United States
Environmental Protection
Agency

EPA/540/F-93/XXX
August 1993

SUPERFUND INNOVATIVE
TECHNOLOGY EVALUATION

Emerging Technology Bulletin

Spouted Bed Reactor

Energy and Environmental Research Corporation

Technology Description: The Spouted Bed Reactor (SBR) technology utilizes the unique attributes of the "spouting " fluidization regime, which can provide heat transfer rates comparable to traditional fluid beds, while providing robust circulation of highly heterogeneous solids, concurrent with very aggressive comminution (particle size reduction through abrasion.) The primary spouted bed provides a zone for volatilization, pyrolysis, and gasification reactions. The gaseous products can then be applied to highly efficient oxidation/incineration in conventional combustion equipment, used for power production in prime movers or, alternatively, chemical products can be recovered. Thus, gasification provides much greater opportunity for product recovery through Advanced Recycling.

The EER pilot plant process flow is shown in Figure 1. Waste is fed into the primary spouted bed reactor via conveyor belt to the extrusion feeder. The extrusion feeder is a very rugged screw type extrusion device which extrudes the heterogeneous feed material into the spouted bed thermochemical reaction zone where solids are comminuted and gasified at medium temperature (1000-1600 °F). Large solids remain in the bed until they are reduced in size through attrition, pyrolysis, and gasification reactions.

Steam and gaseous products elutriate fine particles out of the primary reactor into the secondary slagging hot cyclone where the temperature is increased significantly by addition of oxygen. Fifty to 75% of the solids may be recovered as a vitrified product from the slagging hot cyclone when it is operated at slagging temperatures. The gas stream is then cooled via heat exchange to recover heat and raise steam for the process and the fine particulate is then removed in a traditional baghouse. Dry scrubbing techniques are used to remove acid gases. Baghouse ash may be recycled to the primary spouted bed.

Steam is used as the spouting fluid, highly superheated by a small in-line oxy-fuel burner. The resulting high velocity spouting gases cause aggressive size reduction of heterogeneous feedstocks concurrent with the promotion of thermochemical gasification reactions. Particle size is rate limiting for heat and mass transfer reactions, including pyrolysis and carbon gasification. Therefore, rapid size reduction through comminution in the spouted bed significantly improves reaction rates resulting in greater throughput for a given equipment size. Superheated steam provides heat for endothermic pyrolysis reactions, along with partial oxidation of wastes which react with sub-stoichiometric levels of oxygen injected into the spouted bed primary.

Advanced recycling technology development

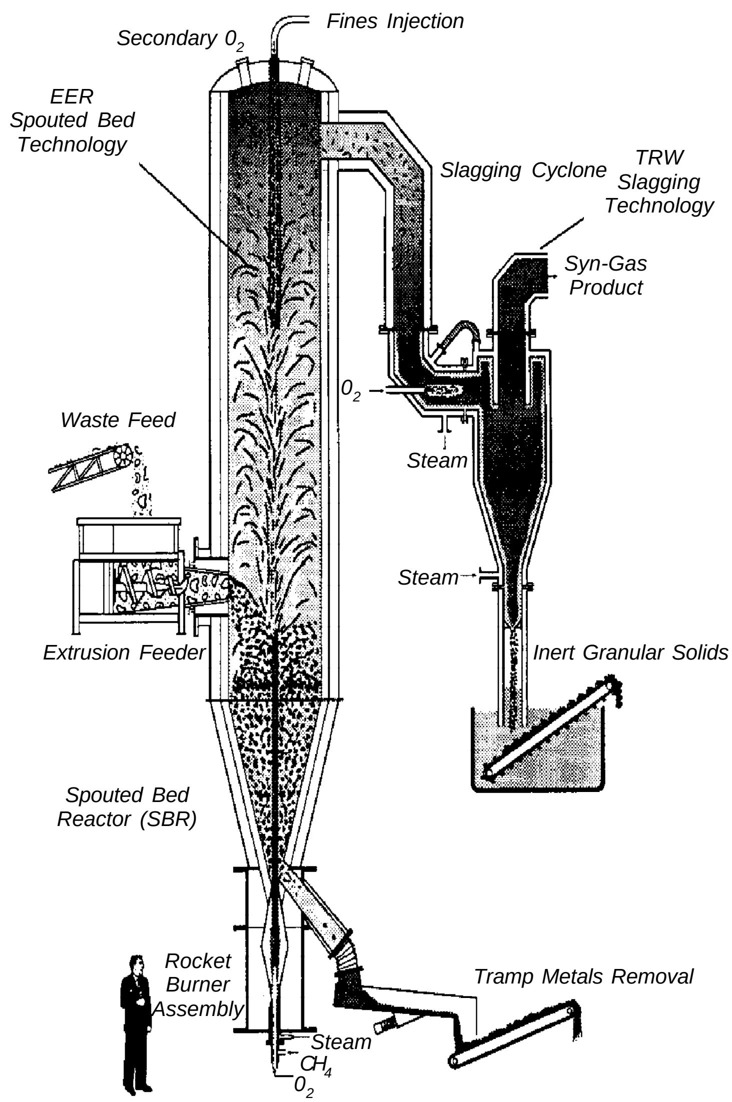

Figure 1. *SBR thermochemical waste recycling system.*

A secondary hot cyclone is fired with additional oxygen to further raise the temperature of gasification products to slagging temperature when a vitrified product is desired. In the presence of excess steam at high temperature, toxic organic compounds that may result during low or medium temperature waste pyrolysis are reduced to H_2, CO, CO_2, and H_2O. Subsequent purification of the $H_2/CO/CO_2$ gas stream can be accomplished using conventional particulate and scrubbing technologies.

Waste Applicability: The SBR Advanced Recycling technology is primarily applicable to waste with significant heat content that are contaminated with toxic organic compounds and heavy metals. The heat content of the waste may range from 3,000 to 12,000 Btu per pound. Soils contaminated with coal tar residues, petroleum refinery wastes, and municipal solid wastes are appropriate for processing in the SBR Advanced Recycling system. Chemical waste, munitions and rocket propellants are also candidate feed materials.

Pilot Plant Test Results: Accomplishments to date have included the design, construction, shakedown, and preliminary operation of a pilot scale SBR facility capable of processing 1000-1500 lb/hr of waste. Trouble-free feeding of “raw” unsegregated Auto Shredder Residue (ASR) plastics has been accomplished at a feed rate of 1400 lb/hr. Limited data obtained during test runs have demonstrated the conversion of ASR to hydrocarbon rich process gas (330-480 Btu/scf), with negligible tar formation, and with 1-2% carbon remaining in the ash constituents. ASR product ash analysis (recovered from the hot cyclone) indicated metals leachability below regulated limits; lead and cadmium, the two metals of primary concern in ASR, were 0.4 & 0.06 mg/l respectively, the limits being 5.0 and 1.0.

Preliminary tests with ASR have been limited to several short duration runs, and some further modification and testing is required in order to complete the development of the SBR gasification technology and to demonstrate its effectiveness at pilot scale. Later phases of development will then focus on issues related to in-process and back-end clean-up of the product gas.

Advanced recycling (thermochemical conversion) of high Btu content wastes can generate a variety of end products. These include pyrolysate liquids, olefins, and syn-gas. EER’s SBR technology can be operated at low, medium, or high temperature in order to generate these respective end products. Bed materials tested to date include 1/16" and 1/4" silica sand, 1/4" alumina balls, and 1 mm steel shot. The effects of bed materials and reactive additives will require careful characterization.

For Further Information:

EPA Project Manager
Teri Richardson
US Environmental Protection Agency
26 West Martin Luther King Drive
Cincinnati, Ohio 45268
(513) 569-7949

EER Project Manager
Donald G. Taylor
Energy and Environmental Research Corporation
18 Mason
Irvine, CA 92718
(714) 859-8851

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use
$300

EPA/540/M5-93/50X

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35