Pyrolysis: the eco-friendly alternative to cremation [2014-2017]

Background

In early 2014 I was invited to a meeting in Dublin to discuss with a potential client their technical and legislative needs around the authorisation of an imported high temperature pyrolysis for operation in Ireland.

The client, Ecolegacy Ltd., had taken an alternative approach to the disposal of human remains: pyrolysis, as an alternative to the 2 conventional approaches of cremation and burial. Ecolegacy took the position that the pyrolysis of human remains could be ecological, sustainable and allow disposal to be more environmentally compliant and reduce fossil fuel use as cremation consumes a significant amount of natural gas releasing ~ 250 kg of CO_2 per cremation. Cremator burners are typically 150-400 kW_{th} running on natural gas and/or LPG.

Ecolegacy took the view that by semi-continuously processing the deceased, energy from the pyrolysis of one body would "fuel" the drying of the next one and reduce energy costs with heat available for space heating onsite. This would allow cost savings to be passed on to customers. The overall flowsheet/approach is summarised in Figure 1.

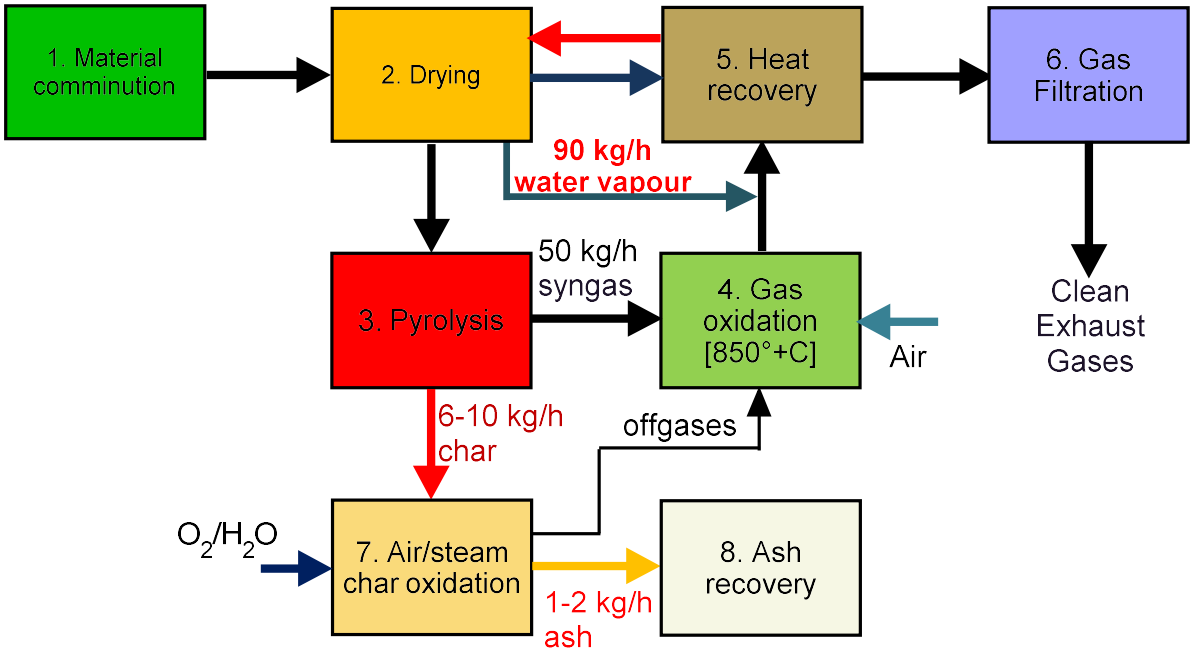

Figure 1: Overall flowsheet for conversion of the deceased to char or ash. Ecolation

The process would be fully IED compliant and meet all CE requirements. One project had been agreed to install an Ecolegacy "ecolator" into the new Dardistown crematorium as a parallel line to the planned to be installed crematorium near Dublin Airport.

The plant I was asked to review and sign off on as ATEX compliant was part of the delivery plan for the Dardistown crematorium.

The first plant onsite, Tallaght, Dublin

I carried out a review of the pyrolysis system from feed handling to gas cleaning and the unit had to be condemned for numerous reasons, mostly in regard to health and safety and non-ATEX compliance along with numerous other Directives and the unit was nor CE marked. Pyrolysis unit shown in Figure 2.

Ecolegacy were surprised, but accepted, the unit's failure to comply with a range of legislation, in particular, operation of the pyrolysis unit within the hazardous zone [Zone 0/1 due to an unsealed pyrolysis system] in the middle of the plant.

The order for a second unit was subsequently cancelled. This placed ecolegacy in a difficult position where they did not have a pyrolysis plant and no way to carry out testwork.

This left Ecolegacy without a machine and a deadline, so efforts were made to source a 2nd hand or replacement unit on ABIS. Ecolegacy had also engaged ThyssenKrupp GmbH to be their overall delivery partner or EPC for projects. The ABIS representatives had 2x 2nd hand pyrolysis units, but these were not ideal, having been used for carbon regeneration and so ABIS directed Ecolegacy to the OEM – Linn High Thermal GmbH to discuss the possibility of getting a pyrolysis unit in a timely manner from them.

Figure 2: Non-authorised pyrolysis plant

R&D Pyrolysis of Pork Pieces: Biogreen, France

As the testing of human remains for R&D purposes is not possible, pork was the closest material to simulate a human body. To obtain operational data, tests were carried out at Biogreen/ETIAs' 10 kg/h facility in Compiegne, France. I already knew this facility and had been there before to carry out other feedstock tests.

Dried and chopped pork was shipped over to Biogreen and trials carried out in early 2015. This material was only dried flesh and not the full dried and chopped pig. The feedstock and recovered char are shown in Figure 3 and the test unit in Figure 4.

Figure 3. Chopped pork pieces Recovered pork char

Figure 4. Biogreen/ETIA 10 kg/h electrically heated pyrolysis unit.

These trials at various temperatures gave a syngas with a satisfactory heating value of 10 $MJ/_nm^3$, however, clearly when fats were being pyrolysed, it would spike to 22-25 $MJ/_nm^3$. The char product yield was very low, due to a lack of bones, of 2.3-4.8wt%. Liquids were also condensed, but this would not be the commercial plan. All of the raw syngas would be combusted after dust removal. The Biogreen trials provided some useful syngas and char analysis data.

How do you comminute the human body?

Some considerable time [15+ months] and money was spent dealing with the practical and ethical question: how do you prepare a human body, or body parts into a size, dried. that can be pyrolysed in less than 30minutes? This presented a wide range of challenges: differing body sizes, possibility of surgical implants [breast implants, hip replacements, pacemakers and similar equipment, skull plate, rods, plates, fixion screws, dental implants and fillings], size and shape. I drew up a range of options, though ethically, the plan was to have non-contact comminution, i.e., water-jetting, laser or similar. There are 4 possible options when it comes to size reduction or comminution:

1. Sonic disintegration
2. Laser cutting
3. Waterjet cutting
4. Mechanical comminution

Options 3 and 4 were the only realistic options. Option 3 was selected as the ethical option to comminute the body, but this created a massive range of issues:

1. Generation of “gore” – pink emulsion of blood, fat, collagen and hair
2. Need for a 70,000 psi non-garnet waterjet pump and use of ultra pure water
3. Treatment of the gore and disposal of the effluent
4. Power consumption for the waterjet and maintenance

Option 4 was not seen as acceptable as the primary stage, so a hybrid of waterjetting for the head and limbs was agreed, followed by an industrial solution using a commercial high shear, slow speed shredder. This would have to be factored into the process time to ensure that a full ecolation cycle was less than 1 hour.

The second plant onsite, LHT, Germany

In 2015 I prepared with ThyseenKrupp [TK] the overall mass and energy balances for the process, coupled to each unit operation to meet the requirements of the process shown in Figure 1. TK managed the supplier selection for the thermal oxidiser, the discussions with LHT and Scheuch GmbH for the gas cleaning and heat recovery. This led to LHT having the order for the pyrolysis kiln and they started the design and build in early 2016 and tests were carried out in Q3, 2016. These trials used fully chopped and dried pork pieces with bone to represent a comminuted body and see if there are any issues in comminution, drying and feeding to the pyrolysis unit.

As each body would have to be delineated during processing, all char from each cycle would be recovered into its own specific receptacle for removal, thus ensuring no cross-contamination and the kiln would run during the drying time to fully empty it. Testwork in August 2016 led to proof of concept and identification of optimal processing conditions and the recovery of char as shown in Figure 5 below.

Figure 5. Dried and chopped pork resultant pyrolysis char

As one option was to have the char futher ashed, some trials were carried out on the char recovered from the LHT trials and this is shown in Figure 6 and was not what we expected. Pigs don't sweat and concentrate metals and anything else they adsorb in their body fat. Pyrolysis led to these being further concentrated and reduced during pyrolysis and then oxidised. The ash was analysed by SEM and the green oxide is Cr_2O_3 – chrome (III) oxide, the white pieces are bone and mostly $Ca_3(PO_4)_2$ as expected.

Figure 6. Ashed pork char

The unit was then shipped to ecolegacy's facility in Tallaght for full assembly for testing.

At this point, my involvement diminished as I'd completed my tasks of getting to a full process and delivery of a kiln that worked. Unfortunately in 2017, Ecolegacy failed to deliver on their

project to Dardistown Crematorium, Ireland and the company went into administration soon after.

Lessons and observations

- Technology and ethics can clash and sometimes a compromise that does not please everyone is needed.
- I had to keep to my own professional standards in the execution of my work and preserve my reputation for standing up for the facts.
- When a non-technical person starts telling you how to do your technical job, that is a serious problem and has to be strongly resisted.
- Internal procedures for monitoring and checking of the business are needed even in SMEs
- Technically it may be feasible; sometimes the world is not ready for the solution.