Bottom-Up Improvement of the Boiler Feedwater System

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ABSTRACT

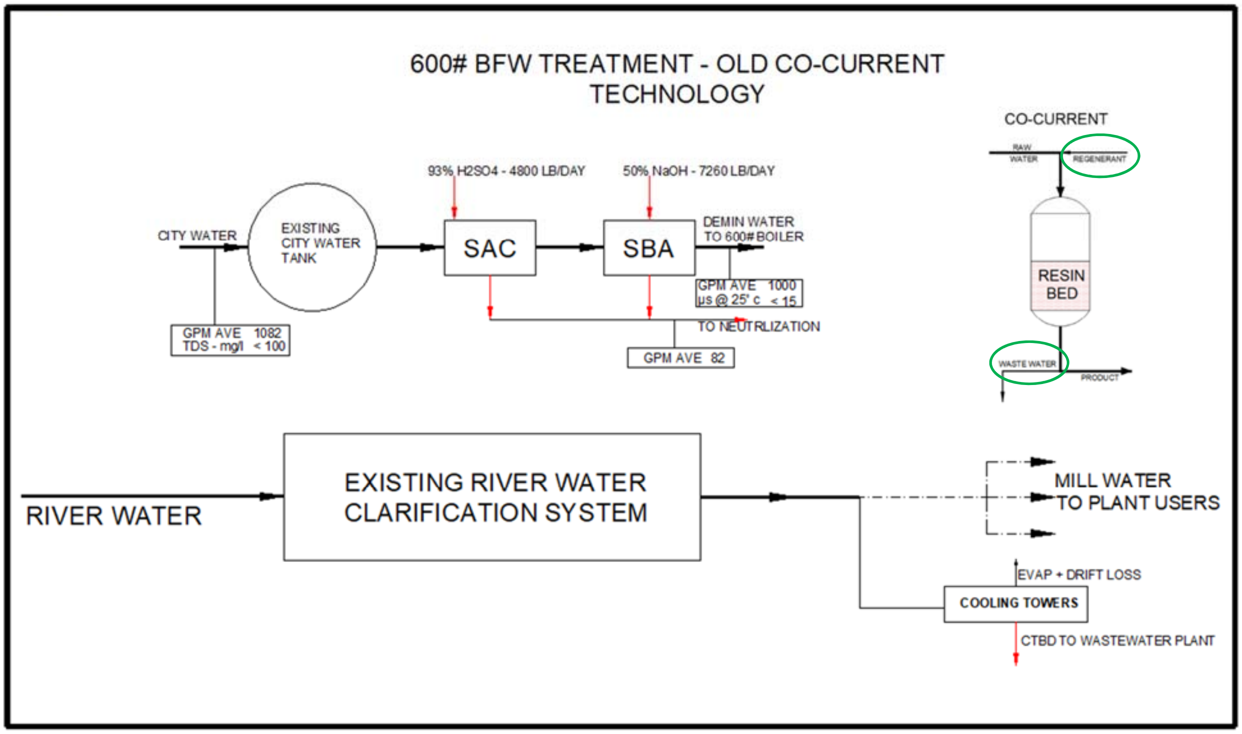
Traditional boiler water treatment has relied on clarifiers and ion exchange (IX) technologies to produce boiler-grade feedwater makeup. Some plants have chosen to use city water as source water for boiler feedwater demineralization. This paper reviews the efficient use of surface water and reusing cooling tower blowdown by pre-treating surface and waste waters with ultrafiltration and reverse osmosis (UF/RO) ahead of ion exchange to provide higher quality feedwater at lower cost with reduced effluent pollutants (sustainability) instead of just adding mixed ed ion exchange polishers.

A membrane system (UF/RO) as pretreatment of surface water provides high quality feed water to the IX units in terms of water clarity/TDS/TOC and low cost (surface and recycled source) water for DI water production. This high-quality feed water decreases the frequency of backwashes and brine squeezes on cation and anion resins, improving overall regeneration efficiency. Adding UF/RO pretreatment for existing ion exchange systems typically increases the throughput between regenerations by 5 to 10 times the previous throughput while utilizing the existing infrastructure; regen/chemical equipment and existing vessels.

INTRODUCTON

Integrated mills (paper and other) built in the 1950s, 1960s and 1970s and converting mills even after that generally included steam systems operating at or below 600 psig. Electric power generation was often not a priority in favor of mechanical drive steam turbines. As these mills modernize and upgrade steam systems, boiler water treatment must also be improved. Ion exchange alone is no longer the most cost-effective solution.

BASE AS EXISTING

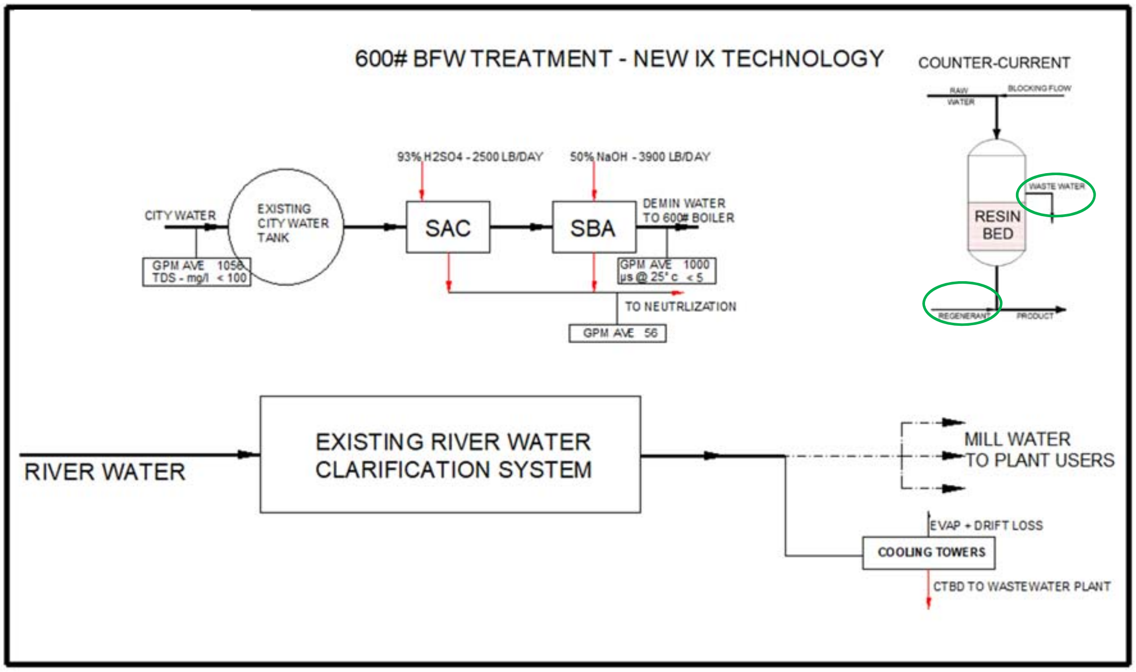


Older existing plants produce boiler feed water (BFW) with conventional ion exchange (IX) demineralization using co-current regeneration as primary technology. Co-current regeneration leaves the discharge-end resin inadequately clean, since the regeneration chemicals wash from inlet to outlet. These plants consume significant quantities of regeneration chemicals and generate a large amount of wastewater while delivering unstable water quality. Some of these plants use city water as primary source water for BFW, since it is generally low in suspended solids and color. The rest of the mill often uses well water or surface water (river/lake) with conventional clarification for process water and cooling tower makeup.

Table 1: - Typical – data for 1000 GPM production of DI Water for older plants using City Water

H_2SO_4 @ Bulk Concentration	lb/D	4800
NaOH @ Bulk Concentration	lb/D	7200
Demin Water Conductivity @ 25˚C	µS	< 15
City Water Consumption	GPM	1082
Effluent % of product		8.2%

MODERN DEMINERALIZERS



Converting demineralizer vessels from co-current to counter-current regeneration reduces chemical consumption, maintains consistent treated water quality and in most cases improved treated water quality. Feeding the regeneration chemicals from the outlet to the inlet puts the strongest chemistry on the resin beads that will be last in the on-line flow path. Fresh resin will be available to maintain product quality until the entire bed is spent. A more thorough discussion of co-current vs counter current regeneration is provided in a later section.

Table 2: - Typical – data for 1000 GPM production of DI Water after conversion

H_2SO_4 @ Bulk Concentration	lb/D	2500
NaOH @ Bulk Concentration	lb/D	3900
Demin Water Conductivity @ 25˚C	µS	< 5
City Water consumption	GPM	1056
Effluent % of product		5.6%

The conversion from co-current to a counter current configuration requires just pipe and valve changes. Typical pay back is less than 3 years with chemical savings and reduced maintenance.

MODERNIZATION FOR HP BOILERS

High pressure (> 1250#) boilers require DI (deionized, not just demineralized) water with conductivity of 0.1 µS or better. An existing makeup water demineralization system can be converted to produce water suitable for high pressure boilers by adding a mixed bed polisher (MB) at the product end (which could be directly piped, or additional pumps may be necessary) while keeping the DI product tanks and down-stream demin (now DI) transfer pump configurations intact.

A modern countercurrent ion exchange DI water system produces BETTER demineralized water conductivity (than Co-Current) feeding into the polishers to keep the MB polishers regeneration frequency down.

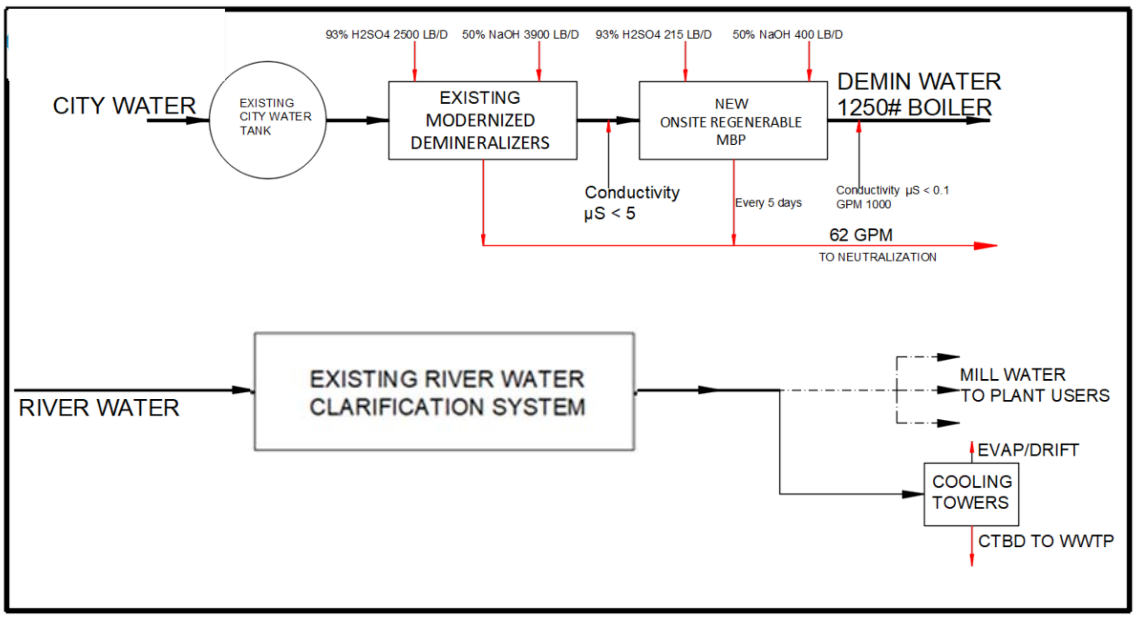


Table 3: - Typical – data for 1000 GPM production of DI Water for HP Boilers

H_2SO_4 @ Bulk Concentration	lb/D	2715
NaOH @ Bulk Concentration	lb/D	4300
Demin Water Conductivity @ 25˚C	µS	< 0.1
City Water consumption	GPM	1062
Effluent % of product		6.2%

Adding the MB polisher increases chemical and wastewater production by 10% using counter current IX demineralization for primary treatment. This can be as high as 20% effluent if co-current regeneration ion exchangers are used as primary treatment.

SURFACE WATER FOR HP BOILERS AND EXISTING DI SYSTEMS

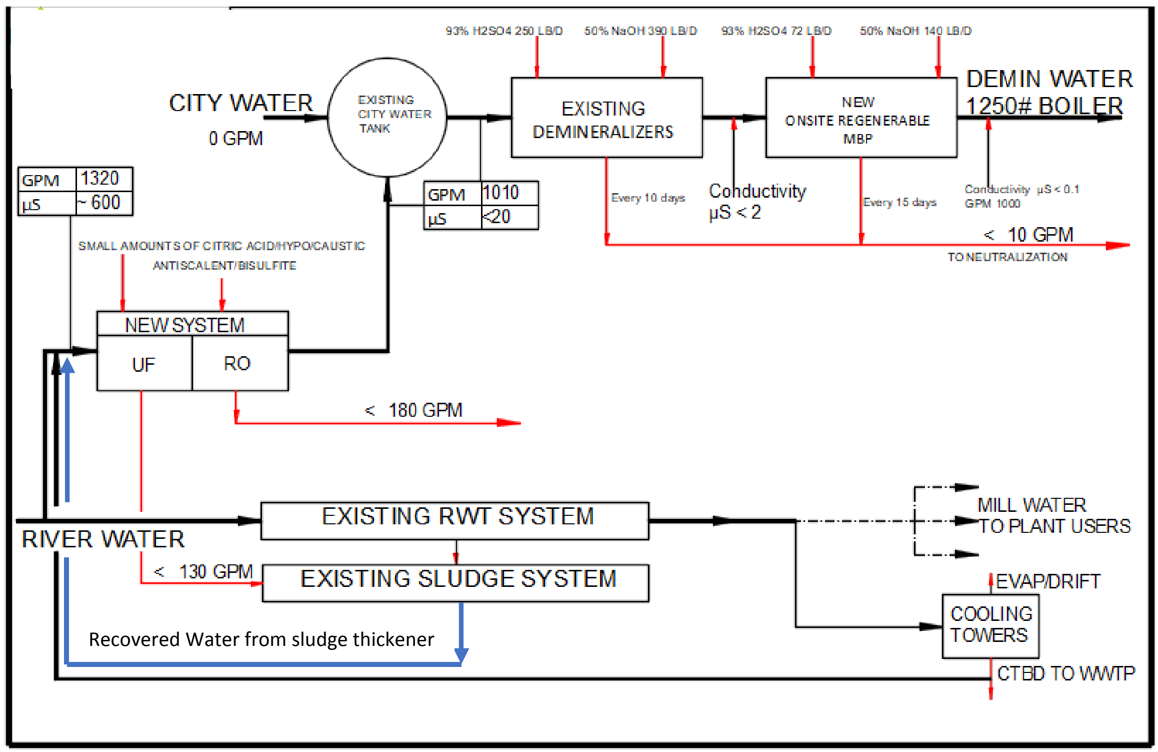


Table 4: - Typical – data for 1000 GPM production of DI Water from Surface water

H2SO4 @ Bulk Concentration	lb/D	322
NaOH @ Bulk Concentration	lb/D	530
Citric Acid @ Bulk Concentration	Lb/D	<5
Caustic (UF) @ Bulk Concentration	Lb/D	<10
Hypo @ Bulk Concentration	Lb/D	<50
Antiscalent @ Bulk Concentration	Lb/D	<100
Bi-Sulfite @ Bulk Concentration	Lb/D	<50
Demin Water Conductivity @ 25˚C	µS	< 0.1
City Water consumption	GPM	0
Effluent % of product*		32%

*including the RO and UF effluent. 19% with UF Reclaim.

City water comes at some unit commodity cost, while surface water is typically free for the pumping. It may be cost effective to displace city water with the same source of water as the rest of the mill.

With proper pre-treatment, the existing process water source (river/lake etc.) can displace city water for BFW makeup. An ultrafiltration/reverse osmosis (UF/RO) system can be added to the front end of the IX system to pre-treat surface water more effectively than a conventional clarifier.

Ultrafiltration primarily reduces particulate and organic loading of seasonally variable surface water. Reverse osmosis removes primarily dissolved inorganic salts. Neither process requires significant chemical additives.

The pretreated product water can be sent to the existing demineralization infrastructure to produce purer DI water than was achievable with city water.

Several benefits of pretreatment include:

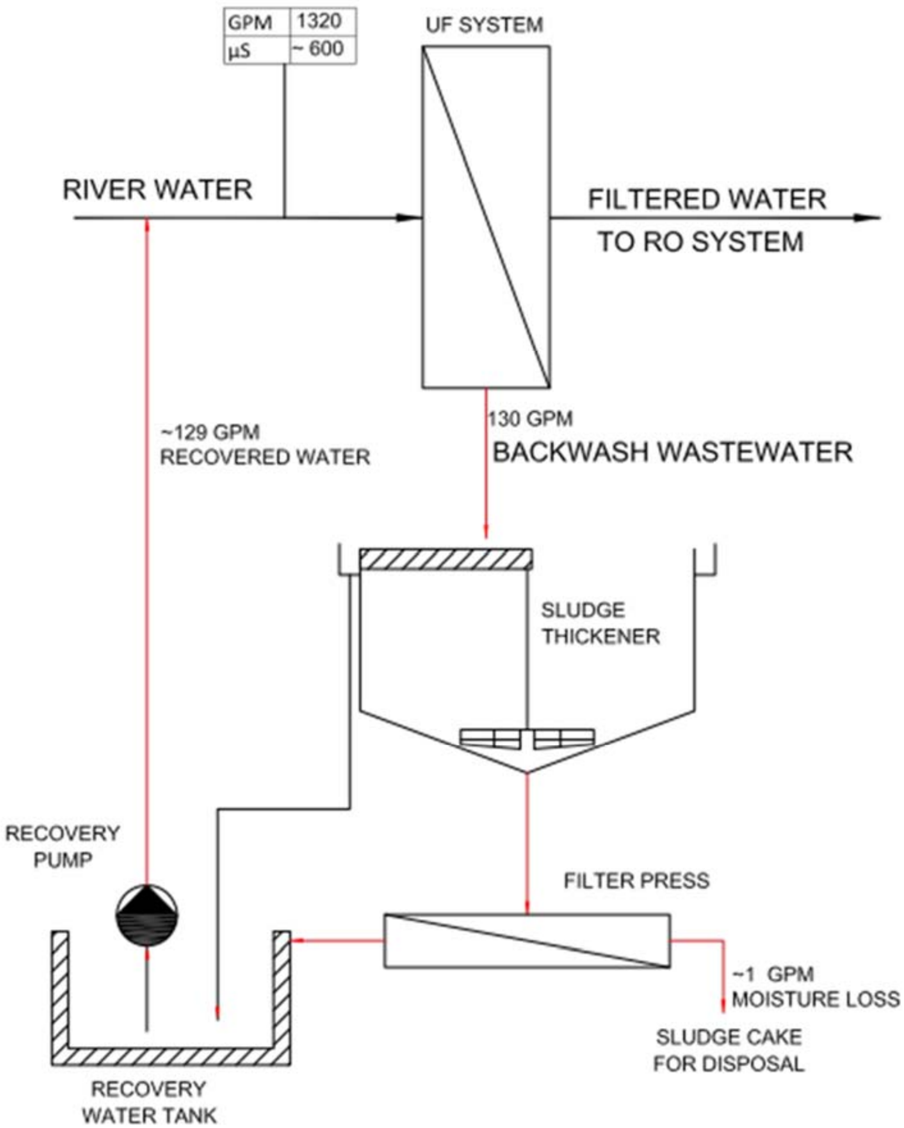
1. Runtimes between IX regeneration increases by a factor of 10.
2. Chemical consumption (acid/caustic) reduced by a factor of 10 (compared to co-current DI). Using the UF/RO pretreatment, the benefit of converting from co-current to counter current regeneration of the IX is reduced, but endpoint quality is better with counter current regeneration.
3. Treated water conductivity from primary IX will improve by a factor of 2.
4. Mixed bed polishers may not be necessary to achieve DI quality, but a portable bottle exchange system (rental equipment) can be added instead to provide the last little bit of polishing.
5. A large benefit over a clarifier/IX/MB solution is that the TOC values entering the boiler will be less than 20 ppb due to the double membrane process (UF+RO); a positive barrier as pre-treatment to the ion exchange system.
6. Low quantity of contaminated effluent. The UF effluent is just dirty water. It has no chemical additives, so it can be either dumped entirely or the sludge can be thickened, and the water reclaimed as fresh surface water.
7. Savings from reduced city water demand and regeneration chemical usage.

COOLING TOWER BLOWDOWN AS SOURCE WATER

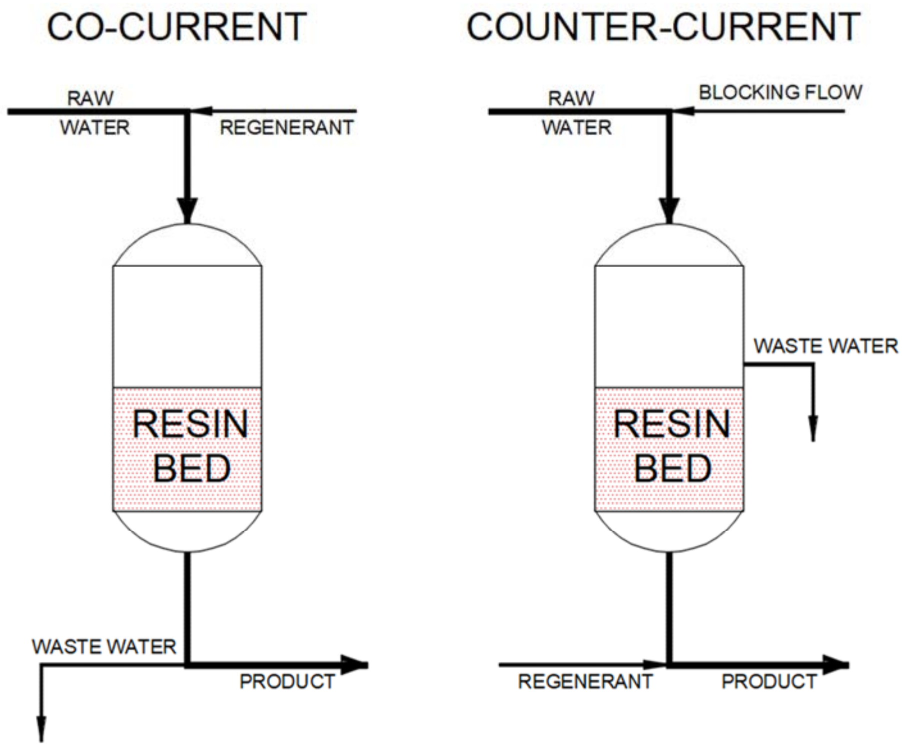
For mills that are trying to minimize their overall water footprint, cooling tower blowdown (CTBD) can be a feed source to the UF/RO system, either 100% CTBD feed or blended with surface water. RO is very good at removing high concentration dissolved solids. The RO product from CTBD will be very similar to surface water product with perhaps a 20 µS conductivity increase owing to the higher dissolved solids loading. This can be evaluated on a case-by-case basis. This is a viable alternative when water intake or discharge capacity is limited or cost prohibitive.

UF REJECT AS SOURCE WATER

Ultrafiltration removes organic and inorganic particulate and some color. The reject stream is just really dirty water. It can be handled in a small, dedicated clarifier/thickener and sludge press with good quality water recovery. This minimizes effluent and reduces effluent pond solids loading.



CO-CURRENT VS COUNTER CURRENT REGENERATION



Typical ion exchange configurations shown above. Co-current regeneration applies the regenerant (acid or caustic) in the same direction as feed flow. In counter-current technology the regenerant is introduced in the opposite direction as the feed flow. Counter current technology prevents the resin from fluidizing (to avoid ineffective regeneration) during regeneration with a blocking flow of air or water opposite the regenerant to keep the bed fixed in position. The regenerant wastewater is drawn from the center of the vessel as shown. Counter current technology has several benefits over co-current:

- Lower chemical consumption (Typically less than 50% of co-current)
- Higher product water quality (lower Na and SiO_2 leakages)
- Lower wastewater volumes
- Typically, longer run times between regenerations

CONCLUSION

Effective pretreatment of variable quality surface water can significantly reduce the operating cost and effluent impact of producing high-quality boiler makeup water.