CHANGING COOLING TOWER BLOW DOWN FROM COLD WATER SIDE TO HOT WATER SIDE IN CW SYSTEM FOR REDUCTION IN EVAPORATION LOSS & HEAT LOAD IN CT

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ABSTRACT

In thermal power plants, blow down is being carried out from cold water side of cooling tower before or after circulating water (CW) pump to maintain desired Cycle of Concentration (COC) in the circulating water. Evaporation loss in cooling tower (CT) is about 1.75 % of total circulating water (CW) flow, including drift loss and spillage etc. Among many uses of water, cooling tower, which consume more than 80% of input water for make up. Cooling towers, works on evaporative cooling methodology requires significant quantity of water to compensate for losses associated with evaporation, drift and blow down. This makes a power plant more water intensive. In the recent past, the state governments have resorted to abnormal increase in water charges approx. 94 to 718 %. Further, the government has issued a notification (on 7 December 2015) to limit the specific water consumption to 2.5 m^3/MWh. Hence, Power plants need to optimize and exercise the measures such as conservation, recycling and reuse practices of water to meet this target.

The blow down may be carried out from hot water side i.e. condenser outlet going to cooling tower to ensure water conservation. This will reduce total water flow in cooling tower, which in turn reduces evaporation loss in the cooling tower. As blow down and evaporation is directly proportional, depending on COC, both evaporation and blow down will be reduced in the proposed scheme. This will result into saving of considerable amount of water with little investment and provides quick result. Make up water saving will be in the order of 8 to 10 cubic meter per hour for COC 6 to 5 and 55 cubic meter per for COC of 2 for a single 500 MW unit. An approx. 1 lakh m^3 per annum of make up water can be saved by this proposal for a 500 MW plant which runs at 4 COC. Hot side blow down would also result reduction in CW pumping power, pre-treatment cost, raw water pumping power, in addition to reduction in loss due to evaporation in cooling towers. These saving can be multifold in the existing plants where the COC is less.

In NTPC, there is a potential savings of approx. 11 million m^3 per year of make up water, APC savings of approx. 1 MW which results into financial savings of approx Rs. 5.5 Crore / year. The proposed modification may be taken up as a measure of conserving water and energy to promote sustainable electricity generation for the present / future plants located across the country.

Keywords: *evaporative loss in cooling tower, water conservation, specific water consumption.*

1. INTRODUCTION

Water is one of the key input requirements for thermal power generation. Water is required for process cooling in the condenser, ash disposal, removal of heat generated in plant auxiliaries, and various other plant consumptive uses [1]. For power plants located on main land, the raw water is generally drawn from fresh water source such as river, lake, canal, reservoir, barrage. Treated sewage water may also be used as source of raw water for the power plants located adjacent to the cities. For power plants located in coastal areas, water for cooling of condenser and auxiliaries is drawn from the sea or creek which provides for water requirement of the wet ash handling system also. The requirement of water for other plant consumptive uses is met from an alternative source or by installing desalination plant. Hence water is a basic input to a thermal power plant.

In general large quantity of water is required for a thermal power plant operation. There are different initiatives were taken to reduce the water demand like zero discharge systems, circulation water system for condenser cooling together with Cooling Towers, Dry ash evacuation etc., But still sincere & number of initiatives are required to reduce the water consumption. Water is a main input to many industries and it is imperative for human life. Difficulties are already being faced in locating thermal power plants due to non-availability of water, particularly in coal bearing states like Orissa, Jharkhand and Chhattisgarh. As per a study conducted by World Resource Institute (WRI), India is the country of most concern for water constraints, and the plants are located in water scarce or stressed areas. Water scarcity is already impacting power projects in India, causing delays and operational losses. NTPC Sipat plant was shut down in 2008 due to lack of water supplies from the state of Chhattisgarh [2]. This problem is expected to be aggravated in future when more sites would be required. Thus there is a need to minimise consumptive water requirement for thermal power plants.

1.1 Cost of Water

Further, as water resources become scarcer in country like India, human consumption like drinking and irrigation uses have got high priority over industrial uses. In the recent past, the state governments have resorted to abnormal increase in water charges approx. 94 to 718 % [3]. The state government of Orissa, Chhattisgarh & Madhya Pradesh has resorted to abnormal increase in water charges. The increase in water charges in respect of stations located in these stations are given in Table 1.

Table 1. Water Charges for a thermal power plant

Sl.No	Station	Increase effective from	Existing Water Charges Rs. / m^3	Revised Water Charges Rs. / m^3	% Increase
1.	Korba I & II	1/5/2010	3.6	7.0	94
2.	Sipat II	1/5/2010	3.6	7.0	94
3.	Talcher I	1/10/2010	0.55	4.5	718
4.	Talcher II	1/10/2010	0.55	4.5	718
5.	TTPS	1/10/2010	0.55	4.5	718
6.	Vindyachal	1/10/2010	2.0	4.5	125
7.	Simhadri	5 % increase in water cost per year , Presently at Rs.15.06 / m^3			

The increase in water charges led to the power plant generator to pray before CERC for recovery of additional cost incurred due to abnormal increase in water charges.

Hence, from the trends of reduction in the norms for water consumption limit and increase in cost of water, it is observed that water is becoming scarce, which needs to be properly utilized leaving no room for wastage, to ensure a sustainable development. At present some of the projects those are already in pipeline are facing hurdles in execution and lacks viability due to unavailability of water allocation. Any level of initiative in the area of reduction in water consumption gains importance at this current scenario. So measures to be taken for reducing consumptive water than the designed value. This paper aims at discussing different aspect of water consumption in a power plant & device a simplified methodology to reduce the water consumption.

2. MATERIALS & METHODS

2.1 Water Requirement for a Thermal power plant [1]

Thermal power plants water requirement is governed by a number of factors such as quality of raw water, type of condenser cooling system, quality of coal, ash utilization, type of ash disposal system, waste water management aspects etc. In the past, power stations were designed with water systems having liberal considerations for various requirements and high design margins. Ash handling system used to be designed for disposal of both fly ash and bottom ash in wet form using lean slurry with ash to water ratio of typically 1:10. The consumptive water requirement for coal based plants with cooling tower used to be about 7 m^3/h per MW without ash water recirculation and 5 m^3/h per MW with ash water recirculation.

In recent past, plants have been designed with consumptive water requirement in the range 3.5 – 4 m^3/h per MW. The typical break-up of plant consumptive water, taken as 4000 m^3/h, for a typical 2x500 MW plant with wet ash disposal without recycling of ash pond water is indicated in the Table 2.

Table 2. Types of Water consumption in a thermal power plant [2 x 500 MW]

Sl.No	Usage type	Quantity [m^3/h]
1.	Cooling tower make up	3450
2.	Ash disposal	1300*
3.	DM water make up	120
4.	Potable & service water	250
5.	Clarifier sludge etc	110
6.	Coal dust suppression	70
	Total	4000

*To be tapped from CW system as blow down water and as such not considered in consumptive
Cooling tower make up amount to = 3450 / 4000 = 86 % to total water requirement.

It may be observed that more than 86% of input water is required for make up to the cooling tower itself. It is mainly due to evaporation of water in the cooling tower in the process of cooling CW. Hence cooling tower make up has got enough potential for improvement and needs further study / optimization.

2.2 Cooling Tower

A cooling tower (CT) is a type of heat exchanger that removes heat from circulating water (CW) and transfers it to atmospheric air. As warm / hot water from the condenser allowed falling through the fill, some of it evaporates, which cools the remaining water and hence it is called as evaporative cooling process. The evaporation of water sustains the cooling process. The cooled water collected at the bottom of the cooling tower is returned to the condenser for removing heat from Low Pressure turbine exhaust steam through CW pumps and thus the cycle repeats.

When water is evaporated during cooling in the CT, leaves behind dissolved solids / salts in the system and increases total dissolved solid (TDS) level. This will increases the cycles of concentration (COC) in the circulating water system. COC refers to the ratio of impurities or the TDS in the circulating water to the TDS in the make up water. Maintaining a particular COC in a CW system is mandatory to avoid any deposition in the condenser heat transfer tubes, which hamper the condenser performance and thus the plant efficiency. Hence to maintain a desirable COC, some amount of circulating water is to be removed on continuous basis from the system, called blow down. The amount of blow down is calculated by the following formula.

Blow down = Evaporation loss / (COC - 1)

The evaporation loss in CT, in general accounts for about 1.75 % of total CW flow, including drift loss and spillage etc [1].,

So there will be two types of loss in the CW system such as

1) Evaporation loss
2) Blow down loss.

Make up water is required to meet these losses. Since the CT is working on evaporation principle, it is imperative for CT to incur this evaporation loss. In recent days, improvements in raw water quality / water treatment technology, COC of CW system has been increased from 1 to 5. This leads large reduction in blow down water requirement. In addition, a technology to reduce the loss still further below the designed value will be very much essential considering importance of water.

2.3 Case Study in a 500 MW Unit

For a 500 MW unit, about 1050 Tons / hour of water has to be removed as blow down. For this purpose the calculated amount of water from the CW system is drained / removed after CW pump i.e. before entering the condenser in the cold water side as shown in Figure 1.

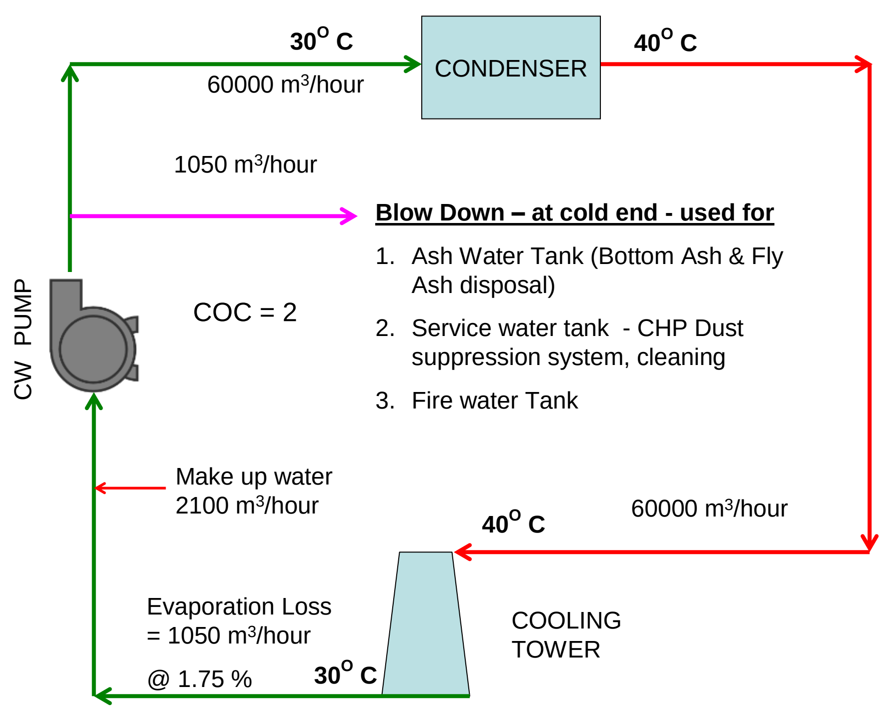

Figure 1. Present system of Blow down (cold water side)

Presently, this blow down water is used as a make up water for the following purposes along with their original water source (either from raw water / clarified water, as the case may be).

1. Ash water in Ash handling system
2. Dust suppression in Coal Handling Plant (CHP)
3. Fire water
4. Service water

It is observed that, an entire amount of CW blow down is being used for the above said applications by the plant to ensure water conservation like zero discharge system. Make up water is added to the CW channel to maintain channel level.

The amount of make up is given by

Quantity of Make up water = Evaporation loss + Blow down

Table 3 provides details about make up water quantity for different set of COC being practiced in various plants.

Table 3. CW Make up water quantity (for 500 MW Unit)

Sl. No	COC	Evaporation [T/hr]	Blow down [T/hr]	Make up water [T/hr]
1.	2	1050	1050	2100
2.	2.5	1050	700	1750
3.	3	1050	525	1575
4.	3.5	1050	420	1470
5.	4	1050	350	1400
6.	4.5	1050	300	1350
7.	5	1050	263	1313

Where

COC Cycle of Concentration
Evaporation loss = 1.75 % of CW flow (60000 T/hr)
Blow down = Evaporation loss / (COC -1)
Make up water = Evaporation + Blow down

The present study aims at reducing the evaporation loss in CT and to conserve water in the CW system. This proposal suggests to carryout blow down of CW system from hot water side of CT i.e. after condenser, in the hot water side, as shown in the Figure 2.

By taking blow down before it enters the CT, the total flow to the CT reduces by an amount equivalent to the amount of blow down. As the evaporation loss in the CT is directly proportional to the amount of CW flow, less water will be evaporated in CT. Because the hot water which is removed as blow down from hot water side before it enters the CT, do not subject to evaporation process in the CT. Hence less water will be evaporated in the CT compared to present system of cold water blow down or the same operational performance. This leads to saving of water, of around 37 Tons / hour for a 500 MW unit.

This kind of water saving is very well applicable & appreciable in any kind of thermal power plant irrespective of their unit capacity / size and the type of cooling tower (natural draft [NDCT] / mechanical draft [IDCT]). Table 4 provides the make up water savings for a 500 MW unit at different COC limits.

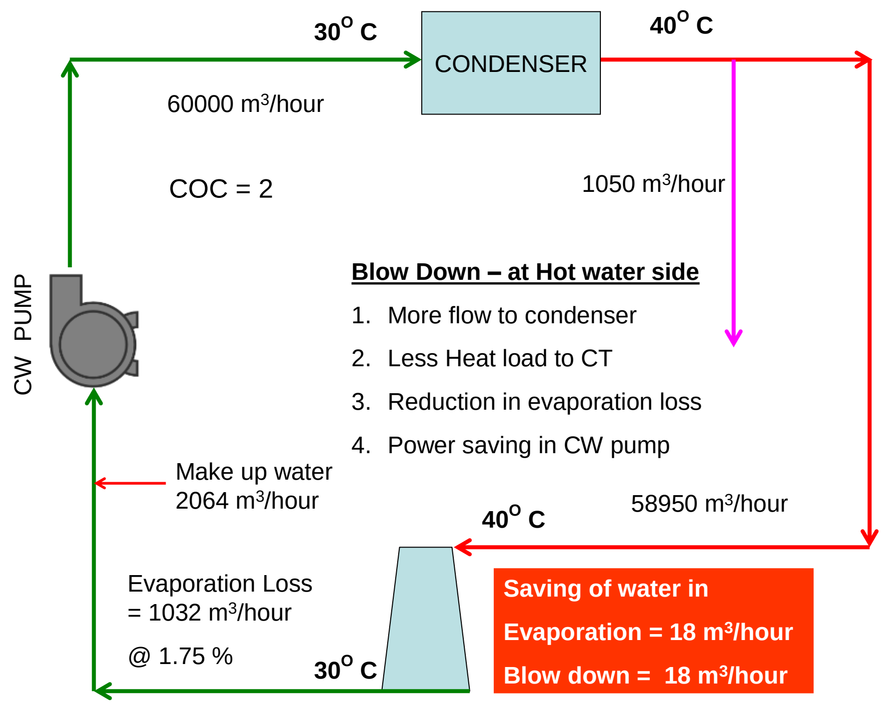

Figure 2. Proposed system of Blow down (Hot water side)

Table 4. Make up water savings with different COC [in a single 500 MW Unit]

Sl.No	COC	Make up water savings [m^3/h]
1.	2	55
2.	3	30
3.	4	14
4.	5	11
5.	6	8

Hence considerable amount of water can be saved in a thermal power plant by this simple modification. The savings of make up water is very significant at lower COC. In addition the following advantages are envisaged

1. Reduction in heat load of CT
2. Reduction in consumption of water / MW (specific water consumption)
3. Reduction in water cost / water cess.
4. Reduction in CW treatment cost in channel.
5. Reduction in water treatment cost (cost of clarified water, where used)
6. Reduction in pumping cost of blow down water (where additional pump is installed for blow down from open channel)
7. Reduction in CW pumping power.

The plants such as Ramaundam, Korba and Talcher in NTPC has already has hot water blow down scheme and running successfully.

Based on experience, it is found that, hot CW blow down water can safely replace cold blow down water without any process related difficulty in the applications like ash water, CHP dust suppression, service water & fire water etc.,

2.4 Specification requirement for blow down.

At present, the specification requirement stipulates tapping of blow down from cold water side, considering earlier practice of dumping of entire blow-down water outside the plant boundary to meet the environment regulation, which prevents hot water discharge from plant premises.

But presently, due to lack of availability of water, various plants were already utilizing the entire blowdown water to different purposes. As such entire amount of CW blow down is being utilized in the plant premises, leaving no water will be discharged outside the plant, which confirms the environmental regulations as well. In this scenario, it is advised to change the point of tapping of blow down from cold to hot side, in order to reduce evaporation loss and thereby the water consumption.

2.5 Requirement for modification

No Shut down is required as the ARV (Air release valve) tapping can be used on hot water header and connected to Blow Down line after valve, as shown in Figure 3. . Basically this modification requires an extra length blow down pipe and an isolating valve. The hot CW water after condenser may be withdrawn from the common header CW line which goes to CT, preferably at the Air release valve. This requires laying of 350 to 450 mm NB diameter (of required size) pipe from CW duct to the present point of CW blow down line. Although this proposed modification requires only a pipe line from CW duct, it was observed that the layout of tapping of CW water and the end point of use varies from plant to plant; hence suitable modification (in length) plan is to be prepared / required on case to case basis.

Figure 3. Hot water blow down tapping from Air Release Valve (ARV)

2.6 Status of Implementation

The system of cold side blow down has implemented under two categories:

Category-I: The suggested modification has been incorporated for the upcoming new plants of coal, which are under pipeline / planning stage.

Category-II: Necessary advisory for implementation of this suggested modification for all the running units has been issued; as such these units are running with low COC, the potential for water savings is high.

2.7 Savings Potential

It is estimated that by implementing the hot water blow down scheme all across NTPC, would result in make up water savings of approx. 11 million m^3 per annum and Auxiliary power savings of approx. 1 MW, which results into financial savings of Approx Rs. 5.5 Crore / year.

3. CONCLUSION

The present study establishes that by taking blow-down from hot side of cooling tower, reduction in evaporation loss and reduction in the water make up to the CW system is achieved, compared to cold side blow-down. The proposed modification has been implemented across NTPC to conserve water. The proposed modification may be taken up as a measure of conserving water and energy to promote sustainable electricity generation for the present / future plants located across the country.

1. Use of Hot side blow-down in Cooling Water system saves max. of approx. 37 m^3/hr of water compared to cold side blow-down system in a single 500 MW unit.
2. The proposed modification has many advantageous in addition to saving in water like, reduction in pumping power, reduction in CT heat load, water cost etc.,
3. The water saving potential is inversely proportional to the COC of the CW system, which varies from plant to plant.
4. In NTPC, there is a potential savings of approx. 11 million m^3 per year of make up water, APC savings of approx. 1 MW which results into financial savings of approx Rs. 5.5 Crore / year.

Considering the total water consumption in a coal based thermal power plant, the water savings obtained by this proposed method is very small in quantity. However whatever savings in water consumption even in very small quantity is very much essential in country like India, where demand for water is huge and in many states water availability is a major point of concern.

4. ACKNOWLEDGEMENT

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