DESIGN MODIFICATION IN IMPROVING COOLING TOWER PERFORMANCE OF JSW ENERGY LTD., RATNAGIRI (A Case Study)

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ABSTRACT

In general, cooling towers are thought of as the least important piece of equipment in most facilities. As a result, most of the cooling towers underperform because of design and maintenance issues. Cooling towers are the biggest heat and mass transfer devices that are in widespread use. The consequences of having an underperforming cooling tower are pretty straight forward. Performance of cooling tower directly affects the performance of power plants as a result of the bottleneck caused by the “supply” water temperatures. 1°C increase in cold water temperature to condenser result in 0.011 Rs/kWh increase in generation cost and for a 1200 MW IPP the revenue loss per annum is 9.33 Cr. This paper presents the major design modification carried out in hot water manifold of Unit # 3 Cooling Tower at JSW Energy Ltd., Ratnagiri station to improve the performance of underperforming Cooling Tower. This was a unique case as the common hot water GRP header pipe (2844 mm OD to 764 OD) running parallel on both sides in front of air inlet at curb level causing obstruction for the free air flow at the inlet of cooling tower. The work is executed in two phases namely Pass - B duct and Pass - A duct during Unit # 3 outage opportunity in the month of December 2015 and July 2016 respectively. The increase in Tower Capability of Unit # 3 observed after implementation of this modification is from 57.7 % to 72.9 %.

ABOUT THE AUTHOR(S)

Mr.Tushar Pande is working as DGM (HOD - Mechanical), JSW Energy Ltd. has completed his Bachelor of Engineering in Mechanical Engineering from Amravati University. He joined JSW in the year 2012 as AGM and has rich experience in diverse areas such as, Operation, Mechanical Maintenance, Renovation and Modernization etc. He has led the team which was associated with the Hot water duct lowering in Unit # 3 of JSW Energy Ltd., Ratnagiri Station.

Mr. Sudharshan Rao Majji currently working as Dy. Manager (OSTS), JSW Energy Ltd. has completed his Bachelor of Engineering in Electrical Engineering from Andhra University College of Engineering and joined JSW in 2007 as Engineer Trainee. He has been associated with Operations and Efficiency of complete station. He was part of the team which was associated with the Hot water duct lowering in Unit # 3 of JSW Energy Ltd., Ratnagiri Station.

Mr. Faeem Baig currently working as Dy. Manager (Mechanical Maintenance - BOP), JSW Energy Ltd. has completed his Bachelor of Engineering in Mechanical Engineering from Finolex Academy of Management and Technology and joined JSW in 2008 as Engineer Trainee. He has been associated with erection during project & then Mechanical Maintenance Works of Balance of Plant. He was part of the team which was associated with the Hot water duct lowering in Unit # 3 of JSW Energy Ltd., Ratnagiri Station.

INTRODUCTION

JSW Energy Ltd. is having an imported coal based coastal Thermal Power Station of 4 x 300 MW capacity at Jaigad in Ratnagiri district of Maharashtra. These units were commissioned in the year 2010 – 2011. Each unit has a sea water based induced draft cooling tower having 12 cells back to back. Since inception, Cooling towers are underperforming due to various reasons. One of the major reasons for underperformance is the obstruction for the free air flow at the inlet of cooling tower because of the common hot water GRP header pipe (2844 mm OD to 764 OD) running parallel on both sides in front of air inlet at curb level as shown in below Figure – 1.

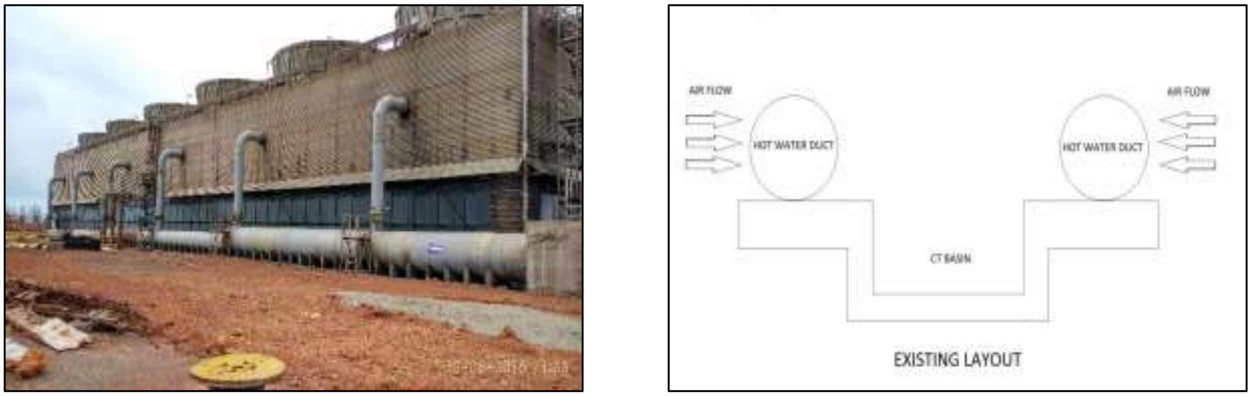

Figure – 1: Hot water manifold before modification.

Detailed action plan was chalked out for improving the performance of Cooling Towers at Ratnagiri station. Unit # 3 CT was chosen for study, analysis and modifications for improving the CT performance. The stepwise actions were described in the following sections.

ACTION PLAN

1. Unit # 3 CT performance test
2. Analysis of CT performance and corrective actions
3. Implementation of corrective action
4. Analysis of CT performance after corrective actions

UNIT # 3 CT PERFORMANCE TEST RESULTS.

Unit # 3 CT Performance Test was carried out by in house on 7th December, 2015 as per CTI ATC 105. The measured hot cooling water (CW) temperature, CT outlet CW temperature and ambient wet bulb temperature (WBT) is shown in below Table 1. It is seen that the average hot CW is 42.5 °C, the average cold CW is 34.7 °C and ambient wet bulb temperature is 22.5 °C.

The design performance curves of the CT at 90, 100 and 110 % of design water flow along with the thermal capability cross plots of the CT are depicted in below Figure 2.

Parameter	UOM	Design	Test Values
Date			7th December, 2015
Wet Bulb temperature	°C	28.05	22.47
Hot Water Temperature	°C	42.50	42.48
Cold Water Temperature	°C	32.50	34.68
Cooling Range	°C	10.00	7.79
Tower Capability	%	100.00	57.69
Approach	°C	4.45	12.21
Effectiveness	%	69.20	38.95
Cold Water Temperature shortfall from design	°C		6.57

Table – 1: Unit # 3 CT Performance Test Results before Hot water manifold modification.

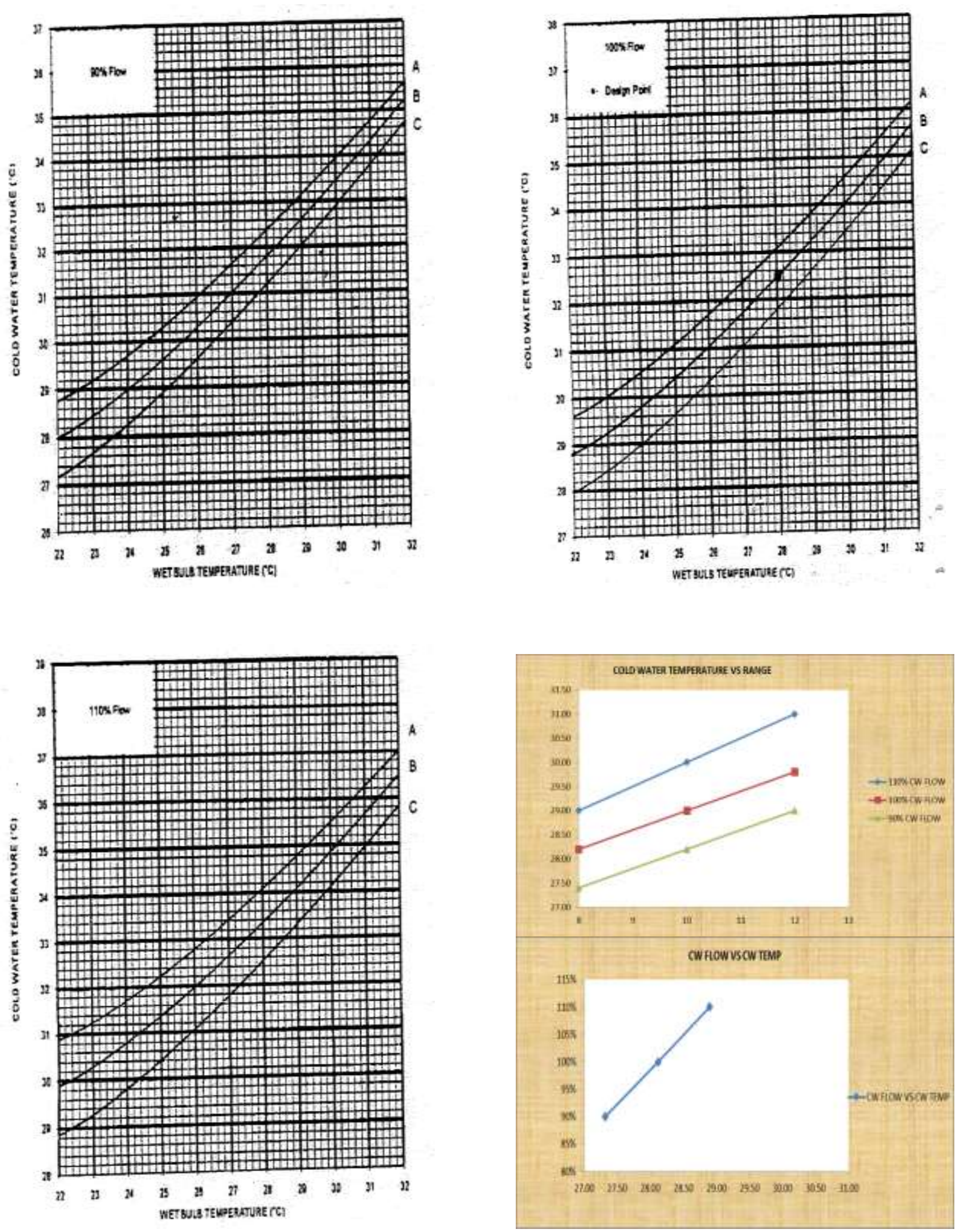

Figure – 2: Performance curves of CT at 90, 100 and 110 % of design water flow and Thermal Capability cross plots before modification.

The overall performance of the Unit # 3 CT is given in the above Table 1. It is seen that the operating range is 7.8 °C and the approach is 12.2 °C against the design of 10 °C and 4.5 °C respectively. The thermal capability is 57.7 % and the short fall in cold CW temperature is 6.6 °C. The operating effectiveness is 38.9 % against the design of 69.2 %.

ANALYSIS OF UNIT # 3 CT PERFORMANCE AND CORRECTIVE ACTIONS

Based on the observations of Performance test carried out, following remedies are listed.

i. Replacement of old PVC V bar Fill material to clog resistant Vertical flute type Fill Material.
ii. Replacement of drift eliminators to reduce drift losses.
iii. Increasing air inlet area by lowering hot water manifold. (At present hot water duct is above ground covering 2 meter from curb level)
iv. Replacement of Fan Blade assembly.

The recommended points replacement of old PVC V bar fills and drift eliminators belong to water side, whereas lowering hot water manifold and replacement of fan blade assembly belong to air side.

For implementation of recommended points i, ii and iv each cell of the CT will be under shutdown for minimum 10 days. Also the estimated cost for one cell will be Rs 37 lakhs and the total cost for one unit will Rs 444 lakhs. Further it will require material supply time of approximately 6 weeks for each cell and CT needs to be operated with shutdown of one cell at a time for 120 days.

The recommended point of lowering hot water manifold can be incorporated in unit outage with time period of 30 days. Also reduction in obstruction area in the air path will increase the air flow which will result in major improvement in performance of IDCT. Therefore it was decided for implementation of remedies to be initiated with lowering of hot water manifold. Hence it was planned to lower the hot water manifold of one pass at a time during consecutive annual overhauling / unit outage.

IMPLEMENTATION OF RECOMMENDED MEASURE – LOWERING OF HOT WATER MANIFOLD

The brief detail of this modification is shown in below Figure – 3 along with the % area of CT Cell air entry blocked by Hot Water Manifold in Table – 2.

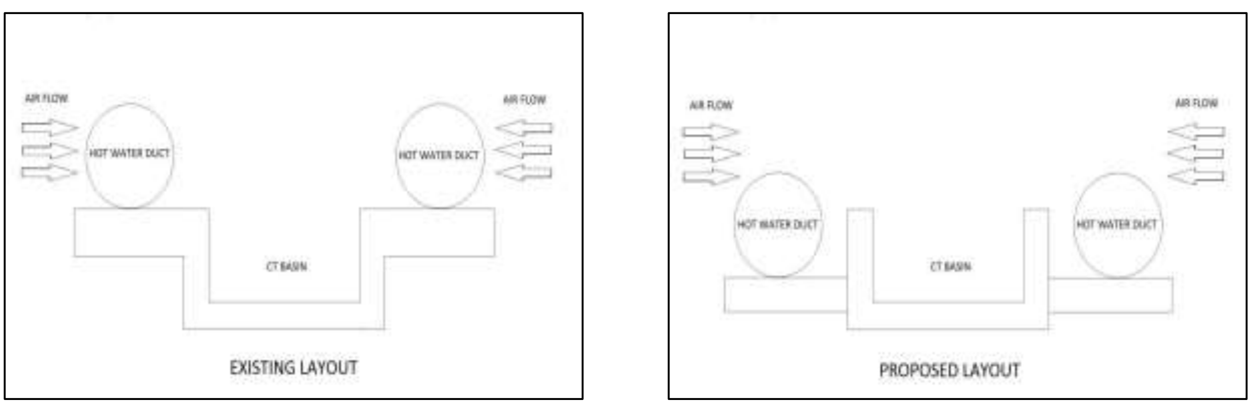

Figure – 3: Hot water manifold existing and proposed layout.

Cell-I (24%)	Cell-II (24%)	Cell-III (14%)	Cell-IV (14%)	Cell-V (7%)	Cell-VI (0%)
Cell-VII (24%)	Cell-VIII (24%)	Cell-IX (14%)	Cell-X (14%)	Cell-XI (7%)	Cell-XII (0%)

Table – 2: % Area of CT Cell Air Entry blocked by Hot Water Manifold.

The implementation has following steps.

- Preparation of work scope.
- Overlaying of works of different departments namely Mechanical, Civil, etc.
- Preparation of BOQ and its QAP.
- Identification of vendors & material procurement.
- Execution of works.
- Commissioning.

The work is executed in two phases namely Pass - B duct and Pass - A duct during Unit # 3 outage opportunity in the month of December 2015 and July 2016 respectively. The work execution has two major departments involved Civil and Mechanical. The better planning, coordination & execution has resulted to complete the work within stipulated time even in heavy monsoon period.

The civil and mechanical work carried out are described below:

Civil Work: Excavation, breaking of concrete blocks, raft, bed preparation, backfilling casting of trust blocks etc.

Mechanical Work: Supply of GRP fittings, removal of existing Hot Water Header, erection, joining, testing and commissioning of new GRP Hot water header.

Following activities were carried out for completion of the job:

- Opening of dummy flange at end of header.
- Removal of access platform near riser valves.
- Cutting of GRP pipe at predefined location and shifting to stipulated location.
- Providing access for cutting of riser pipe by mean of scaffolding.
- Cutting of riser pipes.
- Core cutting of RCC at CT basin junction.
- Breaking of RCC up to 3.5 m depth, mucking and disposal at stipulated location.
- Coating of CT basin by coal tar epoxy.
- Bed preparation by means of sewed sand up to pipe inverts level i.e. 2.5 m.
- Bed compactness up to 90% of proctor density. Same is achieved by flooding.
- Providing pit at predefined location for lamination joints.
- Pipe doubling of GRP pipes i.e. 2034 OD, 1526 OD, 1120 OD, and 764 OD.
- S-bend fabrication as per site requirement.
- Lamination of S-bend to 2034 OD doubled pipe.
- Fabrication of U-loop as per site requirement.
- Erection of GRP pipe, S-bend, pipe spool, and U-loop at predefined location.
- Field lamination joint.
    - 2034 OD - 4 Nos.
    - 1526 OD - 8 Nos.
    - 1120 OD - 4 Nos.
    - 764 OD - 40 Nos.
- Casting of thrust block at reducer and U-loop.
- Erection 764 OD riser valve.
- Putting end dummy in place.
- Erection of 764 OD manholes in between Riser-7 and Riser-8.
- Backfilling of excavated trench by means of sewed sand up to 70 % of trench depth.
- Compactness of backfilled sand up to 90% proctor density by means of flooding.
- Filling of hot water duct.
- Pressurizing of hot water duct up to1 kg/cm2 by running CW pumps.

Figure – 4 shown below represents air inlet portion after modification.

Figure – 4: Hot water manifold before and after modification.

UNIT # 3 CT PERFORMANCE RESULTS AFTER LOWERING OF HOT WATER MANIFOLD.

Unit # 3 CT Performance Test was carried out by in house on 24th August, 2016 as per CTI ATC 105. The measured hot cooling water (CW) temperature, CT outlet CW temperature and ambient wet bulb temperature (WBT) is shown in below Table 3. It is seen that the average hot CW is 42.2 °C, the average cold CW is 34.2 °C and ambient wet bulb temperature is 26.7 °C.

The thermal capability cross plots of the CT are depicted in below Figure 5.

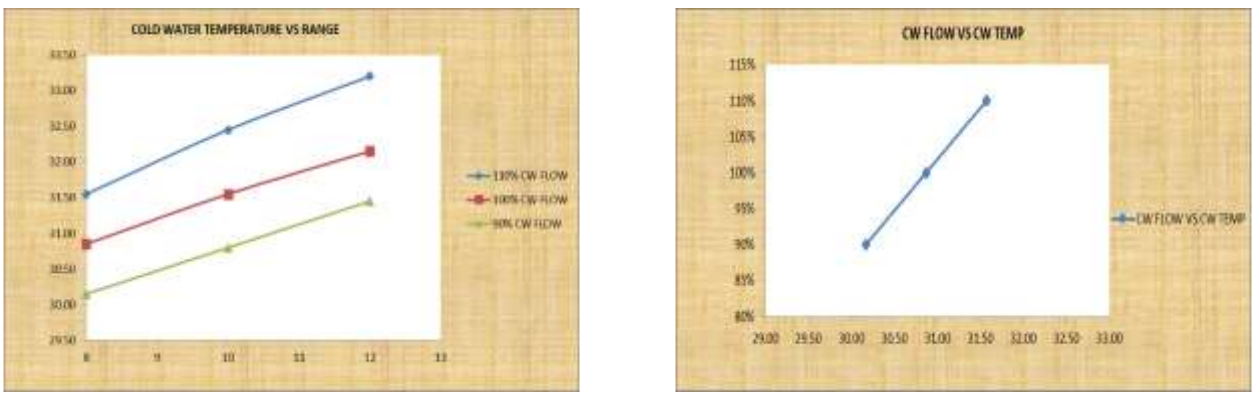

Figure – 5: Thermal Capability cross plots after modification.

The overall performance of the CT is given in Table 3. It is seen that the operating range is 8.1 °C and the approach is 7.5 °C against the design of 10 °C and 4.5 °C respectively. The thermal capability is 72.9 % and the short fall in cold CW temperature is 3.3 °C. The operating effectiveness is 51.8 % against the design of 69.2 %.

Parameter	UOM	Design	Test Values	Test Values
Date			24th Aug, 2016	7th Dec, 2015
Wet Bulb temperature	°C	28.05	26.67	22.47
Hot Water Temperature	°C	42.50	42.21	42.48
Cold Water Temperature	°C	32.50	34.16	34.68
Cooling Range	°C	10.00	8.05	7.79
Tower Capability	%	100.00	72.96	57.69
Approach	°C	4.45	7.50	12.21
Effectiveness	%	69.20	51.80	38.95
Cold Water Temperature shortfall from design	°C		3.29	6.57
Reduction in Cold Water Temperature	°C		3.28	
Improvement in Condenser Back Pressure	kPa		1.73	
Improvement in Turbine Heat Rate	kCal/kWh		23.07	
Cost Benefit @ 300 MW Generation	Rs/day		171710	
Investment for duct lowering	Lac		265	
Simple Payback Period @ 80 % PLF	Months		6.32	

Table – 3: Unit # 3 CT Performance Test Results after Hot water duct modification.

WAY FORWARD

After achieving tangible benefits in the performance of Unit # 3 cooling tower, it was decided to implement the modification in remaining units at Ratnagiri station.

CONCLUSIONS

The main conclusions from the hot water duct modification is listed below:

- The approach has reduced from 12.2 °C to 7.5 °C.
- The effectiveness has increased from 38.9 % to 51.8 %.
- The shortfall of cold water temperature from design has reduced from 6.57 °C to 3.29 °C.
- The tower capability has increased from 57.7 % to 72.9 %.
- Improvement in Turbine Heat rate 23.07 kCal/kWh.
- Improvement in Condenser back pressure 1.73 kPa.