MANAGEMENT OF INTERMEDIATE LEVEL LIQUID WASTE

Problems and Solutions

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ABSTRACT

Intermediate Level Radioactive Liquid Waste (ILW) generated during reprocessing of spent fuel is stored for decades in underground tanks. The ILW is alkaline in nature and contains a high concentration of inactive salts, dissolved organics and ^{137}Cs as the major radioactivity contributors. This ILW is treated using a Cs-selective ion exchange process employing indigenously developed Resorcinol Formaldehyde (RF) resin. The process partitions the ILW into two streams, viz., a high-level caesium-rich eluate stream and a low-level effluent stream. The Cs-rich eluate is concentrated and immobilized in a vitreous matrix. The low-level effluents are managed by various treatment methodologies involving industrially usable precipitants. The process has been adopted for industrial scale treatment of legacy ILW, and more than 2000 m^3 of waste has been treated successfully. An ILW Treatment Plant has been established in Trombay. Based on this feedback, a similar facility is now commissioned at Kalpakkam for the effective management of ILW.

KEYWORDS: Intermediate level liquid waste, Cs-specific resin, Degraded solvent, Ion exchange.

THE Indian nuclear fuel cycle reprocesses spent fuel to recover valuable materials. The reprocessing plant generates various kinds of radioactive liquid wastes (Fig.1).

The major challenges associated with Indian historic ILW have been large volumes, high inactive salt loads, traces of other radio-contaminants, and problematic elements like aluminium. The radioactivity content is primarily contributed by Cs and traces of Ru, which depend on the decay period of spent fuels.

The acidic ILW emanating as the condensates of the evaporation of first cycle raffinates were neutralized and stored. This neutralization step was carried out to facilitate storage in carbon-steel tanks. In addition, Trombay had the unique problem of handling high aluminium concentrations in the ILW arising from the decladding activities. Components generated from degraded solvents of reprocessing also pose issues in treating ILW arising from PHWR spent fuels.

Process and Technology Development

During the initial phase of process selection, bituminization and cementation were considered for ILW treatment. Bituminization process has potential fire hazards and hence it was not explored further. Cementation process would have led to unacceptable consumption of limited Near Surface Disposal Facility (NSDF) space considering the voluminous inventory of legacy waste and factors leading to negative volume reduction. In contrast, the ion exchange offers a simple process for treating this ILW with high decontamination factor (DF) and appreciable volume reduction factor (VRF). Resorcinol Formaldehyde (RF) resin is known to be selective to Cs under these conditions, even in the presence of high concentrations of Na ions. This resin, as depicted in Fig.2, has an acceptable distribution coefficient yielding a good volume reduction factor, high selectivity producing necessary decontamination factor, regenerability allowing reduced secondary wastes generation and acceptable column usage properties enabling plant scale operation[1–2].

Using ion exchange process, ILW is partitioned into two streams, a Cs-rich eluate stream which is high level in nature and a low level effluent which qualifies for transfer to Effluent Treatment Plant (ETP)[3]. The process was deployed at plant scale initially at WIP, Tarapur. Later the process was also used at Trombay and Kalpakkam for the management of ILW.

Based on the above operational experience, a permanent facility named, Pump House Ion Exchange (PHIX) facility at Trombay, was designed for higher through puts. As an

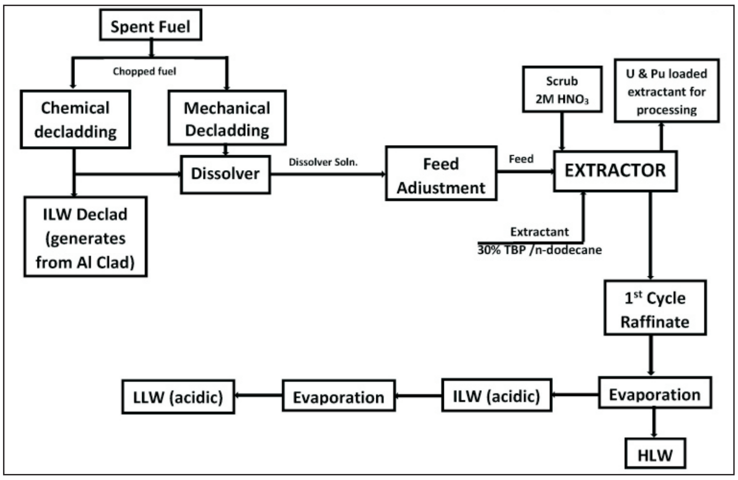

Fig.1: Typical flowscheme indicating the source of ILW.

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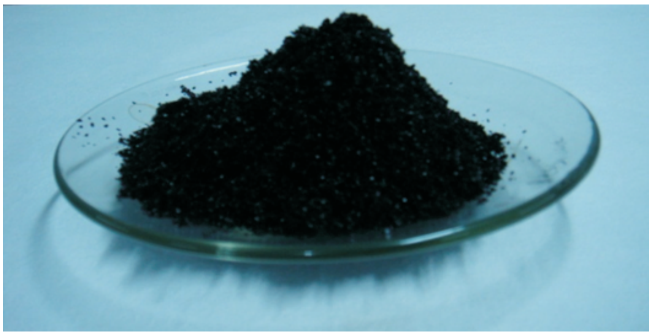

Fig.2: RFPR resin placed on a petridish.

improvement over the previous campaigns, the facility was extensively automated for remote process and column handling operations. Through a PLC-based system, the facility is controlled from a centralized control room. A typical process flowsheet followed for the campaign of ILW treatment and in-cell view of Ion Exchange System is shown in Fig.3 and Fig.4, respectively.

Presence of aluminium in declad waste has been a major challenge. The innovative step of managing downstream effluents containing aluminium was done by converting it into a stable, inert complex using a novel reagent. This addressed the challenges associated with Al- precipitation encountered during pH adjustments of downstream treatment and helped successfully manage Al-bearing legacy ILW.

Challenges in the Processing of ILW From PHWR Fuel Reprocessing

ILW generated during the reprocessing of PHWR fuel comprises two streams viz., the neutralized ILW arising from concentrating the second cycle raffinate stream and the Di Butyl Phosphate (DBP) bearing ILW generated during carbonate washes. These two streams are segregated at the source and stored in designated waste tank farms.

Organic-free ILW is subjected to mainly three processes *viz.* acidification, precipitation and settling, and ion-exchange. This process has a decontamination factor of 105-106.

The DBP-bearing ILW is generated due to radiolytic and hydrolytic damage of Tri Butyl Phosphate (TBP) deployed as a solvent in Plutonium Uranium Redox Extraction (PUREX) process. It has been proven that these degraded products have an affinity for specific metal ions like ^{95}Zr, ^{65}Nb and actinides.

At Kalpakkam & Tarapur, it has been observed that the presence of degradation products of TBP in ILW (5 g/L of DBP) create problem during carbonate killing step. DBP forms a sticky, difficult to handle yellow mass with uranyl ion during acidification. Some portion of the sticky mass tends to float on the solution surface while sticking to the wall of the reaction vessel[4]. This mass also picks up a significant portion of actinides and some amount of beta activity. Passing this type of waste through the present ILW treatment plant without destruction of DBP leads to choking of pre-filter & ion exchange columns, thereby affecting the processing capacity of the plant.

Oxidative degradation of DBP in the ILW stream using Advanced Oxidation Process (AOP) is presently being carried out with ozone and hydrogen peroxide prior to carbonate killing on an industrial scale. The destruction of DBP in the ILW stream makes the waste amenable to conventional treatment schemes.

Operating Experience and Improvement

At Trombay, the ILW treatment facility operates an average processing rate of 100-120 m^3 per month. The overall volume reduction factor of 85 was obtained with respect to eluate volume. This Cs-rich eluate is immobilized in a vitreous matrix yielding much higher overall VRF. Cs decontamination factor in the range of 1000-3000 is obtained. At all the sites, ILW processing adopting this general philosophy of partitioning using highly selective indigenously prepared organic resins with component-specific pre or post-treatment has enabled effective management of ILW.

Conclusions

A permanent facility has been established at the Pump House building of WIP Trombay to treat legacy ILW stored at the reprocessing plant. The robustness and reliability of the process and its systems have been demonstrated for remote operations. A high plant throughput, more than 100 m^3 per month, is achievable by these facilities. Ion exchange processes using these resins are also being implemented for the treatment of other alkaline waste streams.

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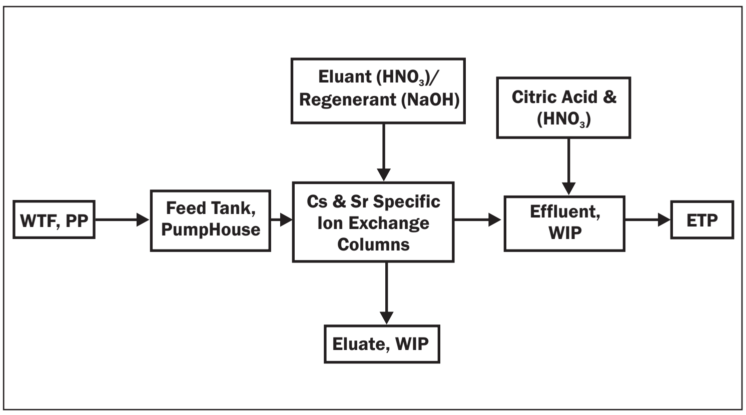

Fig.3: Typical flow scheme indicating the source of ILW.

Fig.4: Incell view of Ion Exchange system.

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