VACUUM DRYING AND SUPERCOMPACTION APPLIED TO REPACKING OF WASTE IMMOBILIZED IN UREA FORMALDEHYDE

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ABSTRACT

The vacuum drying and later supercompacting technique is being successfully applied to the repacking of drums of radioactive waste immobilized in urea formaldehyde polymer, at the Almaraz Nuclear Power Station in Spain.

The volume reduction factor being achieved with the repacking process is between 1/3 and 1/4.

This paper describes the preliminary studies, equipment used and results of the operations, carried out using mobile plants.

INTRODUCTION

The formaldehyde urea polymer was marketed for the first time in 1972 for the immobilization of medium and low radioactive wastes (1).

Since that date several nuclear power stations in the world have implement this system of waste solidification. Later it was detected that this immobilizing agent released the water trapped inside with a very low pH, causing corrosion in the drums.

In Spain the Almaraz Nuclear Power Station (2 x 930 MWe PWR type units) originally installed a radioactive waste solidification system based on this process, and this was utilised until 1983, when it was decided to change over to a system of solidification using cement.

With the urea formaldehyde process approximately 1,900 drums of waste was produced at this power station.

To avoid the risk of the total degradation of the drums it was decided to repack these, eliminating the free water.

Equipos Nucleares, S.A. (ENSA), starting out with the technology of the German firm Gesellschaft fur Nuklear Service mbH (GNS) is using the technique of vacuum drying and later supercompaction of the drums as a method applicable to the elimination of free water, and also to achieve an optimum volume reduction factor.

PRELIMINARY STUDIES

On inactive drums at scale 1:1 and using simulated samples of evaporator concentrates (boric acid) and ion exchange resins, prepared by the nuclear power station, preliminary laboratory tests were carried out enabling us to define some of the fundamental parameters of the process such as the maximum temperature which may be reached by the urea matrix without the hazard of self-ignition, litres of water extracted until total drying, approximate processing time, etc. at the same time as the first problems were detected which were to become determining to be solved and which fundamentally were centered around two aspects:

- Metal drums: Excessive acidity of free liquid (pH 1). Probable corrosion of drums.
- Urea matrix: Deficient heat transfer, decomposition at high temperature, considerable amount of free water (45% by volume).

Furthermore and considering the high number of drums to be repacked (approximately 1,800), it was decided to increase the capacity of the FAVORIT drying equipment, designed in principle to dry six containers of waste of 400 l each, adapting the process to work with six drying booths with a capacity of six drums each (simultaneous drying of 36 drums).

FULL SCALE COLD TESTS

With the final equipment destined for continuous operation, cold tests were carried out, both of drying and compaction, with new drums simulated with the same content as the earlier ones, but older.

The percentage of humidity of a sample of urea to total drying was determined, and it resulted that over two thirds of the sample was free liquid (value much higher than obtained in the laboratory). Also the marked hygroscopic properties of urea formaldehyde were observed, with absorption of the ambient humidity and a large increase in weight.

On the basis of this and later tests, a drying criterion was defined to confirm the correct drying of drums according to the initial and final weights of the matrix and litres of free liquid extracted.

It was found that not only 10% of the drums presented perforations and small holes (as was communicated at first) but also that practically all the drums presented this problem which in addition to being very difficult to detect, made the drum a non-watertight container, causing a loss of vacuum which made the drying process unviable.

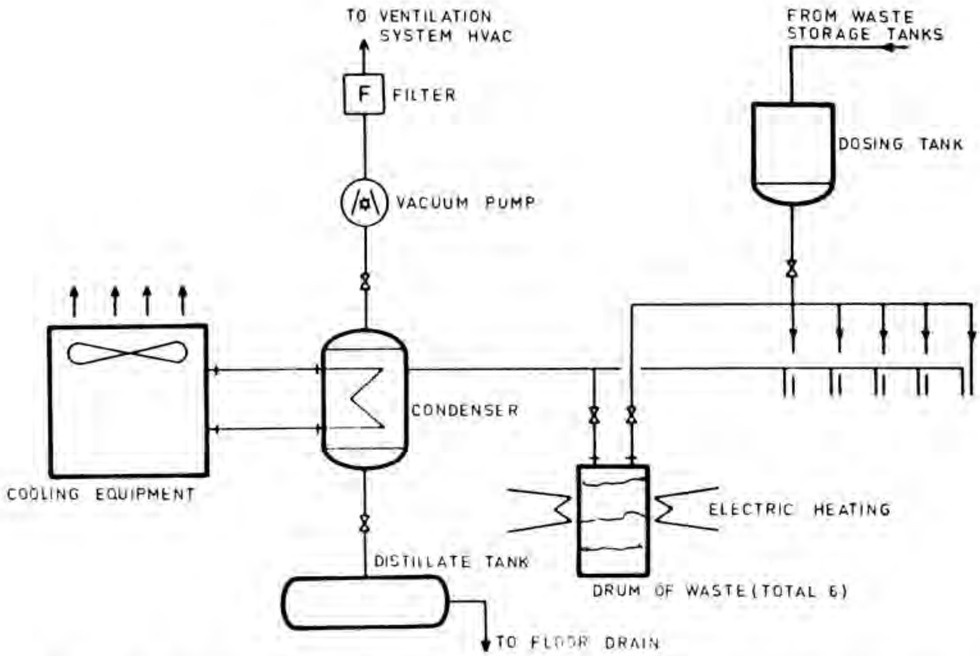

Fig. 1. Mobile Plant Favorit Vacuum Drying of Liquid Radwaste (GNS Process).

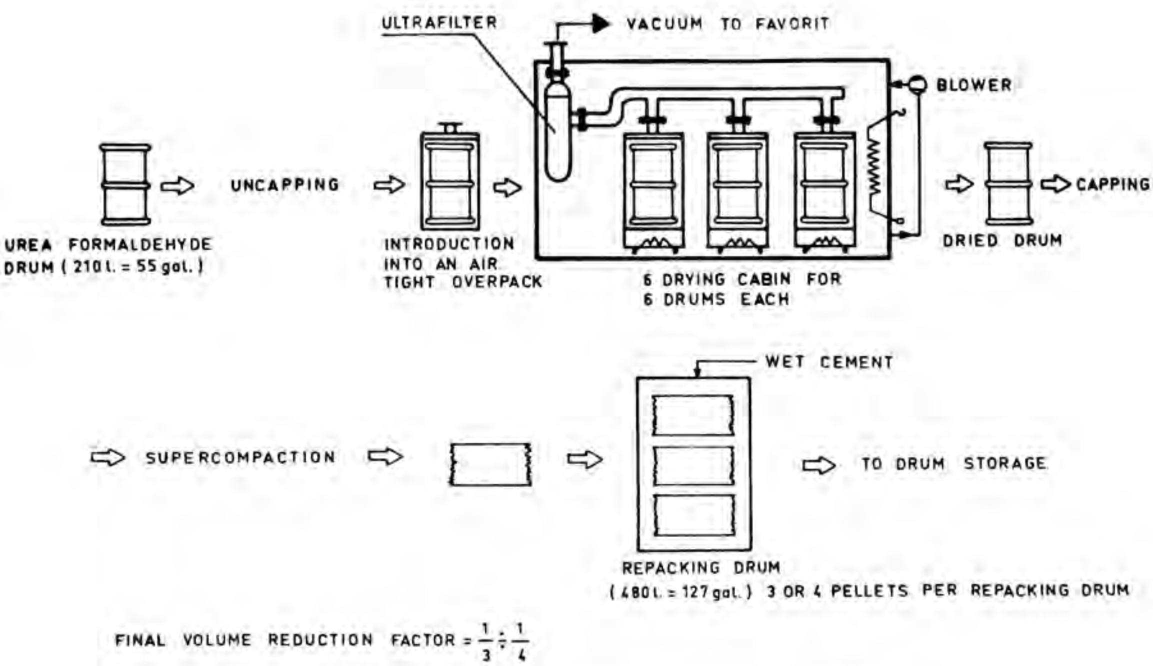

Fig. 2. Vacuum Drying and Supercompaction Diagram.

At first an attempt was made to maintain the integrity of the drums by means of metal bands, silicone seals, external painting, etc. but the results were not satisfactory, as damage to the drum is very difficult to detect. The containers provided to date had to be modified by designing a water tight container (overpack) which covered the drum completely, provided with a sliding filter which was couple directly on the mouth of the drum and with a double seal to maintain an optimum level of vacuum at all times.

Various tests were carried out for the application of the heat to the drum. These included: system of infrared rays, bands of elements place on the collar, but owing the poor thermal conductivity of the urea and the fact that a few hours after the process commenced, the matrix contracted, forming a jacket of vacuum between the matrix and the drum collar, it was decided to introduce an element at the bottom of the drum, without coming into direct contact with the UF matrix.

Furthermore, the interior atmosphere of the drying booth was kept hot, with forced air circulation.

With the tests on the FAVORIT equipment the ranges of temperature and vacuum could be determined to achieve optimum efficiency.

DESCRIPTION OF EQUIPMENT

Two items of equipment are being fundamentally utilised for this process:

- FAVORIT vacuum drying equipment.
- FAKIR supercompaction equipment.

In addition to this equipment the mobile waste repacking plant includes the following auxiliary components:

- Six drying booths (six drums per booth).
- Thirty-six hermetic containers (overpacks).
- Water chilling equipment.

FAVORIT Equipment "Fig. 1".

Using six identical and independent circuits the FAVORIT equipment is capable of making a vacuum and condensing the vapours of up to six drums, containers or group of these.

Each circuit basically consists of one vacuum pump, one condenser cooled by glycolised water, and a number of fittings such as valves, filters, etc.

The process in controlled automatically by the control panel central computer, with the parameters and stages of the process displayed on a frontal synoptic board.

The condensates from the evaporated liquid are collected separately for their adequate radiological control.

FAKIR Equipment.

The FAKIR equipment is a horizontal supercompactor with a 1,300 t compaction force.

There is continuous air extraction from the compaction chamber which passes through a HEPA filter before being discharged into the ventilation system.

Drying Booth.

This is an enclosure of a parallelpiped shape proceded with internal electrical heating elements to supply heat to the overpacks situated inside the booths, and also circulation of hot air. by a general manifold the vapours extracted from each of the waste drums are directed towards the FAVORIT equipment.

The booth has digital internal temperature indicator, and another in the air recirculation (both with indication in the main panel).

The assembly of overpacks is extractable as they are fitted on a trolley.

Hermetic Containers.

The hermetic containers (overpacks) provide the waste drum with the necessary integrity to achieve the degree of vacuum required by the process, which would be otherwise difficult to achieve, in view of the attack of the metal drums by corrosion.

Water Chiller Equipment.

This equipment supplies the necessary flow of cold water to achieve the condensation of vapours from the liquid evaporated from the urea formaldehyde drums.

EXPERIENCES DURING ONE YEAR OPERATION

During 1987 approximately 1,200 drums of urea formaldehyde have been repacked (dried and compacted). The schematic process of the repacking of drums is represented in "Fig. 2".

The mean number of drums processed per month has been approximately 100 (limit value between 80 - 136 drums).

Vacuum values near 75 mm Hg and temperatures below 110°C, have been used in operations, thus lowering the risk of degradation of the urea formaldehyde owing to high temperature.

The condensate collected in the condensate tank has an activity below the detection limit, i.e. $\leq 5E\text{-}7 \mu Ci/ml$ and an approximate pH of 5.3 "Fig. 3".

From the radiological point of view the impact of repacking on the operatives has been very low, with a dose

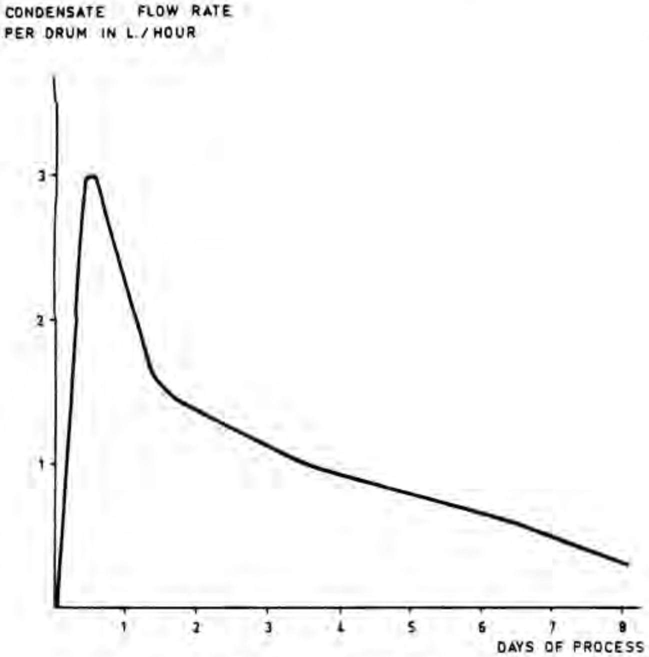

Fig. 3. Evolution of Condensate Flow Rate Per Drum.

per person per month lower than 0.4 mSv (limit value of dose in contact of drums between 0.05 and 1.50 mSv/h).

The reduction in weight experienced by each drum of urea formaldehyde is considerable as with a mean initial gross weight of 210 kg, they are transformed into a drum with a mean gross final weight of 75 kg.

The reduction factor of the total volume of the process (final volume/initial volume) is of the order of 1/3 to 1/4. This is to say, 3 or 4 pellets may be introduced into a 480 l drum.

CONCLUSIONS

The vacuum drying and supercompaction technique shows itself to be a highly appropriate process for the repacking of drums of waste solidified with urea formaldehyde. This method ensures the total elimination of water trapped in the matrix of the polymer at the same time as it achieves a high decontamination factor in the condensate.

A high reduction factor near 1/4 is also achieved.

REFERENCES

1. A. ALAN MOGHISSI ET ALLI, Radioactive Waste Technolgy p. 334, American Nuclear Society, New York (1986).