COMPACTION OF ION EXCHANGE RESINS TO REDUCE VOLUME

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ABSTRACT

The aim in the treatment of radwaste is to minimize the volume of the waste. The reasons for this are better utilization of the storage space available and minimization of handling during transport and storage etc.

For this reason, NOELL developed the compaction process for ion exchange resins. We achieved a minimum volume reduction factor of 3 with this process. We even achieved a factor of 7 at times. However, the volume reduction factor largely depends on the moisture content of the resins.

The waste treatment plants are designed and constructed for services in nuclear power plants. Use the NOELL 2000 metric ton Supercompactor for the compaction process and the resin container for pretreatment of the resins.

VOLUME REDUCTION OF ION EXCHANGE RESINS

Ion exchange resins are produced during condensate purification, reactor water purification and cleaning of the fuel storage pool at nuclear power plants. These are spherical or powdery resins with the addition of inert filtering aid. The largest quantitative share of these resins is only slightly contaminated by radioactivity.

A previously used process was to bind these resins into cement, although this increased the volume of the waste product by a factor of at least 1.6.

NOELL introduced the resin compaction process, with the aim of reducing the volume. This process consists essentially of 3 steps, the sequence of which is as follows:

- drainage to a residual moisture content of less than 5 mass per cent;
- heating up to about 120°C;
- hot-pressing in the supercompactor.

NOELL has mobile equipment for these purposes. Steps 1 and 2 take place in the so-called resin container (a 20 ft container), in which all processing equipment is installed. The processes run automatically as follows: the resin to be heated is sucked from a 200 l drum into the drier and heater using a suction lance. After drying and homogeneous heating, the resin is put into a compacting cartridge and automatically conveyed to the supercompactor. The 3rd step takes place in the supercompactor, where the resin is subjected to a process force of up to 2,000 tons. The compacted puck is picked up by a remote-controlled grab and put into a final storage container.

Due to automation, resins with a dose rate of several mSv/h can be treated.

The volume reduction aimed for, depends on the moisture content of the resins. It is at least 60 % for resins with a residual moisture content of less than 10 mass percent and correspondingly larger for moist resins.

This means that, for example, with the residual moisture mentioned, the contents of a 200 l drum are reduced to a puck with a diameter of 550 mm and a height of 300 mm.

The filter cake thus permanently formed has a solid structure, quite similar to wood. The filter cake is firmly enclosed by a 1 mm thick cartridge.

The aforementioned results are from the inactive test run of the equipment in original conditions. The equipment required - resin container and supercompactor - was rated by the German technical inspectorate agency (TÜV) during this test run and the plants were released for operation by the nuclear licensing authorities.

The waste product fulfills the provisional final storage conditions at the KONRAD shaft, that is, it meets the following requirements:

- the waste product is solid
- the waste product neither decays nor ferments
- the waste product contains no freely moving liquids
- the waste product is not spontaneously inflammable or explosive
- the waste product is fixed in the cartridge in such a way that none of it is discharged from the cartridge at a thermal load of 300°C
- the waste product is stably compacted with a pressing force larger than 30 MPa.

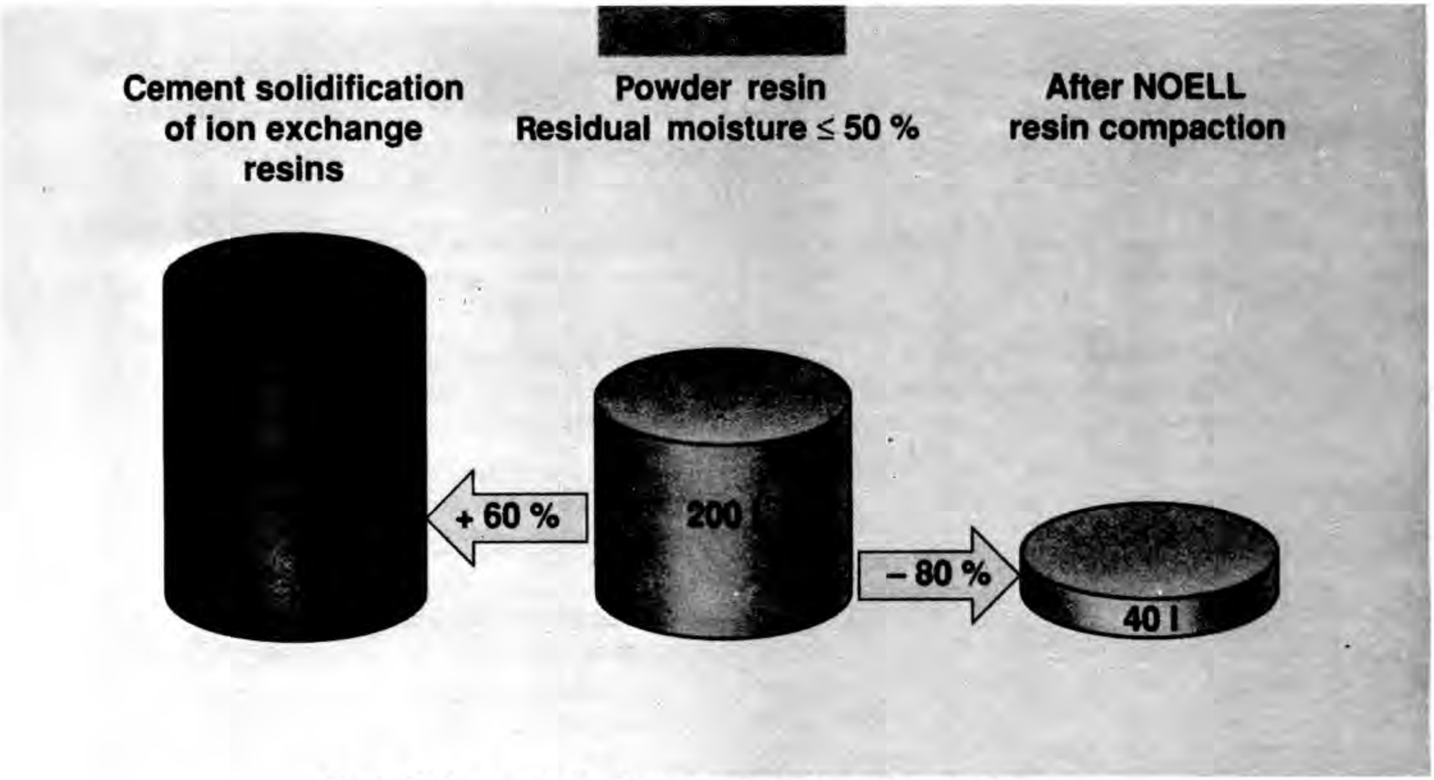

Fig. 1. Volume reduction by compaction ofion exchange resins.

TEST PROGRAM FOR THE QUALIFICATION OF THE PRODUCT

Planning of the test program

The following tests were established and carried out as relevant with regard to the extent to which the pucks produced according to the process described are capable of being put into intermediate storage or final storage.

Impact test with puck in packing

- fall from 5 m height and
- impact at 4 m/s

These tests serve as proof that the waste product is stable and remains so with mechanical loading. Furthermore they show that if a container falls at the Gorleben intermediate storage facility, the release of air-borne activity can be excluded.

Thermal stress of a puck

- heating of a puck to a temperature of 300°C. This temperature must be reached in the whole puck.
- flaming of a puck in an open fire at a flame temperature of 800°C for a period of 1 hour.

These test groups serve as proof of the requirement of the provisional final storage conditions at the Konrad shaft, according to which neither a liquid nor molten waste product may leak out of a puck with thermal stress.

Binding of a puck into a concrete matrix

Determination of the altering of its geometric dimensions.

This test serves as proof that the waste product produced can be brought into contact with filling masses prepared with water, without impairing its stability.

Influence of the air humidity on the long-term stability of the waste product.

Storing of a puck at a defined temperature and air humidity. Determination of the weight change of the puck in relation to the alteration of its geometric dimensions.

This test serves to quantify characteristic sizes in connection with the long-term stability of waste products not cast in concrete.

CARRYING OUT THE TESTS AND THE RESULTS

Impact test

Three pucks were selected at random for this purpose and packed in a standard 200 l drum. The drum has a dead weight of 60 kg and authorization as Type A packing. A 20 mm thick steel plate on an asphalted surface was used as impact surface.

All three pucks withstood the fall from a height of 5 m with a max. velocity of 4 m/s, which simulated the stresses which a correspondingly designed packing would, according to definition, have to withstand, without any damage. No weighable amount of waste product was released from the puck.

Thermal stress

- Heating test

A puck was selected at random for this test. A furnace, normally used to heat welding electrodes, was used to carry out the test. This furnace has a temperature pre-selector adjustable up to 360°C and electrical heating capacity of 4 kw.

The heating test lasted 5 days. The puck was then taken out of the furnace and the actual temperature of the product was determined. It was established optically, that neither liquid nor molten waste product had leaked out.

The rated temperature of ≥300°C to be reached in the puck was therefore safely reached and proved.

Furthermore, a black coating was discovered on the puck. This was caused by pyrolysis gases which entered at the beginning of the heating phase and condensed. The complete pyrolysis of the waste product led to a weight loss of about 1/3.

- Flaming test

During this test, a puck lay on a grate over a 0.5 m^2 large fire tub, containing about 200 l light heating oil. The puck flamed over a period of 70 min. During the whole period of the test, about 30 l heating oil were used. This corresponds to a heat release of 753 MJ. Assuming that 30 % of the released amount of heat contributes to heating of the puck, this results in a heat quantity of 226 MJ or 63 kwh.

The visual check of the puck after completion of the test showed that no molten waste product was discharged. The puck withstood the temperature loads of the fire in spite of additional loads due to the internal pressure building up.

The cause of the pressure build-up was the pyrolytic decomposition of the resin. Due to the unfavourable heat conductivity of the resins, the side turned towards the fire was pyrolyzed. The weight loss of the puck was therefore also only 7 %.

Binding into concrete matrix

The puck which was used for this test was put into a mould in which the ratio of waste volume to binding agent volume, which could be expected in the final storage drum, was simulated. Group 3 mortar (DIN 1053) was selected to bind in the puck. Portland cement PZ 35 F (DN 1164) was the binding agent. Sand (DIN 4226) was used as aggregate. Admixed materials such as flow improver, setting retarder and so on were not used. The water/cement ratio was 0:4.

The test result was: Binding in of the puck did not lead to a measurable increase in volume of the puck due to absorption of moisture from the grouting mould.

Air humidity test

TÜV Hessen was commissioned to carry out this test. During this test, 3 pucks were subjected in an environmental chamber to a temperature of 40°C ± 2°C and an air humidity of more than 98 % (without dewing) for a period of 2 weeks. The absolute humidity content of the air amounts to about 51 g/m^3.

Before, during and after the test, the dimensions of the puck were determined by a dial gauge and the weight of the puck was recorded.

The parameters established regarding temperature and air humidity were selected to provide enough evidence for all storage conditions which could realistically be expected.

The test took place in the period from 12.06.89 to 26.06.89. The 3 pucks were subjected to a zero measurement at 20°C to determine the change in condition.

A coordinate grid was fixed at the front sides of the puck cylinder and the height of the pucks and an average puck height were thus defined. The change in this, the change in weight and in circumference were determined throughout the test period.

The result is that an absolute change in the height is a maximum of 1.4 mm, the change in circumference a maximum of 5 mm and the change in the weight a maximum of 40 g and that the percentage changes thus lie below 1 % and to a certain extent clearly so.

Moreover it is clear that a standstill of all documented parameters is plainly registered towards the end of the test.

SUMMARY

The aim of the tests carried out in the course of this program was to gather evidence with regard to the physical stability of the waste product produced. The demands thereby made of the waste product are determined on the one hand by the provisional final storage conditions at the Konrad shaft, Version 2/87 and on the other hand by the technical acceptance conditions of the federal intermediate storage facility at the Gorleben site as well as the approval at the basis of these acceptance conditions.

The influence of heat with regard to Konrad and of moisture with regard to Gorleben were of particular interest regarding the physical stability.

The test results referring to the influence of heat showed that no liquid or molten materials were discharged from the waste product, that is from the puck containing the compacted resin. This is positive proof that the waste product can be classified in accordance with the provisional final storage conditions at the KONRAD shaft in Germany.

It was proved that, when the possibility of moisture entering is limited, such as is guaranteed for example by the casing with the cartridge, practically no geometric alterations occur. The tests also showed that the waste product can be bound into a concrete mould without this having any consequences for the waste product.

Proof of the long-term stability of the product can therefore be considered to have been furnished.

SCOPE

The demonstration campaign using this new process was carried out from February to April 1990 in the Philippsburg power plant, Germany. About 11m^3 pre-dried resins (average moisture content 10-15 % by weight, corresponding to about 5000 kg) were conditioned to comply with final storage requirements and the volume was reduced by about a factor of 3.

After this successful demonstration, the prototype of the resin container was improved upon and it was subjected to testing. The first commercial plant will be available in 1991. The throughput has been increased once again, e.g. powder resins with about 60 % moisture content max. 1 hour.

In 1990 general approval was given for storage of this waste product at the federal intermediate storage facility in Gorleben.