Treatment of Activated Carbon, PVC, and Other Wastes using the THOR process – Pilot Plant Test Summary - 17399

Howard Stevens – President, Scott Roesener, Chief Engineer, and Adam Foster – Engineering Business Manager/Test Project Manager
Studsvik, Inc., 5605 Glenridge Drive NE, Suite 705, Atlanta, GA,
howard.stevens@studsvik.com

ABSTRACT

This presentation will provide an overview of the first pilot plant study to be conducted for the Japanese Nuclear Market by Kobelco Studsvik Company (A new Joint Venture Company between Studsvik AB and Kobe Steel Ltd.). The test program was scheduled for October 2016, and it was designed to evaluate the treatment of activated carbon, PVC, and other waste types using Studsvik's THOR Process. This new study is being conducted to identify key design parameters required for application of the THOR process in the Japanese Waste Market and to confirm the effectiveness of the THOR technology in meeting the requirements for final waste acceptance. The findings of this pilot plant test will assist in the development of a revised THOR process in Japan that will treat not only spent ion exchange resins but other organic materials generated by Nuclear Power Plants (NPP) during normal operations and D&D activities.

The information shared by this new pilot plant study will provide the audience with an understanding of the adaptability of the THOR process for treatment of various radioactive waste types and the results necessary to successful treat different types of carbon, plastic materials, and other waste types. In addition, it will share the lessons learned regarding how a pilot plant study should be planned and optimized to meet the specific requirements of the Japanese Nuclear waste market.

INTRODUCTION

Following the accident at the Fukushima NPP, Studsvik along with its Japanese partner, began to explore and evaluate the utilization of Studsvik's Fluidized Bed Steam Reformer (FBSR) technology for the treatment of numerous types of organic waste either generated during the accident or the future cleanup of the entire facility. Studsvik's FBSR technology has been demonstrated to treat various types of low, intermediate, and high level wastes. These demonstrations have been conducted by the US Government and commercial clients in various countries. Such demonstrations have utilized both laboratory and pilot plant scale processes to determine the operating conditions required to breakdown the material and create a final form that is safe and stable for final disposal.

As part of Studsvik's research regarding the waste to be treated at Fukushima and other NPP facilities in Japan, it was determined that various waste types should be considered. These included spent ion exchange resins, oils, sludges, dry active waste (DAW), activated carbon from past NPPs, nitrate waste, and other organic materials. In order to efficiently utilize the time available for pilot plant testing, it was determined that tests would be performed for nitrates, DAW (poly ethylene, isoprene rubber, and PVC), and activated carbon.

DESCRIPTION

Pilot Plant Equipment

Studsvik has utilized various pilot plant configurations over the last 19+ years to research and demonstrate the FBSR treatment technology for numerous radiological and non-radiological waste types. A typical pilot plant flow sheet will include the following equipment:

Waste Feed (WF) and DMR Bed Additive and Support Systems (Figure 1)

- WF Batch Tank (WBT)
- WF Transfer Pump (WTP)
- WF Tank (WFT)
- WF Pump (WFP)
- Plastic/Rubber Feeder (FPR)
- Charcoal / Activated Carbon Feeder (FCC)
- Bed Media Feeder (FBM)
- MA Batch Tank (MBT)
- MA Transfer Pump (MTP)
- MA Feed Tank (MFT)
- MA Feed Pump (MFP)
- Steam Generator (STG)
- FG Heater (FGH)

Main FBSR Process Vessels (Figure 2)

- Denitration Mineralization Reformer FBSR (DMR)
- Product Separation Filter (PSF)
- Offgas Treatment System
- Thermal Oxidizer (THX) – Figure 3
- Quencher (QWT)
- Scrubber (SWT)
- Quencher/Scrubber Pump (QSP)
- Offgas Blower (OGB)
- Stack

Process Control

- Supervisory Control and Data Acquisition System (SCADA)
- Continuous Process Monitor System (CPMS)
- Continuous Emissions Monitor System (CEMS)

Utility Services

- Compressed Service Air (SA)
- Instrument Air (IA)
- Nitrogen (N2)
- Oxygen (O2)
- Demineralized Water (DW)

Figure 1: Waste Feed Surrogate Preparation Batch Tanks

Figure 2: DMR and PSF Vessels (DMR is on Left and PSF is on Right)

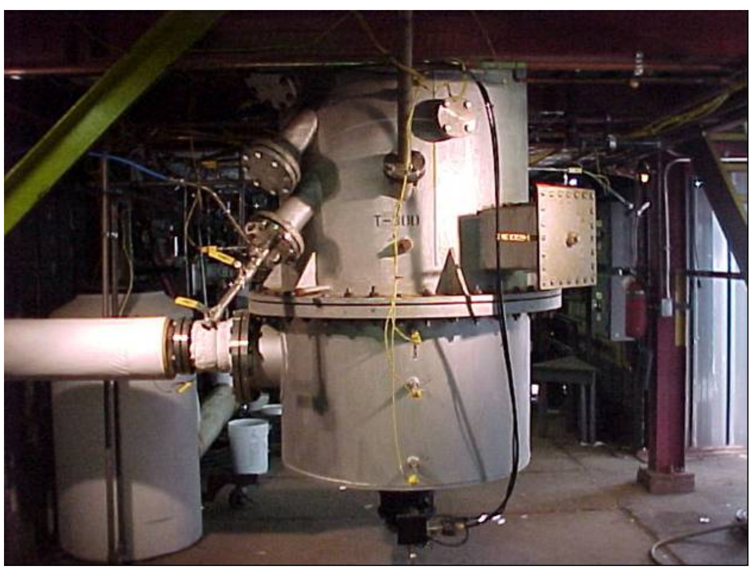

Figure 3: THX Vessel Lower and Middle Sections

Pilot Plant Location - Hazen Research Facility Overview

The THOR FBSR process was initially developed by Studsvik for resin treatment during a test program at the Hazen facility in 1997. Over the past 19 years many THOR FBSR test programs have been performed at the Hazen facility using the same FBSR pilot plant equipment that was used for the KSL pilot plant demonstration program.

The primary reason the FBSR testing has been performed at the Hazen facility in Golden, Colorado, US is that Hazen has a permanent staff of knowledgeable thermal processing experts, engineers, and operations staff. Hazen personnel will assemble the required process equipment, systems, and controls into a fully functional, semi-automated process system and operate the systems in a safe and professional manner. Figure 2-1 is an aerial photograph of the Hazen facility. The building in the far left center of Figure 2-1 (circled building) houses the FBSR pilot plant.

Figure 2-1 Hazen Research Facility in Golden Colorado US

.

DISCUSSION

The pilot plant demonstration program for granular activated carbon (GAC), powdered activated carbon (PAC), and plastics were combined into a single continuous test series described in this section. This is possible as the DMR FBSR operating conditions are similar for treatment of the GAC, PAC, and plastics. These wastes were treated in a single continuous test series for the following reasons: 1) the inorganic ash/residues from FBSR treatment of these wastes did not require any mineralizing additives, 2) the ash/residues comprise very small particles that will essentially completely elutriate out of the FBSR bed, and 3) the process flowsheet from the FBSR/DMR through the stack was the same, as shown in Figures 4 and 5.

The objectives of this GAC, PAC, plastics, and rubber treatment demonstration program were:

1. Operating and Design Basis: Verify design basis and operating parameters for design, construction, and operation of a future Japanese THOR FBSR treatment facility for GAC, PAC, plastics and rubber wastes. This includes collection of operating data, such as: temperatures, pressures, flows, levels, and ash/residue particle size distribution (PSD), density and composition. Determine operating conditions and throughput rates that minimize carbon carryover into residues and provide balanced VOC fuel value in downstream thermal oxidizer.

2. Process Control: Demonstrate reliable, steady-state process operations with consistent FBSR operation and residue production and composition. Demonstrate consistent off-gas emissions levels for HCl, SOx, VOCs, and CO that are within projected Japanese emissions limits. Demonstrate minimization of carbon carryover into residues.

3. Determine Volume and Mass Reductions: Demonstrate acceptable material balance closure for feed constituents, residue production, scrubber salts, and gases in the production run. Collect mass flows and compositions of liquids, solids and gaseous streams during production run. Determine volume and mass reductions of incoming waste surrogates to residues.

In addition, the DAW testing were designed to provide additional information related to the following areas:

- Demonstrate that FBSR treatment of non-radioactive surrogate PE (Polyethylene), IR (Isoprene Rubber) and PVC (Poly Vinyl Chloride) will reliably and safely volume reduce the plastics to produce a low volume, low carbon content residue.
- Demonstrate that during PVC treatment the Cl removed from the plastic can be efficiently removed by the wet scrubber system as NaCl salts.
- Demonstrate that the increased VOC concentration in the process gas can be safely and efficiently oxidized in the THX and that the plastic feed rate can be efficiently controlled to balance the heat load in the FBSR and THX to maintain stable FBSR and THX temperatures and operations.

The objectives of the Nitrate demonstration program were focused on treating non-radioactive, surrogate nitrates to produce final waste forms that will be shown to meet the Japanese disposal requirements. The objectives of the nitrate treatment demonstration program are:

1. Operating and Design Basis: Verify design basis and operating parameters for design, construction, and operation of a future FBSR nitrate treatment facility. This includes collection of operating data, such as: temperatures,

pressures, flows, levels, final product particle size distribution (PSD) and density, and solids compositions.

2. Process Control: Demonstrate reliable, steady-state process operations with consistent FBSR operation and NAS solids production and composition. Demonstrate consistent off-gas emissions levels for NOx, VOCs, and CO that are within projected emissions limits.

3. Determine Volume and Mass Reductions: Demonstrate acceptable material balance closure for feed constituents, NAS production, and gases in the production run. Collect mass flows and compositions of liquid, solid and gaseous streams.

4. Perform solidification of the NAS product material using Ordinary Portland Cement to make solid monoliths. Determine crush strength resistance of solid product monoliths.

In order to achieve the objectives stated above for all waste types, the pilot plant test plan was also divided into several phases which included the processing of nitrate, activated carbon, and then DAW consisting of plastics and rubber (PE, IR, and PVC). . Each phase of testing was conducted during stable conditions and process parameters were monitored closely to ensure complete destruction and proper evaluation of off-gas emissions.

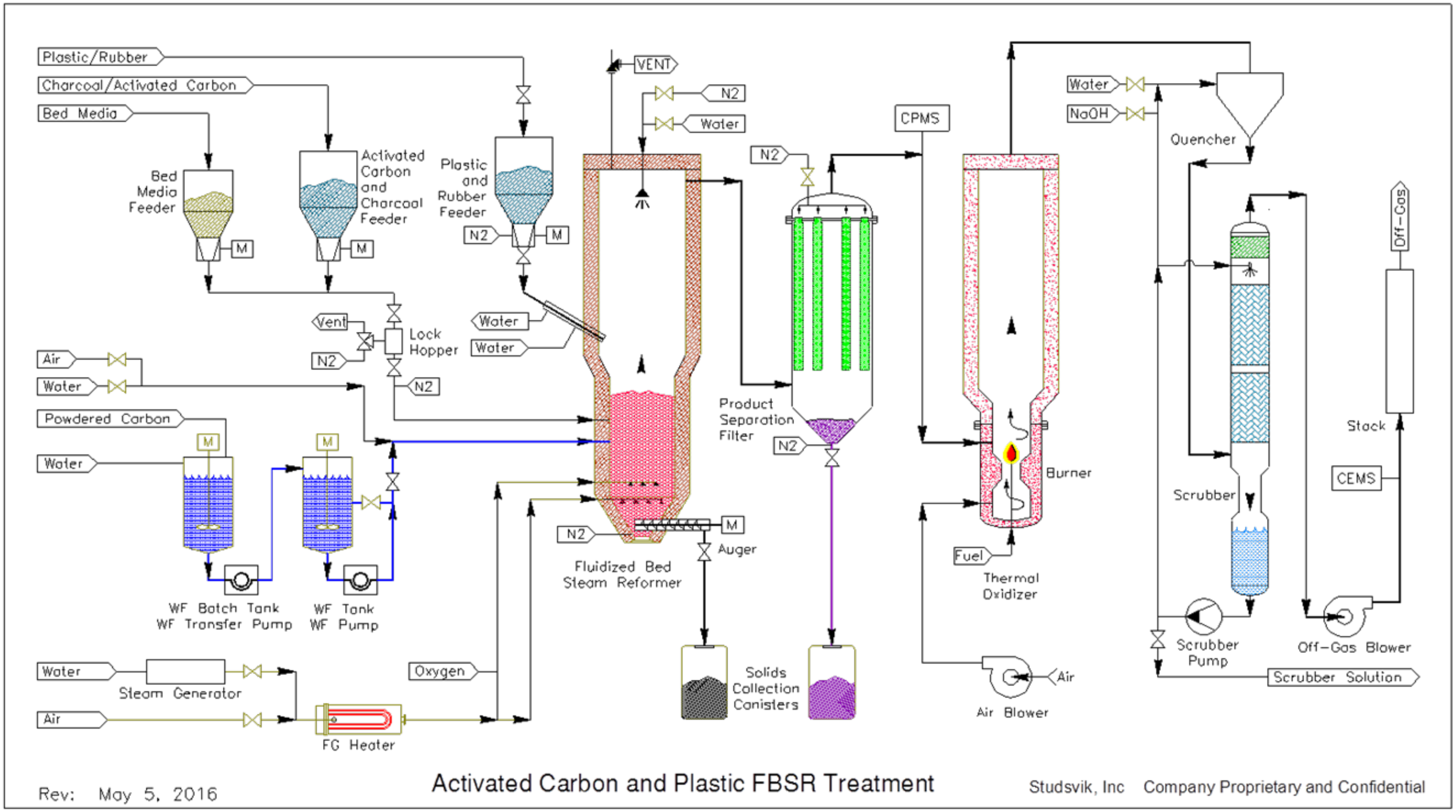
Plastic/Rubber
Charcoal/Activated Carbon
Bed Media
Bed Media Feeder
Activated Carbon and Charcoal Feeder
Plastic and Rubber Feeder
VENT
N2
Water
CPMS
Water
NaOH
Quencher
Vent
Lock Hopper
Air
Water
Powdered Carbon
WF Batch Tank
WF Transfer Pump
WF Tank
WF Pump
Fluidized Bed Steam Reformer
Auger
Product Separation Filter
Burner
Thermal Oxidizer
Fuel
Scrubber
Stack
CEMS
Off-Gas
Scrubber Pump
Off-Gas Blower
Scrubber Solution
Steam Generator
Oxygen
FG Heater
Solids Collection Canisters
Air Blower
Rev: May 5, 2016
Activated Carbon and Plastic FBSR Treatment
Studsvik, Inc Company Proprietary and Confidential

FIGURE 4

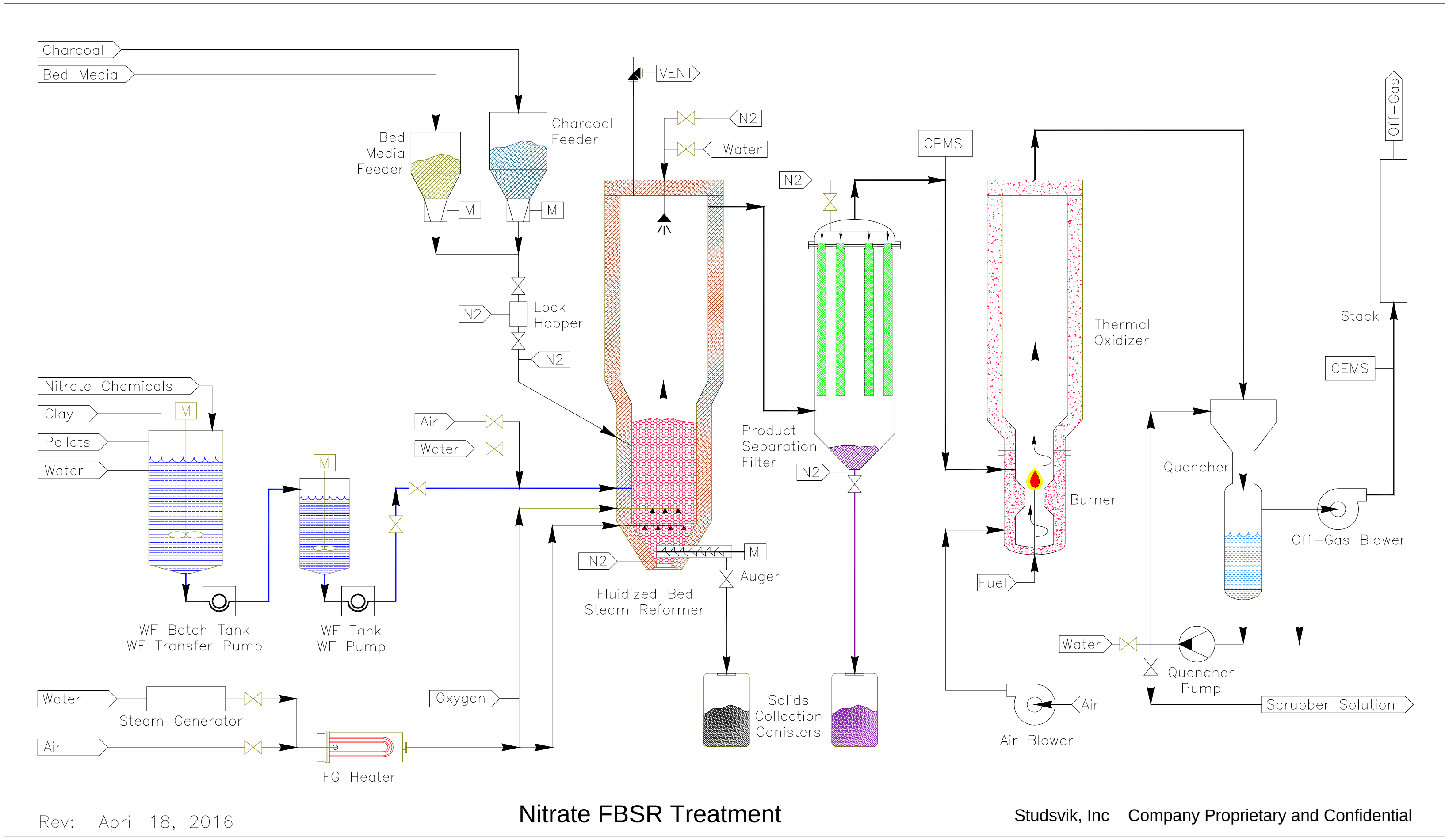
Charcoal
Bed Media
VENT
N2
Water
Charcoal Feeder
Bed Media Feeder
M
M
CPMS
N2
Lock Hopper
N2
N2
Thermal Oxidizer
Off-Gas
Stack
CEMS
Nitrate Chemicals
Clay
Pellets
Water
M
M
Air
Water
Product Separation Filter
N2
Quencher
Burner
Off-Gas Blower
N2
M
Auger
Fuel
Fluidized Bed Steam Reformer
WF Batch Tank
WF Transfer Pump
WF Tank
WF Pump
Water
Quencher Pump
Water
Steam Generator
Oxygen
Solids Collection Canisters
Air
Air Blower
Scrubber Solution
Air
FG Heater
Rev: April 18, 2016
Nitrate FBSR Treatment
Studsvik, Inc Company Proprietary and Confidential

FIGURE 5

PRELIMINARY RESULTS

During the month of December, 2016 several pilot plant tests were performed with respect to the treatment of nitrates and activated carbon. Additional tests related to DAW were unfortunately delayed until January 2017 due to client needs and holiday schedules. It is anticipated that the preliminary results of the DAW test will be included in the public presentation during the WM2017 Conference.

But the results of the Phase 1 demonstration for the nitrate tests have shown that nitrates and activated carbon can be treated effectively through the use of the FBSR process.

The following preliminary observations were made for with respect to the nitrate and activated carbon testing:

- DMR fluidized bed operating temperatures were held below 750°C which allows for the use of carbon steel with insulative refractory and only a thin inner metallic liner Additionally, an operating temperature 750°C is well below the volatilization temperature of most radionuclides.
- As demonstrated in past test programs, THOR was successfully used to destroy nitrates to a level necessary to achieve a stack gas compliant with applicable air emissions regulations for NOx
- Final product solids contained no measurable amount of nitrate, indicating that all of the nitrates in the liquid feed were converted into gaseous species
- 99% of the NOx produced during the destruction of the nitrate waste were destroyed (converted into nitrogen gas)

- Results show that simultaneously treatment of nitrate and AC Activated Carbon can be achieved.
- Normal coal feed can be reduced when using the AC/nitrate feed, which indicates that the AC added to the feed can be used to replace a portion of the normal coal additive feed that is needed to operate the DMR (maintain temperature and destroy NOx)

Additional results will be collected over the next two months. This data will include final particle size, final product composition, process gas analysis, and off-gas chemical analysis. In addition, complete mass balance evaluations will be completed for each process demonstration and final volume reductions calculated.

CONCLUSION

The use of the FBSR technology is adaptable and scalable to the various waste types identified within the Japan nuclear market. Although additional pilot plant testing may be required to provide additional design details, Studsvik is confident that the FBSR is a premier technology for the treatment of spent ion exchange resins, nitrate wastes, oils, sludges, activated carbon, and dry active waste.

As the costs for final disposal increases, the ability to reduce the amount of waste and provide a safe and stable final waste form will become invaluable for the nuclear market. We believe that technologies such as FBSR can and will provide these benefits as proven in this pilot plant study and others conducted over the last 19 years.