

ENHANCING THROUGHPUT OF CONDENSATE POLISHING UNIT IN STAGE-IV OF NTPC VINDHYACHAL: A CASE STUDY

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ABSTRACT

Deep-bed condensate polishers

A deep-bed polisher is typically employed in applications requiring very pure condensate, where it's vital to remove every trace of contamination. They normally use a mixture of bead type strong acid cation resin and strong base anion resin. These are contained in service vessels which treat the condensate at a relatively high specific flow rate (high rate per m³ of resin) as the higher rates improve filtration and reduce the number of vessels and the amount of resin required.

This polisher contains a mixture of cation and anion resin beads in a bed about 3 to 4 feet deep. The resin mixture can consist of varying cation-to-anion resin ratios, depending on the amount of dissolved contaminants expected, with 2-to-1 and 1-to-1 resin ratios being the most common. Due to the large volume of resin present, the ion exchange capacity of this type of polisher is high; however, its filtering capability is limited. Large quantities of total suspended solids can cause plugging and high pressure drop issues in deep-bed condensate polishers. Filtered particles may also cause fouling of the resin, particularly the anion resin beads, and loss of polisher efficiency. When exhausted, the resin is generally transferred to external regeneration vessels for cleaning and regeneration. Usually a spare charge of resin is stored in one of the regeneration vessels to immediately replace the emptied vessels. At VSTPP St-IV CPU, the cation to anion ratio is 2:1

Proper regeneration of the condensate polishers is one of the key factor in maintaining and enhancing the performances of the condensate polishers. The paper describes various problems faced by the station while initial commissioning of the condensate polishers of its stage IV units, various measures undertaken to overcome the problems and steps taken to sustain the improved condensate polisher performances.

I. INTRODUCTION

Condensate polishers are resin-based ion exchange systems that are commonly used in power plant condensate systems to remove dissolved contaminants (Chlorides and Silica etc.) and suspended contaminants (iron or copper oxide particulates). Condensate polishers maintain cycle purity and efficiency by controlling the effects of corrosion transport, ingress of impurity through make up water, condenser cooling water leaks, and condenser air in-leakage. Polishers lessen the impact of chemistry problems and often allow a plant to continue operating with a minor condenser tube leak or air in-leakage problem that might otherwise require an immediate outage.

II. THEORY OF AMMONIUM FORM OPERATION

Ammonium Form Operation (AFO) has been known and used for over 30 yrs. It involves operating mixed or separate beds with the cation resin fully in the ammonium form so that the polishing plant ceases to remove ammonia. Thus ammonium form beds can remain in service for several months, in the absence of any condenser leak or other impurity ingress. The run time is usually determined by increase in pressure drop of the polished water or by operating experience. Full condensate protection is maintained with the ammonium form plant being capable of removing influent impurities should a condenser leak arise and continue to act as a filter to remove particulate impurities. This mode of operation is attractive for significant cost savings that it can achieve.

In an Ion exchange process the equilibrium is established between the concentration of an impurity in the water phase and that in the resin phase.

In condensate polishing applications employing mixed beds of cation resin in the H⁺ form and Anion resin in OH⁻ form (H-OH form beds), the H⁺ ion concentration is, ideally, reduced by the ion exchange process to that of pure water, i.e., 1x10⁻⁷ equivalents/litre.

It has been shown experimentally that water containing Sodium levels less than 2 ppt can be prepared by H-OH form polishing plants. Even lower levels of Sodium in water, below the current limits of analytical detection, are predicted by theory and possibly attained in practice.

In the case of Sodium exchange on H⁺ form cation resin, the effective equilibrium constant is the selectivity co-efficient. Anion exchange reaction is described in similar way. Reactions in H-OH form mixed beds, are driven almost to completion as the [H⁺] and [OH⁻] concentration are moved towards that of pure water, 1x10⁻⁷

Eq/l. Some condensate polishing plants operating in the H-OH form consistently yield water containing less than the current limit of detection of chloride, about 5 ppt.

There is however two major changes that effect the behaviour of ammonium form mixed bed making them significantly different to conventional H-OH form beds. In cation exchange, the very low $[H^+]$ term (1×10^{-7} eq/l) is replaced by an ammonium concentration which, at pH 9.6 is over two orders of magnitude higher (40×10^{-6} eq/l). Similarly, in anion exchange, the OH^- term in the equilibrium equation also increases from 1×10^{-7} eq/l to 40×10^{-6} eq/l. The effect of this is that the water phase concentration of sodium, $[Na^+]$, and chloride, $[Cl^-]$, have to increase to balance the equations. In brief, in ammonium form operation the impurity levels in polished water increase by several orders of magnitude relative to what they would have been if operating under neutral conditions.

The second change affects sodium exchange and the leakage behaviour of this impurity from resins operating in the ammonium form. The selectivity of a typical strongly acidic H^+ cation resin for sodium is about 2, i.e., the resin prefers sodium rather than the hydrogen ion. In contrast, the selectivity of an ammonium form cation resin for sodium is lower at about 0.75-0.9 so that the resin prefers the ammonium ion rather than the sodium ion. At equilibrium the low selectivity contribute to a higher sodium concentration in the water phase and hence higher levels of leakage of sodium. Anion exchange is however will governed by the same selectivity coefficient that control ion exchange in H-OH beds.

Hence, two factors, the water phase ammonium concentration and the ammonium/sodium selectivity of the cation resin, control the behaviour of sodium in beds operated in ammonium form operation. It is this leakage behaviour of sodium that dominates any consideration of ammonium form operation.

III. a) ADVANTAGES

Ammonium form operation has the advantage that condensate polishing beds, when running in this mode can operate for long periods provided condenser leaks start ups and shutdowns are absent thus reducing the operating cost. There has been report of running for 100 days.

b) DISADVANTAGES

The disadvantages of operating in the ammonium form compared to the conventional H-OH mode must be clearly understood by any user. They include the facts that : The levels of ionic impurities, such as sodium and chloride, in polished condensate from ion exchange beds operated in the ammonium form will always be higher than the levels of these impurities that could be obtained from the same resins if they were obtained in the conventional H-OH mode. To overcome this potentially high level of equilibrium leakage, it is necessary to regenerate resins intended for operation in the ammonium form to a far degree than resins intended for use in the conventional H-OH mode of operation. Ideally this requires the use of very effective separation procedures for the mixed beds together with additional, post regeneration, techniques for further purifying the resins. Resin beds intended for operation in the ammonium form are usually returned from regeneration and placed into service with cation resin in the H^+ form.

The cation resin is allowed to ammoniate in-service as this is the simplest way of achieving this state. Following the breakthrough of ammonia from the mixed bed there is, invariably, an increase in the level of sodium in the final polished water. These sodium levels can reach peak values of several ppb depending on the efficiency of regeneration of the resin and whether the bed has picked up sodium in service. The "sodium throw" in ammonia cycle generally peaks over a period of about five days with sodium levels in polished water then gradually falling over the next five to ten, or even more, days to a steady state value. As discussed earlier, the steady state level of sodium leakage under ammonium form conditions is two to three orders of magnitude higher than that seen in the earlier part of the service run when the CBD would be operating in the H-OH mode.

IV. RESIN CROSS- CONTAMINATION

Resin separation is the most important step in mixed bed regeneration. Improper separation leads to cross-contamination of the resin. Anion resin left in the cation resin regeneration vessel will be converted to the chloride form when exposed to hydrochloric acid during cation regeneration.

Likewise, cation resin in the anion regeneration vessel will be converted to the sodium form when exposed to caustic soda during anion regeneration. Cross- contamination of resins will lead to increased sodium and chloride leakage during the next service cycle and is the single most important contributor to leakage of ions from condensate polishing vessels. Thus resin cross contamination must be minimized.

With considerable care conventional mixed bed separation plants can achieve cross contamination levels of 1% cation in anion resin i.e., 1% of the apparent volume of the separated anion resin is, in fact, cation resin. With cation to anion resin ratio being 2:1, this cross-contamination means that 1% of the cation resin will be put into the sodium form. The cross contamination arises from several effects one of which can be incomplete separation owing to the presence of cation resin fines, i.e., fragments of broken resins and also small cation resin beads from the manufacturing process. Small cation resin beads or fragments will not have a sufficiently high falling speed to separate from the anion resin. These cation resin fines once formed are difficult to remove. Proprietary procedures base upon using high density i.e., high concentration reagents such as sodium hydroxide or less commonly ammonium sulphate can successfully remove them.

V. CPU AT VSTPP:

The 2x500MW station of NTPC Vindhyachal has deep bed type full flow Condensate polishing system supplied by M/S Driplex.

The condensate Polishing Plant consists of two sets of two units per set, each unit capable of 50% flow of 640 M³/Hr. The resin being used in the polishing units are:

Cation resin - Lewatit SP 112 H (Qty-3.54 M³)

Anion resin - Lewatit MP 500 CL (Qty- 2.36 M³)

These resins are selected for their physical strength when used with condensate for their resilience considering that they need to be removed from the service unit to be regenerated, as well as their performance qualities.

The function of resin is:

- to behave as a filter & remove all suspended solids from condensate.
- to preserve the quality of the condensate by removal of the dissolved solids.

The resin will be operated through from the hydrogen form into the ammoniated form. The plant is designed to operate for 50 hrs based on an additional influent load corresponding to 2000 ppb (TDS) on top of the normal analysis loading. During this period the sodium content will be limited to 2.0 ppb.

The resin beds are supported on a flat nozzle plates into which are fitted stainless steel nozzles. The incoming water is distributed over the resin bed by distributor inlets, and after passage through the resin bed is collected by the nozzle collecting system before being passed to the outlet.

The regeneration units are rubber-lined pressure vessels, each complete with a header and lateral distribution system for the regenerant chemical injection, which is located just above the resin bed. The resin is supported on an epoxy-bonded sand matrix in the anion unit (CONSEEP technology), into which is set a collection/distribution lateral system. This matrix retains the resin while allowing flow of air or liquid. Its open nature will also allow removal of fine particulate matter by the combined air scour/rinse down technique. The cation regeneration unit features an optimized dished nozzle-plate design with little or no solids removal required within this vessel, while still allowing free flow of fluid.

VI. Problems faced in Operation of CPU in recent past :

On an average, after throughput of approx 70000 M³, sodium levels at CPU outlet increased up to 2.5 ppb (as shown in fig-1). It further resulted in increase of boiler water pH. To maintain boiler water parameters, CPU was taken of service & fresh lot (regenerated resin) was taken in service. In brief, CPU throughput was restricted to an average of 70000 M³.

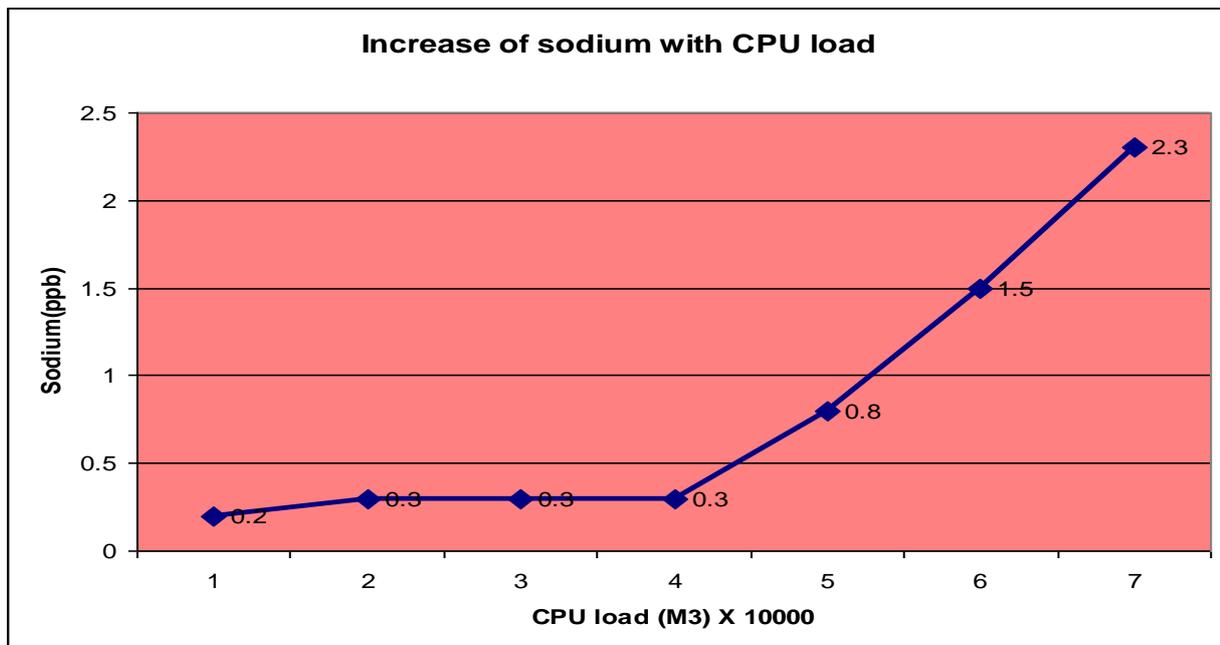


Fig: 1: increase of sodium value with CPU load.

VII. REMEDIAL MEASURES:

1. Avoid cross contamination.

During separation / transfer of cation resin from ARU to CRU prior to chemical dosing, there is every possibility of resin contamination. To avoid this, resins at the interface is being taken in IRU (of 500 L capacity) & remain in exhausted condition.

2. ABRO (air bump rinse out) in CRU instead of ARU.

During initial phase of commissioning at stage-IV, matrix provided at ARU was broken (fig-2). ARU vessel with complete assembly was sent to OEM's site for matrix replacement as well as design modification. (shown in fig 3) After recommissioning cleaning process was shortened in fear of further damage. With the help of site C&I the cleaning is now been done in CRU.



Fig-2: damaged matrix of ARU

3. Soaking during regeneration.

After chemical dosing, the resins are kept in soaking condition for at least 8 hrs.

4. Ensuring availability of air blower at vessel side.

Two nos of air blowers per unit are provided at service vessel. From the very beginning, the blowers could not run for desired duration. With the help of maintenance people, the problem was arrested & accordingly safety limit switch of all the blowers were replaced.

5. Operating CBD at CPU changeover.

It was made a practice to operate CBD during CPU changeover.

6. Resin top up

Undoubtedly the question will arise that higher Na at CPU outlet is because of lesser quantity of anion resin. Resin quantity of all 5 lots was checked & top up was done as per requirement.

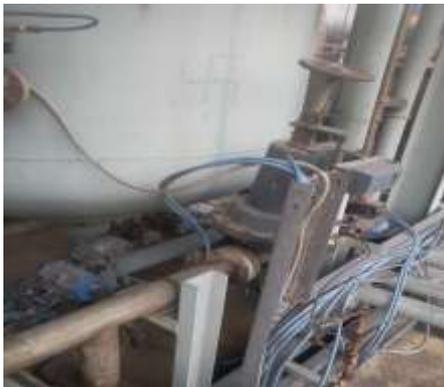


fig 3: Before & after modification. Flange was provided at ARU to hold the matrix.

VIII.RESULT & CONCLUSION:

The results obtained are depicted in fig-4 & fig-5. It is observed that avg monthly CPU throughput is now approx 120000 M3.

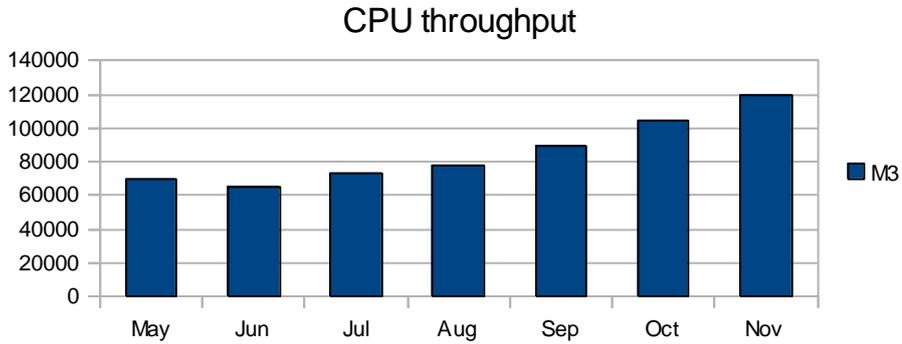


Fig 4: monthly average of CPU throughput.

The study will be very much helpful for other stations using same technology at CPU. In recent days, conesep technology is being provided at different power stations & already more than four cases have been reported so far of matrix damage.

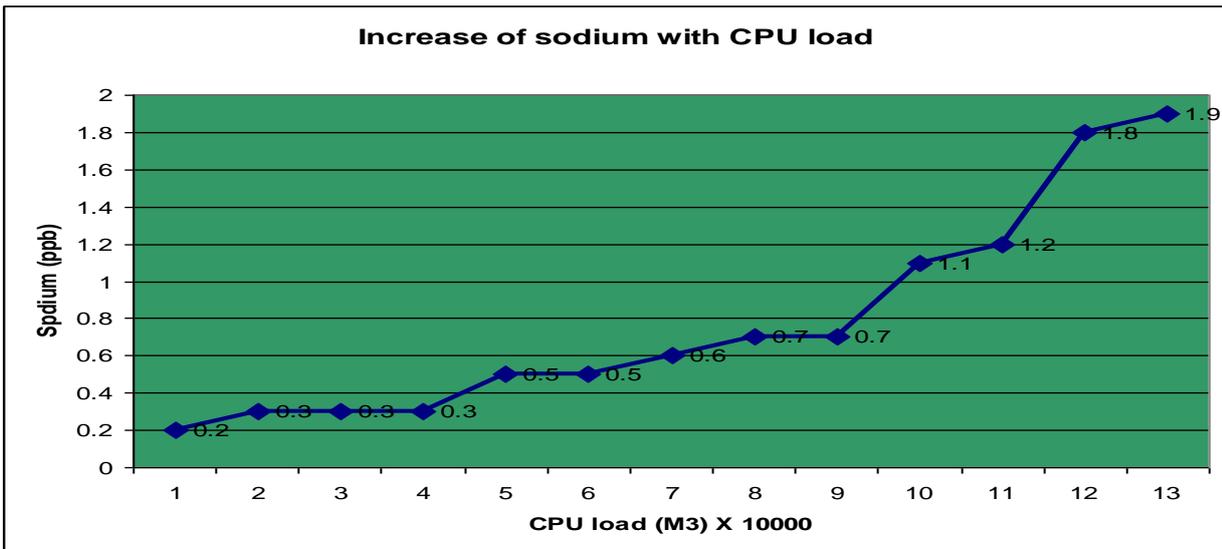


Fig-5: Sodium value at CPU O/L at different load

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3. Condensate polishing by G.J.Crits