The Building and Commissioning of the Batch Pyrolysis Plant in Studsvik, Sweden - 12447

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ABSTRACT

After a sequence of lab scale and bench scale trials the building of a pyrolysis plant could begin at the Studsvik site in Sweden. The facility is primarily aimed at treatment of uranium contaminated organic waste originating at fuel manufacturing plants and other facilities where the main contamination is uranium.
The plant is an extension/addition to the already operating incinerator. In order to further widen the waste acceptance criteria the design of the off-gas treatment system does not have the same design as that of the incinerator.
The building of the facility began in April 2011, and the first heating of the facility took place in late December, 2011. The site acceptance tests are planned for January, as are the first inactive trials aimed at optimisation of process control. The facility is planned to be operating with radioactive materials from February 2012.

INTRODUCTION

Since 2006, Studsvik in Sweden has worked with one of its customers to solve their problem with treatment of their organic uranium contaminated waste. The waste is mainly paper, plastics and fabric, in the form of discarded coveralls or cloths, but it also contains ion-exchange resins and resin bearers. The waste is slightly contaminated with uranium, and the wish of the customer was that any treatment would not prevent later leaching of uranium from the treatment residues.

Destruction of organics like the above waste forms is easiest done by incineration. However, in a standard furnace, incineration will create chemical compounds between uranium and silica that are difficult to dissolve in a standard nitric acid dissolution and leaching process. There are other processes that can be used but the problem is still the same, *i.e.* that the chemical compounds are difficult to dissolve. The formation of these compounds is further aided by temperatures above 700°C.

Destruction in a vessel/furnace where the amount of silicon is limited and at a temperature below 700°C will reduce the risk of forming the hard to dissolve components and will therefore make the separation of uranium from the ashes by dissolving it possible, either directly or at a later time.

Based on these pre-requisites, trials with a batch pyrolysis system began in 2006.

METHOD

Early trials

The first trials were done in a laboratory sized pyrolysis vessel inserted in a muffle furnace with real waste samples containing uranium from the customer site. Trials were focused on weight reduction and general feasibility. Weight reduction for some waste fractions is displayed in Figure 1.

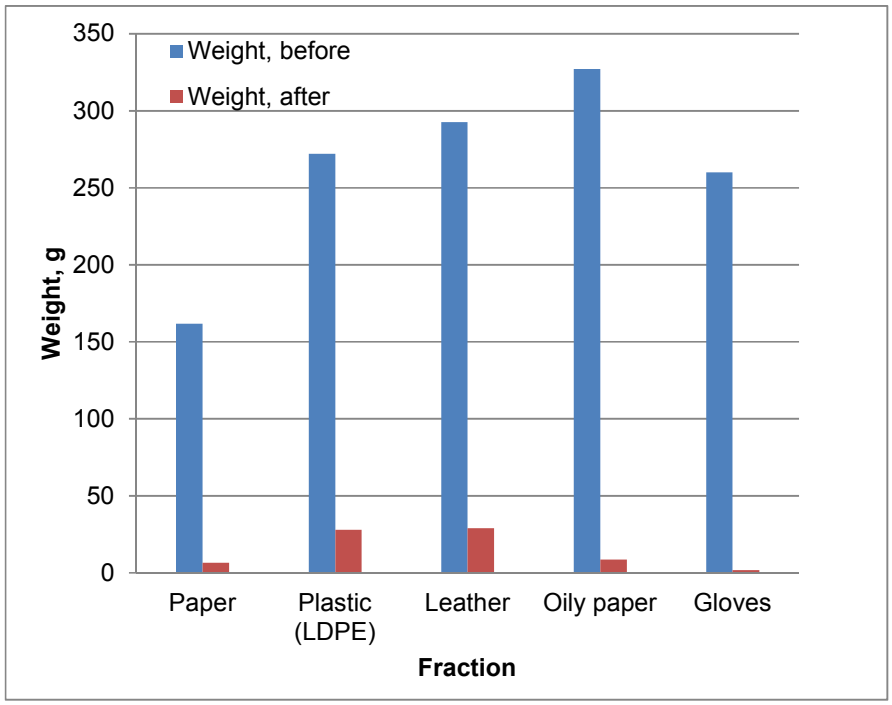

Figure 1
Weight before and after pyrolysis, first trials

These samples were also subjected to leach tests by the customer. The results were satisfactory and discussions began on how to continue the process of commissioning a facility for pyrolysis and on what other work needed to be done before that.

Further tests included pyrolysis of ion exchange carrier and ion exchange resin. Promising results were obtained from these early trials, with a weight and volume reduction factor of more than 10, even though no further process optimisation was performed.

Regulatory and Licencing issues

The building of a new facility or extending an existing facility is two completely different things when it comes to the licencing and regulatory issues. In the case of building a pyrolysis unit at the Studsvik facility in Sweden the chosen option was to make an addition to the incineration facility. The incinerator already had a permit for treatment of 600 tonnes per year of which about 500 tonnes were allocated.

Complementing the incinerator with a pyrolysis unit that has a capacity of up to 100 tonnes per year, to start with, therefore seemed like the most logical option. The pyrolysis unit was therefore described as an extension, and an application was made to the environmental court based on this. As the two units, incinerator and pyrolysis, are two treatment processes under the same licence, they use the same chimney as well as the same off-gas monitoring system.

The licence was given for installation of a pyrolysis unit at the Studsvik Incinerator in February 2010.

Small scale tests

In order to decide what design to use for the thermal part of the pyrolysis, small scale tests were performed at a vendor's site in Sweden. Several different trials were performed.

As the trials were performed on non-radioactive materials the equipment had no restriction based on radioactivity, as is seen in figure 2 below.

Figure 2
Preparation for small scale pyrolysis trial

The main outcome of the trials was that the technical solution for heating of the pyrolysis furnace was verified and that the temperatures used during the lab scale trials were confirmed to fully destroy the inserted waste, meaning also that a satisfactory heat transfer inside the pyrolysis vessel could be obtained.

Design of the full scale pyrolysis plant

In the design of the full scale pyrolysis plant, the footprint of the building was the limiting factor, together with the license limitation of 600 tonnes totally for the incinerator complex, of which about 100 tonnes was available for the pyrolysis plant.

As the pyrolysis is a complement to the incinerator it was decided that the design of the off-gas treatment system should not be the same as for the incinerator. The incinerators' off-gas treatment consists of a dust filter and a dry scrubber before the chimney. The pyrolysis unit on the other hand, was designed with a dust filter, a wet scrubber and an activated charcoal filter. Schematic of the process design is displayed in Figure 3.

Using a wet scrubber instead of a dry scrubber will make the pyrolysis unit suitable for treatment, for example, of ion-exchange resins without exceeding any environmental permit levels for air releases, as the scrubber will neutralize any acidic gases from the thermal treatment operation.

The charcoal filter is installed to catch mercury. Mercury should not be present in the waste as it is a prohibited item in the Waste Acceptance Criteria, but based on earlier experience there are sometimes mistakes in the sorting procedure and mercury can therefore enter the system. The charcoal filter will then catch the mercury and prevent a release to the environment.

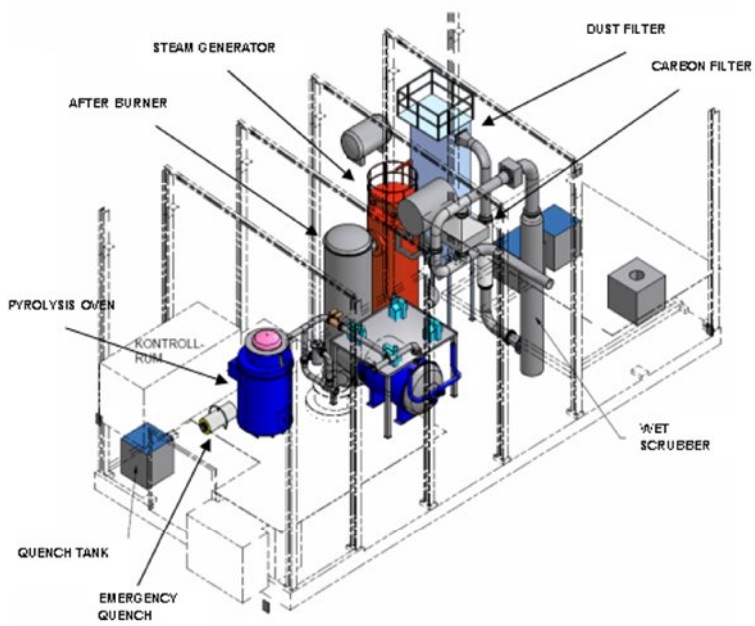

Figure 3
Principal design of pyrolysis unit

Preparatory work

Before the building phase could start there were a number of other tasks that had to be performed. A major task was the writing, review and submission for approval of the preliminary safety case for the facility.

Safety cases in Sweden are reviewed in two different review boards before being submitted to the relevant authority, which in Sweden is the SSM, Swedish Radiation Safety Authority. The SSM then has 3 months to review the safety case, under which they of course can ask as many questions as they want. The preliminary safety case was approved by the authority, which meant that the building phase could commence as planned, as can the inactive verification operation, but the facility cannot be taken into active commissioning before a renewed safety case, updated to reflect the facility "as built", is submitted to and approved by the SSM.

Other minor tasks include obtaining a building permit from the municipality shortly after the ruling of the environmental court, and carrying out a radiological ground investigation of the building site, as encouraged by the authorities.

The purpose of the ground investigation was to verify that the ground was free from contamination, as the Studsvik Site has been in operation since 1955. The investigation verified that there was no contamination in the ground.

Building

After the design of the pyrolysis plant and approval of all regulatory paperwork the building of the plant could commence.

The start of the building phase took place in March 2011. During the summer of 2011 the building started to take shape, as seen in Figure 4. The main components were thereafter placed on the concrete slab and the building was subsequently finalized around them. The reason for doing it this way was that some of the components are relatively large and bulky and placing them in the correct position was much easier without the walls or ceiling of the facility in the way.

Figure 4
Pyrolysis plant partly built

The building of the facility and installation of all the equipment was finalized in November 2011. During December the verification of the installation was carried out, and the first heating up of the full system was done in late December, 2011.

DISCUSSION

The pyrolysis unit is primarily aimed at treatment of uranium contaminated waste, under conditions that facilitate leaching and recovery of the uranium from the ashes. However, a number of other uses are conceivable. The batch fed pyrolysis unit, with its chosen design of the off-gas treatment system, enables treatment of some waste fractions that are difficult to treat in the incinerator. For instance small campaigns, i.e. smaller quantities of waste (typically <5 tonnes), or waste containing high levels of chlorine and sulphur are possible to treat in the pyrolysis unit.

The pyrolysis unit is also expected to perform well in the treatment of other “difficult” waste fractions, for instance waste containing pyrophoric materials, or other types of waste that benefit from the high level of process control, *i.e.* control of temperature and atmosphere throughout the process, that can be obtained in the pyrolysis unit compared to the incinerator.

Furthermore, treatment in the pyrolysis unit minimises the risk of cross contamination between different waste treatment campaigns. This feature is obtained thanks to the low gas flow rates in the vessel, which means that a higher retention of nuclides in the ashes is obtained, but also through a design that facilitates cleaning of the pyrolysis vessel and the system beyond this, or even exchanging the most critical components, such as the pyrolysis vessel itself, if need be.