INCINERATION OF SPENT ION EXCHANGE RESINS AND SOLIDIFICATION OF ASH

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ABSTRACT

Organic ion exchange resins are widely used for cleaning of coolants of nuclear power plants. One part of the large amount of spent resins arising annually is only low charged by radioactive particles and thus its volume reduction would be highly desirable.

Because of the considerable high specific volume and other physical and chemical qualities as well the spent resins are not appropriate for immediate final disposal prior to further conditioning. For most of the burnable wastes both volume reduction and conditioning suitable for final disposal can be achieved by incineration and special treatment of the ash.

For any type of waste the feasibility of incineration has to be proven with respect to off-gas requirements both in terms of activity retention and release of conventionally harmful constituents and the proper ties of the final waste products have to be in compliance with the requirements of the repository.

The feasibility of incineration of powder resins in the a.m. sense was examined by characterizing of the resins, laboratory scale test incineration in a commercial facility, ash-solidification test and characterization of the final waste products.

CHARACTERIZATION OF THE WASTE

The material to be treated consisted of mixed anionic and cationic exchange resins stabilized in urea-formaldehyde-polycondensate (UFP).

The specific activity (beta + gamma) of the resins was in the range of 1000-5000 Bq/g primarily consisting of Co-60, Zn-65 and Mn-54.

The UFP-stabilized resins were delivered in 200 l drums containing up to 70% moisture. Because of the high humidity of the material a substantial part of the combustion heat was spent for water evaporation (proven by differential thermal analysis of the material).

LABORATORY SCALE INCINERATION TESTS

As the behavior of the UFP-resin mixture, when being heated up or incinerated was unknown, initially incineration tests were carried out on a small scale in a resistance heated tubular furnace equipped with thermoelements, controlled air flow and off-gas analysis system.

The following major results of the incineration tests were achieved: The activity content of the resins was nearly completely retained in the ashes; no activity could be detected in the off-gas filter system.

After having been subjected to temperatures up to 1000°C over 20-30 minutes the combustion was completed and no further reaction could be observed.

The mass reduction factor by the incineration was between 34 and 110 depending on the type of resins. The ashes primarily consisted of iron oxide with minor amounts of sulfur, calcium, zinc and copper.

Generally a release of about 30 g sulfurous oxides per kg of resin in the as-received condition was observed. Because this is supposed to impair the operation of a commercial incinerator the feasibility of reduction of the sulfurous oxid concentration in the off-gas was examined.

The addition of calcium carbonate to the resins prior to incineration at a 50 %-excess to stoichiometry - related to the sulfurous oxides-was capable of reducing them by a factor of three.

LARGE-SCALE INCINERATION OF ION EXCHANGE RESINS

Prior to commercially processing of ion exchange resins at the Siemens/KWU facility ARAK, an incineration campaign was carried out at the similar incinerator of KFA-Juelich, for which technical and legal preconditions for the treatment of this material already existed. The efficiency of volume reduction and the accordance of the process with regulations and technical specifications was to be proven by this test.

The incineration process applied (Fig. 1) consists of two stages: an initial pyrolysis step and a final incineration step. Off-gas is cleaned in a dry system in three mechanical filtering stages; these comprise a hot-gas filter which operates at temperatures of about 800°C, a safety filter of similar design operating at 250°C and finally HEPA filters operating redundantly. This arrangement guarantees a decontamination factor of at least 400,000 (see Ref. 1,2).

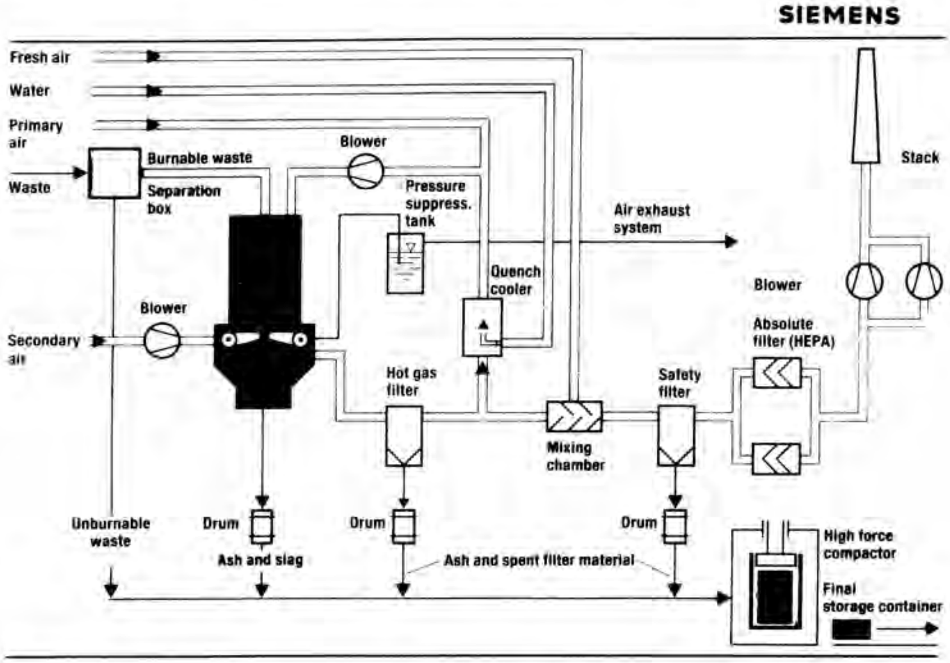

Fig. 1. Incineration System.

Composition of Incineration Batches

In order to achieve a self-sustaining and continuous combustion the resins had to be mixed batchwise with other burnable waste forms. Figure 2 shows the composition of the incineration batches by weight.

As shown five different types of burnable material were used: wood, paper, mixed waste, filter and resin. The filter material consisted of synthetics with aluminum spacers and wooden frames and was only used to a small extend at two days. In total 6895 kg of resins were burnt together with 5800 kg of other material corresponding to 54 % of resin.

The original volume of the resins to be burned of 8.6 m^3 was increased by the rearrangement for producing burnable batches to a volume of about 12.6 m^3.

Method of Incinerator Operation

The incinerator was run at only one shift a day. At the beginning of the shift in the morning, the incinerator was heated up to the operating condition for 1-2 hours burning primarily filters. After reaching working temperature 100-150 kg batches of resin were added in time intervals of 0.5 to 1.5 hours.

According to the temperatures recorded during operation mixed burn able wastes were added in order to keep the combustion at operating conditions. As earlier mentioned the ratio of resin weight to the total amount of waste was 0.54 at the average indication a problemless sustaining of the combustion process. As shown in Fig. 2 this ratio was lower at the beginning of the campaign and was increased towards the end.

Volume Reduction

The volumes of the different types of waste incinerated during the campaign and the corresponding amounts of ash are shown in Fig. 3.

An average waste volume reduction factor - without regarding further reduction by compressing and conditioning of the ashes - of 25 was observed.

As shown in Fig. 3 the highest reduction factors were achieved when a maximum part of resins were added to the other types of waste indicating the good combustion capability of the resin.

According to the increasing part of resins added higher volume reduction factors were gained by the end of the campaign. The low reduction factor of seven achieved when only a very limited amount of resin was burnt is due to the large portion of incombustible material in the mixed waste added.

Off-Gas Analyses

In order to assess the detrimental portions of the off-gas during the resin incineration a mobile facility for on-line off-gas analysis was installed. The main harmful substance is SO_2 in the off-gas. Fig. 4 shows the off-gas analysis depending as different waste compositions. The SO_2 concentration lies above the limits set by the new Clean Air Requirements. Therefore we have decided to instal a off-gas scrubber in the plant as soon as 1988. This is designed to allow

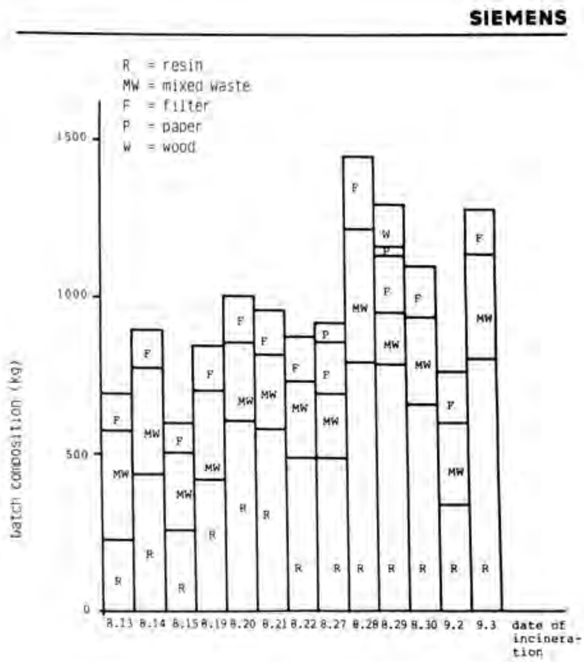

Fig. 2. Composition of Incineration Batches.

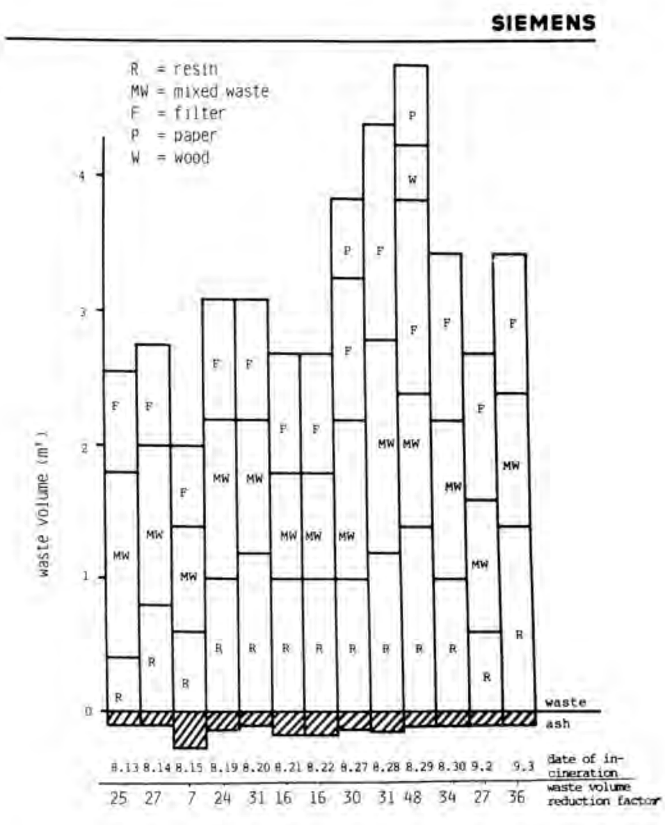

Fig. 3. Waste Volume Reduction by Incineration.

harmful gas (mg/m³ N)	Test Waste 1	2	3	Limit new clean air requirement
CO	19,6	57,8	24,2	100
NO_X	157	206	293	-
C_mH_n	20,7	36,4	39,6	20
SO_2	43,3	366	68,6	100
HCL	344	769	2723	50
HF	9,0	23	21	2

1 Waste from Nuclear Medicine
2 Ion Exchange Resins and mixed Waste (50/50)
3 Waste from older NPP

Fig. 4. ARAK-OFFGAS Analysis Depending on Different Waste Composition.

continuous incineration of higher quantities of PVC, rubber and slightly-contaminated ion exchange resins in the future.

SOLIDIFICATION

Ash and slag is discharged from the incinerator into 180-liter (approx. 50-gallon) canisters.

Our customers, who intend to dispose ash and slag of their waste through sea dumping or shallow-land burial, has to fulfill particular requirements as regard their resistance to leaching and to pressure. This ash and slag is solidified through supercompaction with cement. This means that cement and water is added to the ash in the canister. Tumbling of the sealed canister mixes the contents and the canister is subsequently compacted in the supercompactor with a pressing force of 1650 t. The volume reduction factor for this process is 1.5 to 1.7. The overall volume reduction factor is therefore 40. After hardening the product resembles hardened cement paste and has appropriate chemical and mechanical properties with respect to final disposal.

ASH PRODUCT QUALIFICATION

Together with the Juelich research center we have worked out the necessary parameters for mixing the ash, cement and water required for supercompaction with cement. The result is that the canisters are 70% filled with ash. The weight of the ash in the canister is then deter mined. 25 wt% cement and 12 wt% water is added to the ash. A large number of sample bores from the hardened product were then subjected to the following:

- Test for absence of free liquid (ANSI/ANS 55-1)
- Measurement of compressive strength (ASTM/C39)
- Examination of resistance to immersion
- Thermal cycling (ASTM B553)
- Leach test

The results were satisfactory. Following the immersion test it was found that the compressive strength was increased. The reason for this was that the ash had absorbed water before hardening, therefore preventing proper hydration of the cement in the first step of solidification.

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