Pilot-scale design

The main requirements for the pilot-scale are to treat approximately 500-700 kg of plastic per day into a continuous or semi-continuous mode. The system should be able to deliver multiple fuel fractions that can be adjusted in accordance with market needs and feedstock suitability. Part of the technical aspects of the process was developed with the Technical University of Keilir. A simple process diagram is released below.

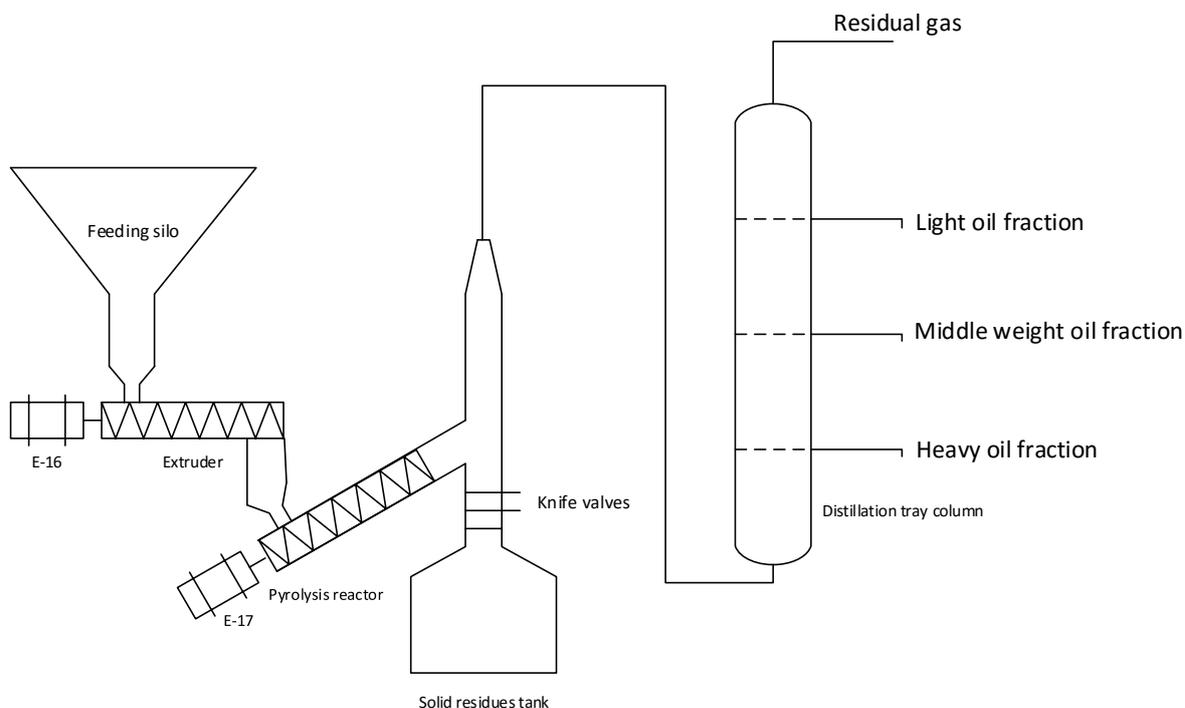


Figure 7 - Conceptual design of the pilot-scale continuous process pyrolysis system

Future development work

Research funding

ReSource International is planning to apply for additional research funding to go deeper into the development of its process. The main funding in focus is the technical development funding from RANNIS and the company would like to reapply to Orkusjóður funding in 2016 in order to continue the pilot-scale and full-scale development.

Pilot-scale

The pilot-scale building was initiated during the project but not completed before this report. The company will continue to build the pilot-scale according to available research funds and own funds. The extruder part have been acquired and the major work left is on the distillation column.

Market development

In Iceland market for renewable fuel exists. However during the project it was discovered that legislation in the country for production of fuel from plastic waste does not follow the same rules that production of fuel from organic waste (e.g. biodiesel).

If fuel is produced from plastic waste, the fuel or oil resulting from the processing is still considered as waste. Thus market value for the oil is inexistent and can even be a cost of being disposed within the waste management system. The legislation writers concerning end-of-waste rules have been notified and a new regulations on the classification of pyrolysis system as waste recycling process should come before the end of 2015 or beginning of 2016.

In addition of surveying national Icelandic market, ReSource International have been developing business network within by-product and recycling industry In Northern Europe. Business opportunities exist especially with rubber fraction from tires. Rubber from tires has large potential for producing fuel as well as recovering the metal fraction for recycling.

Conclusion

In conclusion, the laboratory scale process is in operation and further test and analysis will be conducted. The design of the pilot-scale is advanced, and the building of the machinery has started but could not be completed before this report was delivered. Thanks to Orkusjóður support, it was possible to demonstrate the feasibility of the process and start to build up a network on plastic waste knowledge, pyrolysis and oil production for fuel.

The company ReSource International has also developed itself with a change in ownership and access to bigger business network especially in Northern Europe.