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SODIUM CLEANING AND DISPOSAL METHODS IN EXPERIMENTAL FACILITIES

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Abstract

At Indira Gandhi Centre for Atomic Research, major sodium facilities are designed and operated at Engineering Development Group as a part of development programme towards experimental and Prototype Fast Reactor. After the test programme many equipments and components were removed from the sodium facilities and sodium removal and disposal was carried out. The experience gained in different cleaning methods and waste sodium disposal are discussed.

INTRODUCTION:

At Indira Gandhi Centre for Atomic Research, major sodium facilities are designed and operated at Engineering Development Group as a part of development programme towards experimental and Prototype Fast Reactor. On completion of experiments, the sodium facilities were dismantled and the piping, components etc. were taken up for sodium removal and cleaning. The experience gained over these years in different cleaning methods adopted for components, waste sodium accumulated and its disposal method are discussed.

The following are the major experimental facilities dismantled over the years.

1. Sodium purification facility for FBTR
2. Flow meter calibration loop
3. Dummy fuel pin test loop
4. Experimental setups for testing mechanisms, bellows etc.
5. 500 kW sodium loop for heat transfer components (still in service).

SODIUM PURIFICATION FACILITY:

About 150 t of sodium required for FBTR was processed in a separate purification facility. Since the Indian Manufacturers could not supply the sodium in tankers in those days, they were received as dry bricks (without paraffin coating) of 16 kg each. During storage in gasketed drums and during handling, the surface layer gets oxidized and the quantity of surface impurities were estimated as 1 % of the sodium processed. The purification process was carried out by melting the bricks in the melter tanks (2 nos, approximately 2.4 cu.m volume each). The molten sodium was transferred to another buffer tank (2 nos, 7 cu.m volume each) through two course filters kept in series. From the buffer tank, the sodium was transferred to one of the two 30 tonne capacity tanks through sintered stainless microfilters. The sodium in 30 tonne tank was further processed by cold trapping.

On completion of purification, the complete facility was dismantled. The buffer tank and the storage tanks were redeployed as such whereas the other components like melter tanks, coarse filters, microfilters and pipe lines were treated for sodium.

MELTER TANKS:

Large accumulation of impurities occurred in these tanks (Fig. 1). On melting sodium, three distinct layers were observed in these tanks, the non-wetted impurities as flakes and cakes floating at the top, the molten sodium in the middle and the impurities wetted by sodium settled down at the bottom.

The flakes at the top were removed when sodium was in solid condition and subsequently when sodium was in liquid condition at 135 C. A special bucket with lid was introduced inside the tank with special tools and the impurities were collected in the bucket. A continuous purge of Argon was maintained in the tank during this period. The impurities in the bucket were taken to the disposal yard and converted to sodium hydroxide by a fine spray of water. Major quantity of impurities were removed by this process.

The impurities settled at the bottom of the tanks were relatively less, hence these were removed once in every 30 tonnes of processed metal. First the sodium available in the tank was transferred to the extent possible. The thick pasty layer at the bottom of the tank was also removed in a way similar to that of flakes. But the removal was carried out at a temperature of 135 C. These impurities were removed to the sodium disposal area in drums with a purging of Argon/Nitrogen in vented tanks. These impurities were disposed of partly by burning and partly by conversion to NaOH by a fine spray of water. During the whole process, the wastage of pure sodium metal that remained in the tanks were kept to a minimum.

At the end of the purification programme, the melter tanks were also cleaned by a fine spray of water after dismantling the flange available on the diameter of the tank. The tank was kept horizontal with a slope to enable easy draining. This assisted in smooth draining of reaction products.

COARSE FILTERS:

At the end of the purification process, six coarse filters (Fig. 2) were taken for disposal. Each filter contained 19 nos. of perforated tubes with SS wiremesh wound over them. The filters were mounted in the facility such that self draining was possible. Hence on removal from the facility, it was observed that these filters were not full of sodium, but impurities were remaining around the wiremesh. The filters were made of carbon steel and hence recovery was not attempted. The shell of the filter was cut by gas torch gradually, with a continuous purge of inert gas at a location shown in Fig. 2. On dismantling into two parts, they were cleaned by using a fine spray of water. Burning of sodium/impurities were allowed at few locations.

MICROFILTERS:

In this facility, one sintered stainless steel filter (Fig. 3) containing six filter elements was cleaned by alcohol (methylated spirit). By keeping the filter horizontally, alcohol was gradually added inside the microfilter shell. The temperature was monitored and purging with inert gas was also maintained. The temperature was not allowed to raise by more than 10 C. All the sodium and impurities were allowed to react in this way. Subsequently, the water content in alcohol was increased gradually upto 100 %. On completion of water wash, the filter was degreased and passivated. By following this process, the filter is available for reuse.

MECHANICAL PUMPS:

On many occasions, the sodium centrifugal pump (capacity: 100 cu.m/h)(Fig. 4) used in the 500 kW Sodium Loop was taken up for cleaning. Steam cleaning was used for such mechanical components. The pump was removed in a polyethylene hood at a temperature near melting point of sodium and was taken to the steam cleaning setup. Since the quantity of sodium adhering to the surfaces are quite small, steam was admitted after preheating the pump to 150 C. Steam mixed with Argon/Nitrogen was passed during the initial one hour of operation, and subsequently, steam was admitted fully. For easy dismantling of hydrostatic bearing sleeve and bolts, steam cleaning for long duration of more than 12 h was found necessary.

CONTROL ROD DRIVE MECHANISMS:

The lower part of CRDMs which were used in the test facilities to study its performance, were subjected to sodium removal. Its critical components are the two long welded type bellows amongst others. On one occasion, vacuum distillation was used and on other occasions, alcohol cleaning was followed. Both methods removed the sodium in the bellows. However, the vacuum distillation was not very effective due to fall of temperature of bellows on evaporation of sodium and due to back diffusion of oil vapours from vacuum pump.

OTHER COMPONENTS:

From the other experimental facilities components like electromagnetic pumps, electromagnetic flowmeters, SS bellow sealed valves and large quantity of piping were subjected to sodium removal operation and reused. In all these cases the major quantity of sodium was drained first and then alcohol cleaning was adopted. For draining sodium from e.m. pumps, the preheating voltage was applied with inert gas cover inside the pipes and on melting the sodium was drained. In other cases where the quantity of sodium is more, the component (valves, pipes etc.) were immersed in an oil bath at nearly 130 C and the bulk sodium drains down. Subsequently the component was treated with alcohol. Many such cleaned bellow sealed valves were reused. Only one 50 NB size bellow sealed valve failed recently on reuse. It failed in the initial stages of operation at nearly 350 C, probably due to caustic stress corrosion cracking.

DISPOSAL OF SODIUM:

The major quantity of sodium that were removed in the oil bath, or the sodium wastes collected from the purification facility were disposed off in a disposal yard located at a remote place near the back waters and away from the laboratories. The sodium was ignited by a fine spray of water and was allowed to burn. The residues were dissolved with a fine spray of water. The sodium hydroxide accumulated was treated separately.

SUMMARY:

The sodium cleaning methods adopted for the different components in the experimental facilities over the past two decades offered valuable experience. The information and confidence gained will assist in evolving better design of systems for sodium removal and sodium waste disposal.

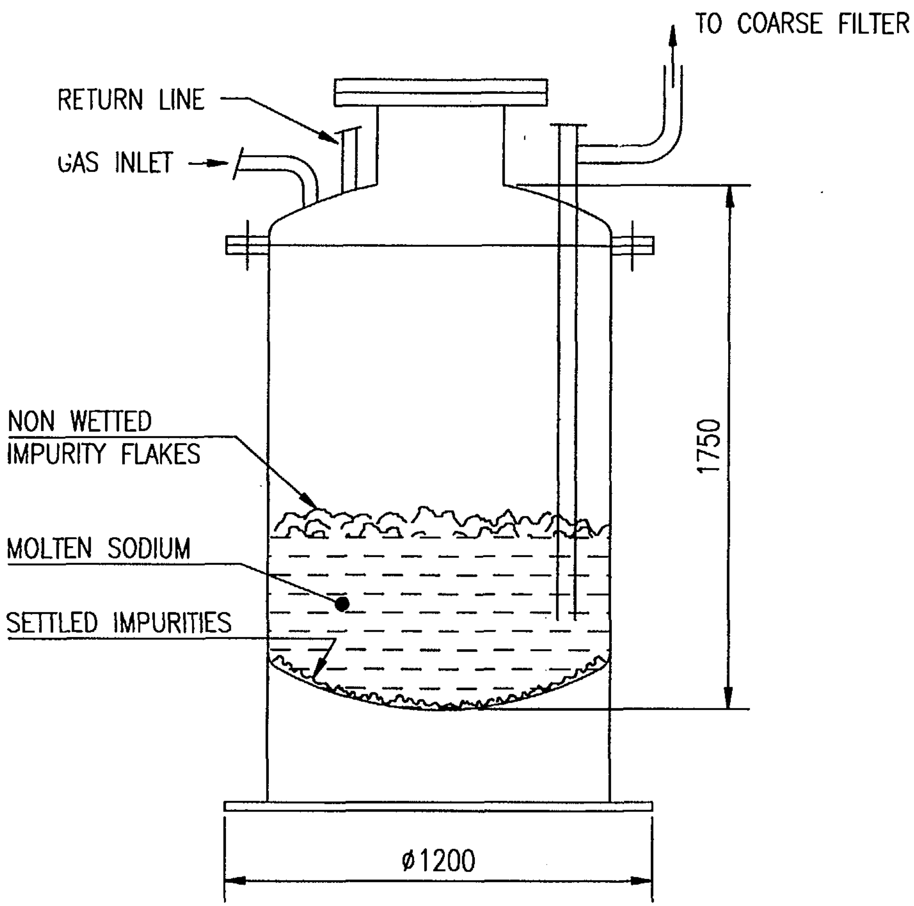

Fig. 1 MELTER TANK

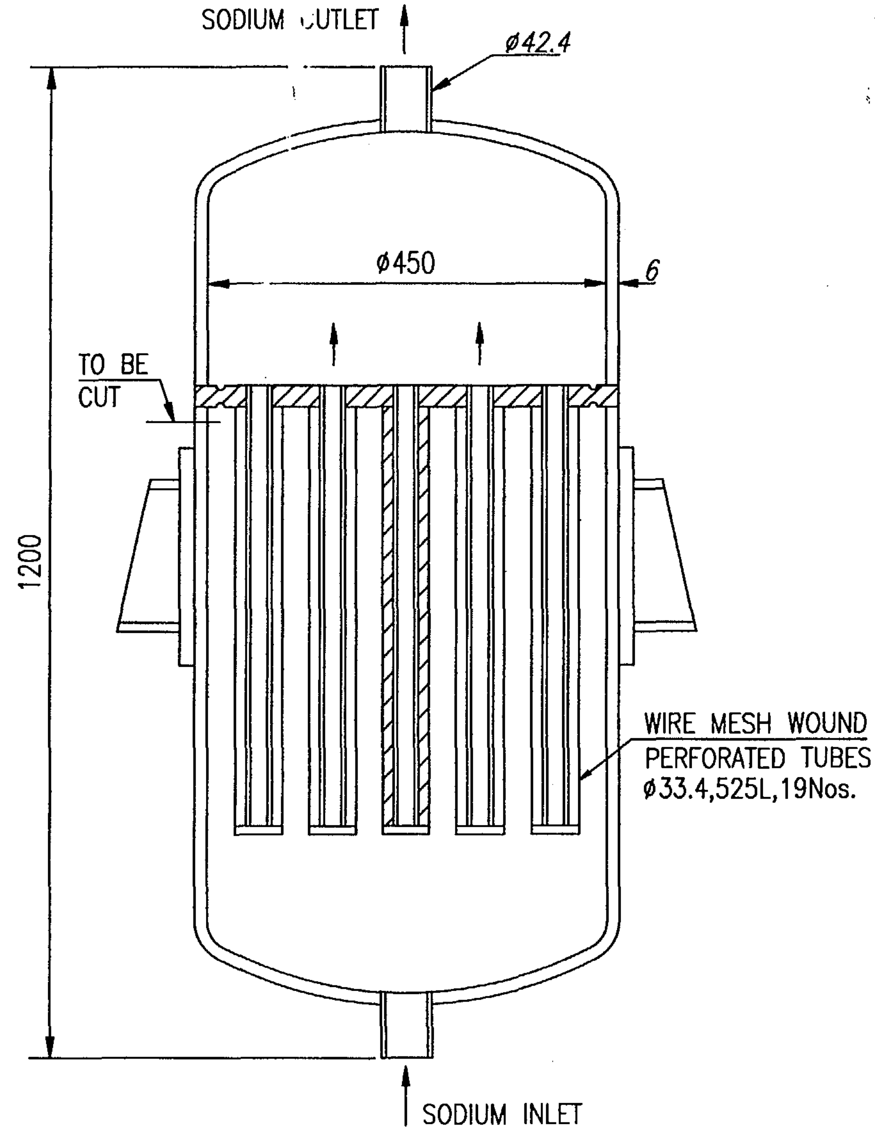

Fig. 2 COARSE FILTER

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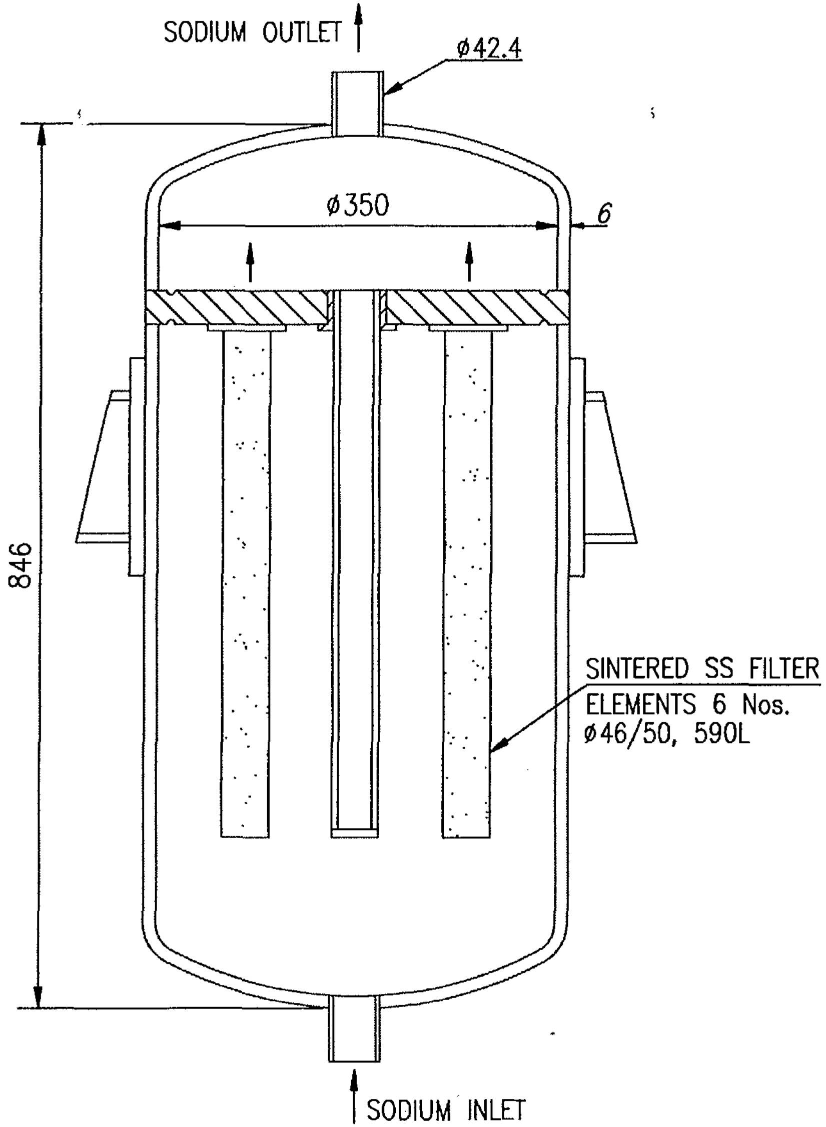
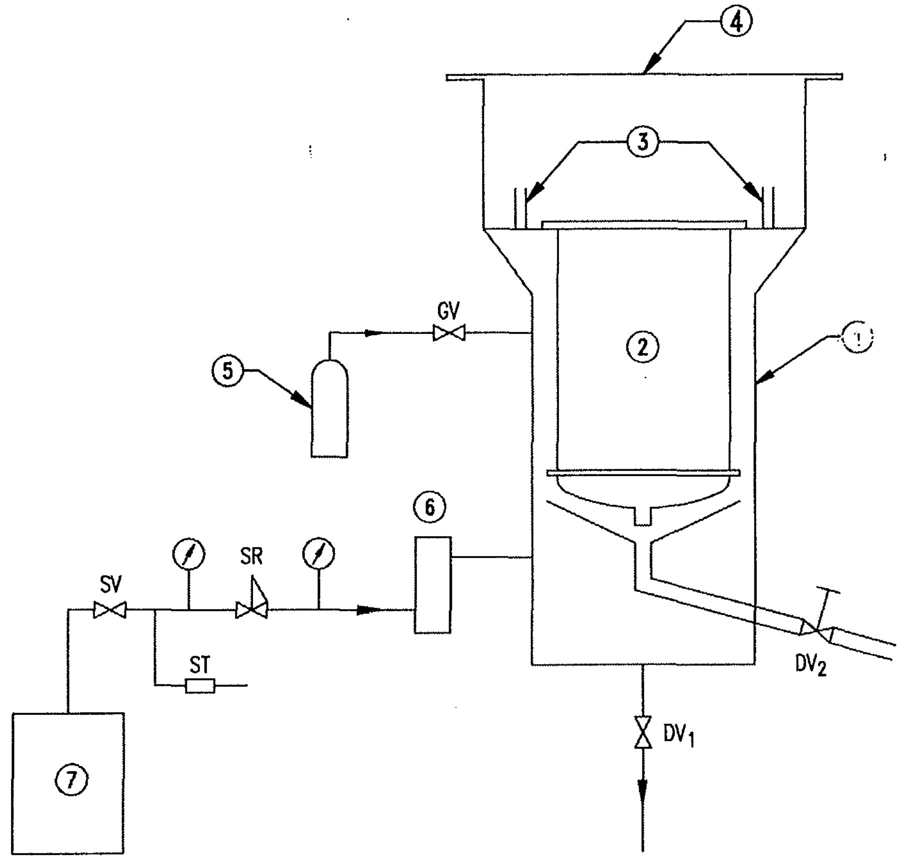


Fig. 3 FINE FILTER



1. CLEANING JACKET
2. SODIUM PUMP
3. VENT
4. TOP LID
5. NITROGEN
6. STEAM SEPERATOR
7. BOILER

SV – STEAM VALVE
ST – STEAM TRAP
SR – STEAM REGULATOR
GV – GAS VALVE
DV_1, DV_2 – DRAIN VALVES

FIG. 4 SODIUM PUMP DECONTAMINATION SET UP
(STEAM CLEANING METHOD)