SPRAY DRYING OF LIQUID RADIOACTIVE WASTES

Richard F. Abrams
Koch Process Systems, Inc.

Jamie P. Monat, Ph.D.
Abcor, Inc.

ABSTRACT

Full scale performance tests of a Koch spray dryer were conducted on simulated liquid radioactive waste streams. The liquid feeds simulated the solutions that result from radwaste incineration of DAW and ion exchange resins, as well as evaporator bottoms. The integration of the spray dryer into a complete system is discussed.

INTRODUCTION

This paper describes the design and test work that has been performed on a spray dryer system that is used to dry liquid radioactive waste, consisting of evaporator bottoms and liquid blowdown waste from an incinerator scrubber system. The test work was performed in a full scale dryer system located at the Abcor test facility. Dry products that resulted from the testing were analyzed for various chemical and physical characteristics and were sent to solidification system vendors for encapsulation testing.

BACKGROUND

Volume reduction of radioactive waste in a nuclear power plant is becoming an effective method for reduction of utility radwaste disposal costs. One volume reduction technique that has received considerable attention is low level radwaste incineration. A radwaste incinerator can be equipped with a wet scrubbing offgas system in order to achieve very high removal efficiencies (decontamination factors) for radionuclides that may be present in the incinerator effluent. A wet scrubbing system also neutralizes acid gases that result from the combustion of chlorine compounds (e.g. PVC) and sulfur bearing compounds. The caustic scrubbing liquid absorbs and reacts with these acid gases, producing sulfate, sulfite and chloride salts that are dissolved in the scrubbing liquid.

As more acid bearing waste is burned, more salts are generated. To prevent plugging, corrosion, and other problems, the salts must be discharged from the scrubbing loop well before saturation and precipitation occurs. The salts are discharged via a liquid blowdown stream radioactive and which must be handled as liquid radwaste. A power plant typically does not have excess liquid radwaste processing capacity to handle this stream.

Furthermore, conventional radwaste processing equipment is not capable of treating streams with such high chloride concentrations.

Further volume reduction of concentrated liquid radwaste in a plant is economically feasible. The bottoms from a plant's radwaste evaporator contain a large amount of water. If this water is removed, a significant additional volume reduction can be achieved.

Koch Process Systems recognizes that the liquid blowdown stream from its volume reduction system, the VR System 350, must be eliminated internally for the incineration system to be compatible with power plant operations. If the blowdown elimination system could also process evaporator bottoms material, the entire system would then be that much more cost effective. Also, the concept of processing evaporator bottoms to dryness either as part of an entire VR-system or independently is certainly attractive. The use of a spray dryer to process these streams was conceived and testing was done to verify performance.

TEST DESCRIPTION

Koch Process Systems contracted with Abcor, Inc. (both are subsidiaries of Koch Engineering Company) to run extensive tests in the Abcor spray dryer pilot plant has been utilized for over 5 years on dry FGD research and the personnel have extensive experience in the design of the dryer vessels, the two-fluid atomization nozzles and the inlet gas distribution system. All three components are key ingredients in the design of a high performance dryer system.

The Abcor pilot plant utilizes a propane burner to produce simulated flue gas. Fig. 1 depicts the flow diagram of the Abcor system. In order to simulate the high temperature gases (1200°F) that would be discharged from the radwaste incinerator to the spray dryer, certain modifications of the Abcor facilities were made. At 1200°F inlet gas temperature, and with the maximum propane rate to the burner, a liquid feed rate of approximately 1 GPM at 6% dissolved solids was possible. This flow rate equates to full scale operation of a 350 lb/hr incinerator system containing 10% PVC in the feed.

Two sets of tests were conducted. For the first, two feed mixtures that simulated the scrub solution chemistry resulting from two different incinerator feeds were prepared. Mixture 1, shown in Table I, consisted of a 6.8% sodium chloride solution that also contained sodium carbonate, decontamination solution, fly ash and sodium sulfate/sodium sulfite. Mixture 1 was representative of the blowdown stream that would be generated when burning trash that contained PVC. Mixture 2, shown in Table II consisted primarily a sodium chloride, sodium carbonate, fly ash and decontamination fluid as well as ferric oxide. This mixture simulates the blowdown stream that would be generated from burning trash and spent ion exchange resins.

TABLE I

Mixture 1 (Composition)

Component	Wt. % of Total
Water	88.96
NaCl	6.8
Na_2SO_4/Na_2SO_3 (50/50)	.04
Flyash	0.9
Na_2CO_3	2.3
Turco 4521	1.0
	100.0

TABLE II

Mixture 2 (Composition)

Component	Wt. % of Total
Water	87.5
NaCl	2.2
Na_2SO_4/Na_2SO_3 (50/50)	6.5
Flyash	0.2
Fe_2O_3/Fe_3O_4 (50/50)	0.5
Na_2CO_3	2.1
Turco 4521	1.0
	100.0

For the second set of tests, simulated evaporator bottoms material was dried. Again, 1200°F flue gas was used as the heat source and a stream shown in Table III consisting of sodium sulfate, sodium chloride and crud was dried in the spray dryer in a manner similar to the blowdown streams.

TABLE III

Mixture 3 (Composition)

Component	Wt. % of Total
Water	79.6
Na_2SO_4	20.0
NaCl	0.4
	82.0

The drying tests were conducted using the Abcor two-fluid nozzles. These nozzles produce a fine, uniform dispersion of droplets. Droplet size and, therefore, drying time can be varied by varying the atomizing air pressure. For the tests on the three feed materials, 60 psig atomizing air pressure was used.

The droplets discharge from the nozzle into a proprietary mixing device which insures good liquid/gas mixing. The mixture enters the dryer vessel where sufficient residence time is provided for drying. During the tests, a nine second residence time was utilized.

In each test, the dry product was collected from the baghouse and sampled. Once the initial performance data on spray dryer operation was collected, the unit was operated in a production mode in order to gain long term operating experience and to generate dry product for solidification testing. Dry product samples from the various feed mixtures were analyzed for particle size distribution, moisture content and distribution for feeds 1 and 2.

The operation of the spray dryer system was trouble-free and very tolerant of fluctuations in feed flow rate, inlet gas temperature or salt concentrations. This can be attributed to the high efficiency of the atomization nozzles and the high dryer residence time.

The powders produced were free-flowing, dry to the touch and uniform in appearance. The powder from mixture 2 was reddish due to the presence of iron oxide. The powders from mixtures 1 and 3 were light gray in color.

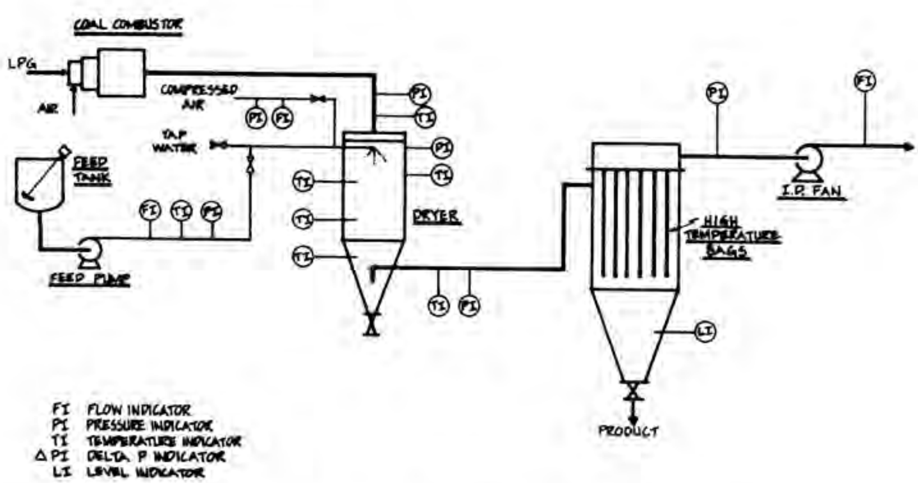

FIG. 1 SPRAY DRYER SYSTEM AT ABCOR FACILITY

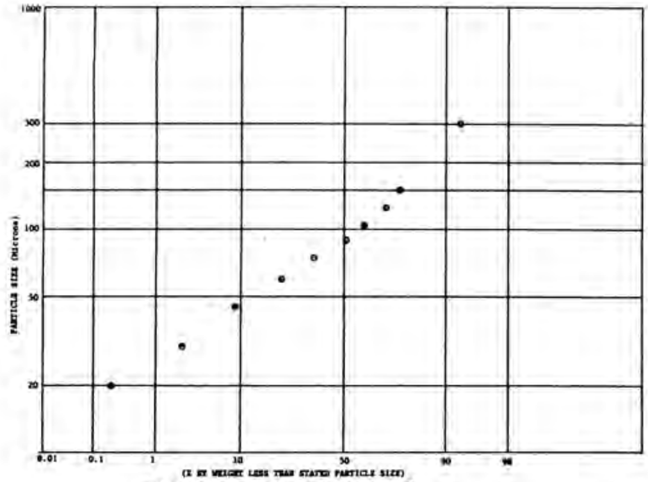

FIG. 2 Particle size distribution for feed mixture #1.

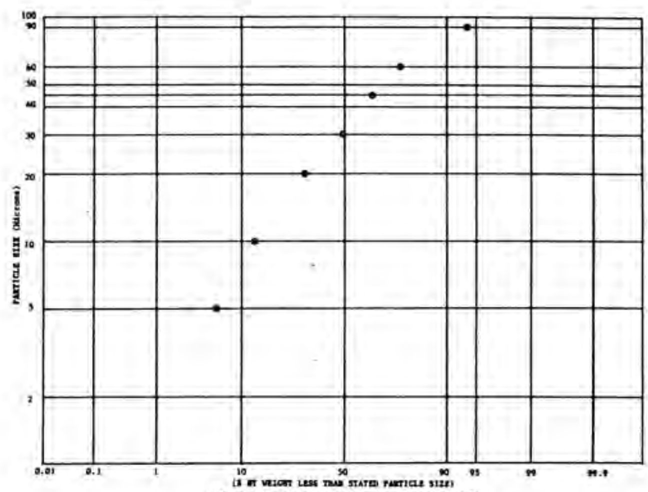

FIG. 3 Particle size distribution for feed mixture #2.

The solidification tests were performed by two different solidifier vendors using both Dow polymer and cement as binders. The vendors reported that high quality monoliths were produced and high loading factors observed for both binders. Since the testing showed that the powder transferred and discharged from equipment easily, the interface between the ash removal system and solidification system poses no significant problems.

SYSTEM DESIGN FOR RADWASTE USE

The spray dryer can be used for liquid radwaste processing by providing a source of hot gas for drying is provided. When the blowdown liquid from an incinerator is to be processed, the Koch system utilizes a slipstream of hot (to 2200°F) incinerator effluent gas. Figure 4 depicts which is the flow diagram for this system. The gas is prequenched to 1200°F by a small spray of water to minimize the problems in the selection of proper materials of construction. The gas enters the dryer, mixes with the liquid, the liquid evaporates and a dry powder is produced. The dry powder is then entrained in the cooled gas (approx. 250°F) to the ash removal system. The bulk of the powder drops out in a cyclone and the final traces are removed by sintered metal filters.

Since the flue gas may still contain some acid gases (particularly SO_2), the gas is routed to the packed column. The acid gases are neutralized and remaining flue gas is routed through the HEPA filters and charcoal bed after which it is discharged.

When an incinerator system is not supplied, the spray dryer can be supplied with an air heater package to provide the hot air required for drying. This package heats air to 1100°F; the process in the dryer is the same as described above. The powder is discharged to a cyclone/sintered metal filter powder separation system which interfaces with the plant solidification system.

CONCLUSION

The results of the full scale testing at the Abcor facilities prove conclusively that a spray dryer that utilizes a portion of hot incinerator effluent gas or heated air as its heating medium is a practical solution to eliminate the blowdown stream and for evaporator bottoms VR. Furthermore, the particle size distribution of each of the dry products shows that the VR-System 350 ash removal system is a practical method of separating the dry product from the flue gas stream.

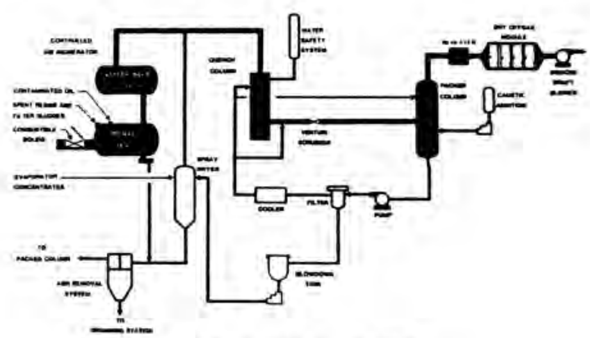

Fig. 4 VR-System 350 Flow Diagram