Drying and Pelletizing of Nuclear Power Plant Radioactive Wastes

Makoto Kikuchi[a], Koichi Chino[a], Takao Koyama[a], Tetsuo Ito[a], Hideo Yusa[a], Susumu Horiuchi[b], and Masaru Hayashi[c]

INTRODUCTION

The radioactive wastes generated in a light water reactor, as liquid and slurry forms, are concentrated waste, spent resin, filter sludge, and miscellaneous solid wastes. In Japan, most of these wastes have been packaged in drums and stored on site, since a final disposal method has not yet been decided. Increasing amounts of radioactive wastes have necessitated extensive efforts to treat these wastes to further minimize final volume.

To cope with this situation, Hitachi Ltd, and Tokyo Electric Power Company have jointly developed a drying and pelletizing technique with which the waste can be remarkably reduced in volume and stored in such a flexible form that it can be processed by any future disposal method. The first plant designed for processing the concentrated waste was adapted for Fukushima No.1 Nuclear Power Station and is now under construction.[1]

Our initial drying and pelletizing technique was further developed to treat spent resin, filter sludge, incineration ash, and other slurry wastes.[2,3]

a Energy Research Laboratory, Hitachi, Ltd.
1168 Moriyamacho, Hitachi, Ibaraki 319-12, JAPAN
b Hitachi Works, Hitachi, Ltd.
3-1-1 Saiwaicho, Hitachi, Ibaraki 317
c Tokyo Electric Power Co.
1-1-3 Uchisaiwaicho, Chiyoda,
Tokyo 100

OUTLINE OF THE SYSTEM

Fundamental processes in the drying and pelletizing system are shown in Fig. 1. The wastes are transformed into dried powder by evaporation, pelletized to the pellet form and then, conveyed to the storage tank for interim storage. At disposal to be carried out in the future, the stored pellets will be removed from the storage tank and immobilized in drums by a proper method. The interim storage process serves to reduce the specific activity of the wastes, thus maximizing the waste content in the drum at the same surface dose rate. If the specific activity is low, the pellet can be directly immobliized.

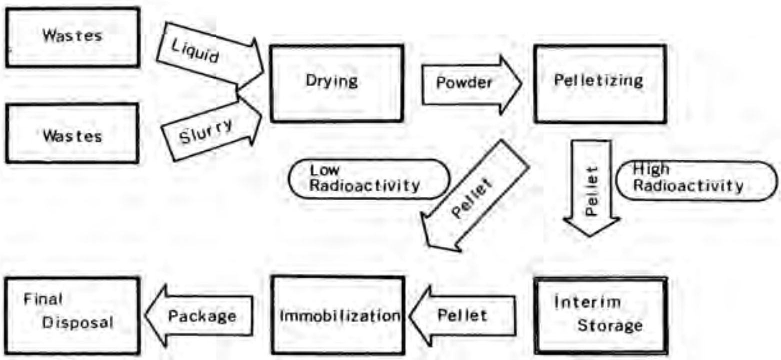


Fig. 1 Fundamental Process Scheme of Drying and Pelletizing System

A schematic diagram of the drying and pelletizing system is shown in Fig. 2. The system consists mainly of the following four processes:

(1) Drying process

The wastes in the feed tank are transformed into dried powder by the thin film evaporator (Fig.3 (a)). The optimum operating conditions of the evaporator to keep moisture content under a specified level are automatically controlled.

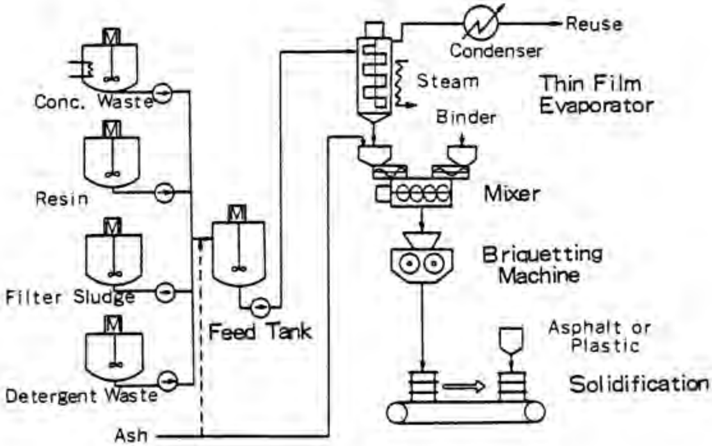
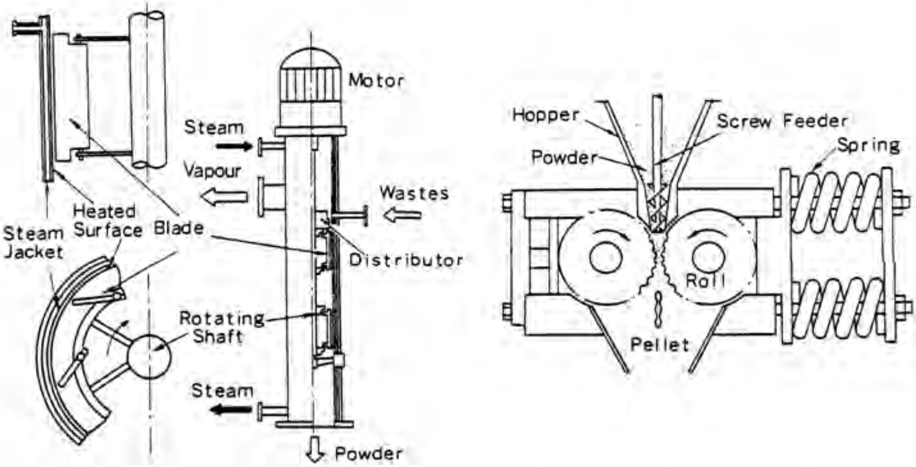


Fig. 2 Schematic Diagram of Drying and Pelletizing System



(a) Thin Film Evaporator (b) Briquetting Machine

Fig. 3 Schematic Diagram of Evaporator and Pelletizer

Table 1 Comparison of Volume Reduction Factor (V.F.)

Waste	V.F. (Compared with Raw Waste)	V.F. (Compared with Cement Solidification)
Conc. Waste	1/52	1/8
Powder Resin	1/35	1/4
Bead Resin	1/2	1/4
Filter Sludge	1/5	1/6

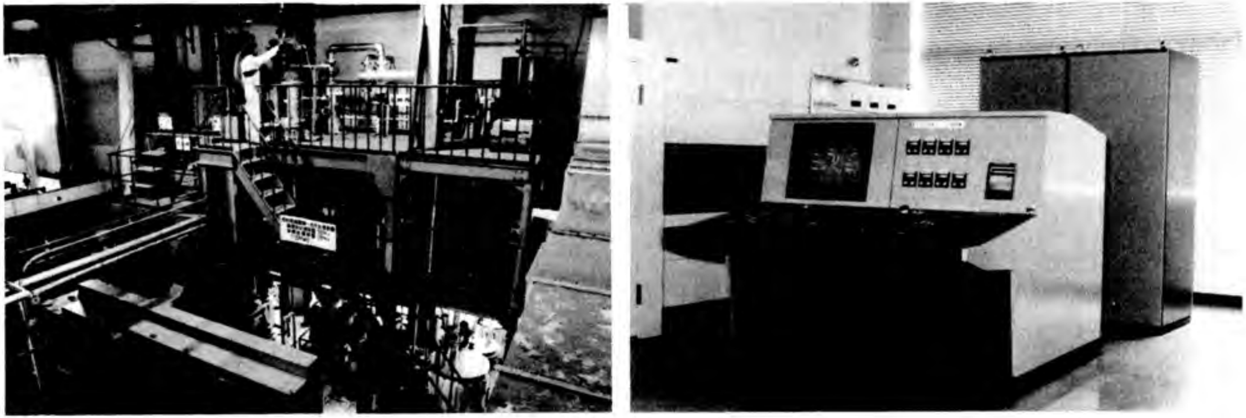
In order to prepare for the final disposal system which will be put into practice in the future, the waste is kept in interim storage in such a form that it can be disposed of by any method available in the future. When the solid waste is disposable or the waste has a low radioactivity concentration, it can be solidified immediately after pelletizing without going through the storage process.

PILOT PLANT

Figure 4 shows an outer view of the full scale pilot plant. The pilot plant has a remote control console for automated computer operation.

Drying and Pelletizing

Typical drying characteristics of the thin film evaporater are shown in Fig. 5. Powdered ion exchange resin and concentrated waste (main component: Na_2SO_4, 20 wt%) were selected since they are the two main wastes in a BWR plant. The reason for higher



(a) Drying and Pelletizing Unit

(b) Remote Operating Console

Fig. 4 Full Scale Pilot Plant

moisture content in resin (5 - 7 wt%) than in concentrated waste (less than 1 wt%) is due to the fact that water was absorbed into the resin micropores. In the case of mixed waste, moisture content was an approximately weighted average of resin and concentrated waste, indicating that mixed wastes drying was the result of no one particular phenomenon.

The production of firm pellets is important to prevent dispersion of the powder during the packing process and deterioration of the pellets during storage. Ion exchange resin is the most difficult waste to pelletize by a briquetting machine due to its elasticity. A small amount of organic binder, up to 20 wt%, is added to the waste containing ion exchange resin. In the case of concentrated waste, the density and compressive strength of the pellet are about 2.4 g/cm^3 and above 50 kg/pellet, respectively.

The changes in quality and firmness of the pellet during interim storage, in particular, due to moisture absorption from the environment, would lead to dispersion of radioactive powder and corrosion of the container. In order to evaluate the pellet deterioration, fundamental experiments of effects of humidity and temperature cycles, and γ-ray exposure were carried out. Long term storage experiments on concentrated waste pellet showed that moisture content and compressive strength were fairy constant during a four year period, i.e. below 2 % and above 100 kg/pellet.[1,2]

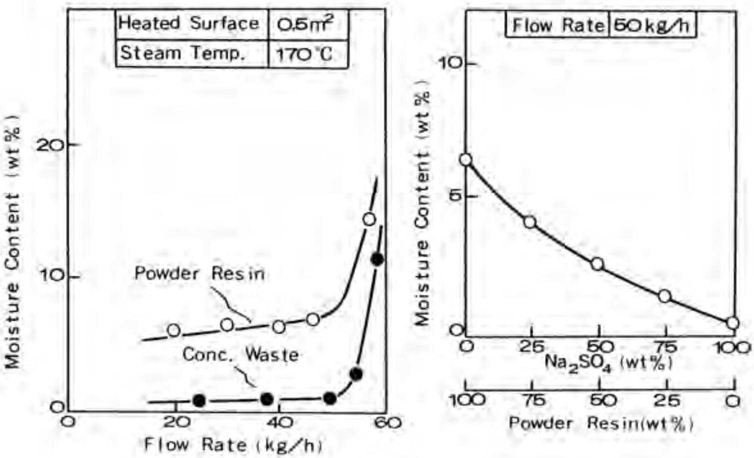


Fig. 5 Drying Characteristics of the Evaporator

Such moisture content control is one of the outstanding features of this system and essential to production of hard pellets. The vapour from the evaporator is condensed and reused after further purification.

(2) Pelletizing process

Powder, with less than the specified moisture content, is formed into almond-shaped pellets by means of a briquetting type pelletizer (Fig.3 (b)). A small quantity of binder is added, if necessary, to the powder to produce pellets of the desired strength.

(3) Storing process

In order to maintain proper quality levels of pellets during interim storage, the relative humidity in the storage tank should be kept low depending upon the pellet composition.

(4) Immobilization process

The pellets can be immobilized with such fixing agents as bitumen or plastic depending upon the best method to be determined in the future.

Should not be indented as it applies to the general text.

FEATURES

The most outstanding features of the drying and pelletizing system are:

(1) significant volume reduction;

(2) safe storage of the wastes, as a stable solid, in the plant; and

(3) flexibility regarding the final disposal.

Table 1 shows the volume reduction capacity of the drying and pelletizing method as applied to various kinds of wastes.

When the drying and pelletizing method is applied to the concentrated waste, and waste volume is reduced to about 1/8 of that produced by a cement solidification method.

Remote Control

Figure 6 shows the software configuration for the control system, which consists of a remote control console and two sub controllers installed in the drying pelletizing unit. The two important points for the operating control system are to keep the moisture content of the powder under the specified level and to produce the pellet with a certain compressive strength. In the remote control console, the operating conditions such as feed rate and roll speed of the briquetting machine are determined based on the estimation of powdering conditions and pellet strength. This information is tranferred to the sub controllers by optical fiber, and the parameters such as wastes mixing ratio and amount of binder are controlled. Important information is displayed on the color CRT, thus the operator can easily understand the system performance.

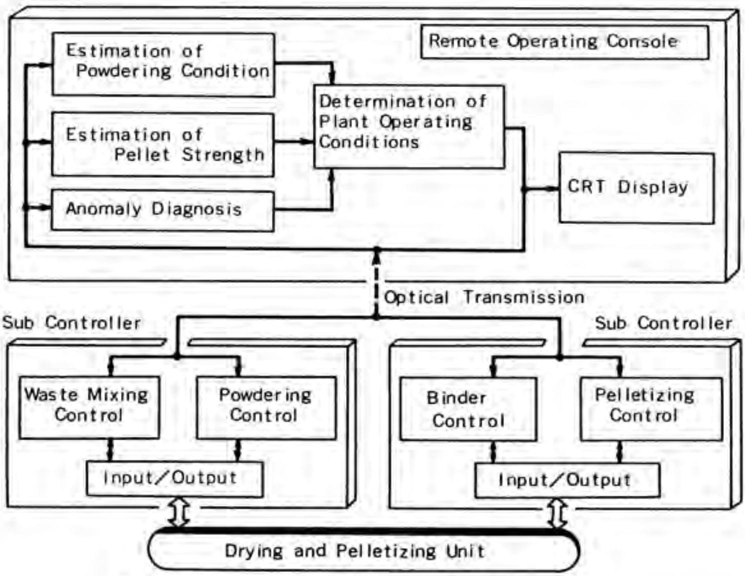


Fig. 6 Software Configuration of Control System

Immobilization of Pellets

The package shape for the final disposal and a flow diagram of plastic solidification using thermosetting resin are shown in Fig. 7.

The unique feature of the package is that the pellets are contained in an inner mesh basket and that a layer of about 1 cm thickness is formed between pellets and the drum by a solidifying agent such as plastic or bitumen. This uniform layer prevents swelling and leaching of radioactive materials into the ocean. This swelling, resulting in an increase of leaching rate was a problem in the conventional monolythic package, particularly when the Na_2SO_4 waste content was high.

Plastic solidification can easily be carried out. Measured amounts of plastic monomer and catalyst are transfered to a measuring tank and the necessary amount of plastic is pored into the drum containing the pellets. The amount of plastic fed is accurately measured by both the leveler and load cell, and thus overflow can be prevented. Since this system does not require mixing of plastic with radioactive waste, it is much simpler than previous systems in such points as off-gas treatment and maintenance.

In order to examine the suitability of the pellet package for sea disposal, two hydrostatic pressure tests were carried out under deep sea conditions. One test involved a leaching test using a full size package at the Japan Atomic Energy Research Institute (JAERI). The ^{134}Cs was used as a tracer and the experimental couditions were a pressure of 500 kg/cm^2 and temperature of 2°C. A lower leaching ratio, i.e. about 5×10^{-7} for a pellet bitumen package, was obtained as compared with previously reported results for other package.[2]

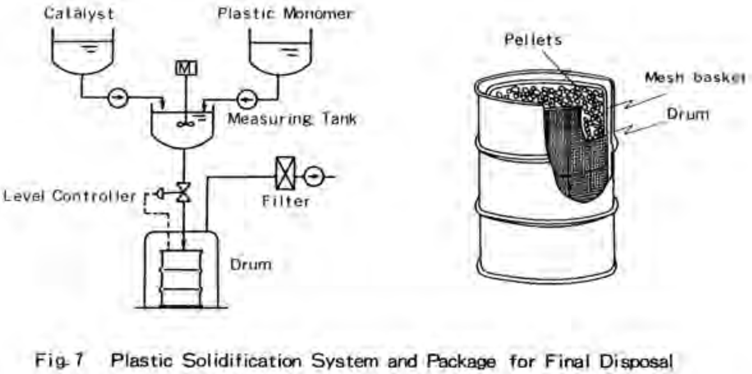


Fig. 7 Plastic Solidification System and Package for Final Disposal

CONCLUSION

A radioactive waste volume reduction system, a drying and pelletizing system, was developed. The new system is superior to previous methods employed in terms of volume reduction, safe storage of the wastes and its flexibility regarding the final disposal.

The system consists of a thin film evaporator for the direct solidification of waste, a pelletizer for producing hard pellets from the powdered waste, a pellet storage unit, and an immobilization unit for the final disposal. Tests using a full scale pilot plant showed the waste volume reduced to 1/8 as compared with cement solidification.

ACKNOWLEDGEMENTS

The authours wish to thank Dr. A. Ito of JAERI and their respective coworkers for conducting high pressure tests. The authors also express their appreciation to Messers A. Oda and H. Miura for pilot plant experimunts and to Professor K. Kudo of Hokkaido University for valuable discussions.

REFERENCES

1. M. Kikuchi, et al. "A Nuclear Power Plant Liquid Waste Solidification System", ANS Topical Meeting "Waste Management '81", P. 547, Tucson, Arizona (1981).

2. S. Horiuchi, et al. "Development of Drying and Pelletizing Technique for Radioactive Waste", IAEA Seminar on the Management of Radioactive Waste from Nuclear Power Plant. IAEA-SR 57/16, Karlsruhe, (1981).

3. K. Chino, et al. "Radioactive Wastes Volume Reduction System", ANS Winter Meeting, San Francisco, California (1981).