OPERATION OF ONCE THROUGH COOLING WATER SYSTEM – THE CHALLENGES

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Introduction:

A once-through cooling water system is installed for a 2X 520 MW Coal Fired Thermal Power Plant, which is located along the coast of Bay of Bengal, at distance of about 700 m from the coast. Sea Water is used for Condenser cooling, Ash Handling System and as an input to Desalination Plant of 12.5 MLD capacity. About 1, 82,000 Cu.M /hour of sea water is drawn from the Intake wells known as caisson, one caisson is installed for each unit, located at 650mtrs from the coastline. From the caisson, seawater is pumped to each unit to meet the requirement of Condenser cooling, Ash Handling and Desalination Plant through intake pipes and the hot water from the condenser is sent back to the diffuser tank on the jetty through outfall pipes. The hot water from the diffuser tank is diffused to sea through diffuser piping.

Circulating Water System Description:

The circulating water system for 2 X 520 MW plant is an open cycle (once through) sea water system. CW system for each 520 MW Unit comprises of Two Vertical Turbine Pumps, each of capacity 45500Cum/hr. and TDH of 27 m. There are total 4 numbers of CW Pumps for both the units without any standby. Two pumps of each unit are connected to pipe header of 3600 Dia MS (cement mortar lined). Two 3600 Dia CW Intake pipes are interconnected with 2100 Dia pipe inside the plant boundary.

Cooling Water System consists of

- Two (2) Nos CW Pump house, one pump house dedicated to meet the water requirement for one unit
- Two (2) Nos CW Intake pipe line, 3600 dia MS (inside and outside cement mortar lined) from CW Pump house to condenser inlet, each pipe dedicated to meet the water requirement for one unit
- Two (2) Nos CW Outfall pipe line, 3600 dia. MS & GRP pipe from Condenser to Seal pit to diffuser tank on jetty, each pipe dedicated to discharge the water of one unit
- One (1) Nos Common RCC Seal pit inside Plant boundary
- One (1) Nos Common Outfall Diffuser tank on the jetty
- Outfall Diffuser system with 6 pipes of 1600 dia., arranged in angular pattern to discharge water in the Sea
- Interconnection Valve joining two 3600 dia. pipeline inside Plant boundary to facilitate interchanging of pumps between units.
- Hydro-Mechanical system like Bulk Gate, Trash Rack, Travelling Water Screen, etc., at the suction of each pump
- Sealing & Cooling water system for CW Pumps
- NaOCl dosing system
- Each discharge pipe has 10 number of Air release valves (DKAV’s) as surge protection device.

Aerial view of CW System:

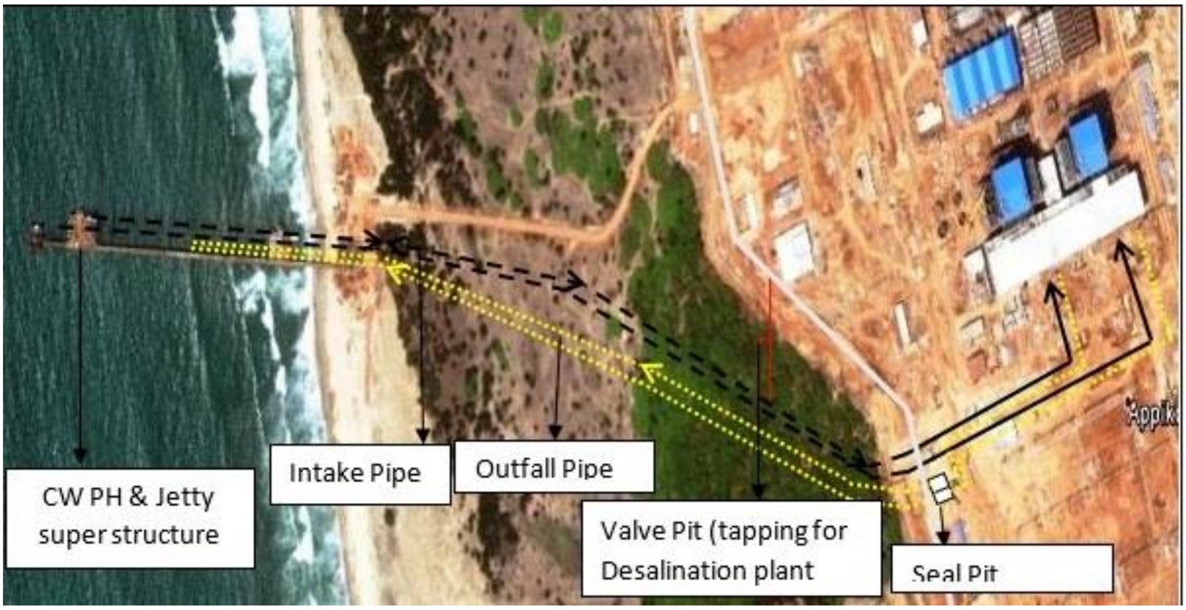


FIG - 1

Major commissioning challenge:

Generally, every Powerplant encounters some or the other challenges during commissioning phase. In the above referred plant, one of the major challenges encountered during commissioning was the stabilization of CW system. One of the major issue during this phase was deformation of pipe support system of CW intake lines, which had delayed the synchronization of the unit.

Incident:

During the first trial operation of the CW pump, after completion of all the commissioning activities like Protections & Interlocks checking, initial filling of the duct, discharge valve operation testing, etc., pump was started from the local PLC. Pump was kept in operation for about two (2) hours. During this two-hour trial operation, all operational parameters related to the pump, like motor current, discharge pressure, bearing & winding temperatures, vibrations, sealing and cooling water flow, etc. were noted to be normal.

After stabilization of all parameters, it was decided to stop the pump. For stopping the pump, first pump discharge valve was to be closed as envisaged in the pump operational manual. Accordingly, close command was given from the hydraulic panel. But before the discharge valve could close fully, pump tripped on motor bearing temperature high protection. It was observed that after giving close command to the discharge valve, when the valve closed by 70%, motor non-driving end bearing temperature increased from 63^0C to 145^0C abruptly, causing tripping of CW pump. It was later confirmed that the motor NDE bearing temperature RTD malfunctioned which caused tripping of the pump.

Consequence:

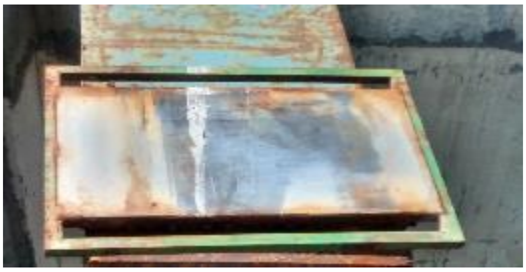
After tripping of the pump, deformation was noticed in the pump discharge pipe support structures and the buckling of the intake pipe. Major deformation of the supports on jetty was observed on the portion of pipe adjacent to the expansion bellow and on both sides of the expansion bellow.

Fig-2

Analysis:

Physical inspection of the discharge pipe support structure was carried out. Post inspection, following points emerged as preliminary analysis.

- PTFE bearing surfaces, on which the pipe support saddles rest, was found with grit and concrete debris, which might have restricted free movement. The insert plate on which the PTFE bearing was resting, was found deformed and the point of contact was not full, which could have affected the load-bearing capacity of the bearing.



- There is a possibility of inadequacy of information available for design of CW piping system

Surge and Water Hammer:

When the velocity of a fluid in a pipe changes, during conditions such as starting and stopping of pump, there is a change in the fluid momentum. In accordance with Newton's second law, if there is a change in fluid momentum, the fluid must be subject to an external force. In a pipeline, this external force is provided by a change in pressure or a pressure transient.

For steady state flow calculations, it is usual to assume the fluid is incompressible. However, for unsteady flow this assumption is not so valid, particularly if the change in fluid velocity is very rapid. This compressibility means it takes a finite amount of time for a velocity change in one part of the pipe to propagate along it. A velocity change propagates along the pipeline as a wave at the sonic speed. Alongside this velocity wave, there is also a pressure wave, which forces the fluid velocity (momentum) to change. The movement of these pressure and velocity waves along a pipeline can lead very high and low-pressure transients.

Transient analysis report

The transient analysis report highlighted that the piping structure will be subjected to the transient conditions during operation and during these conditions, the entire piping system will be subjected to heavy surges.

The surge analysis was carried for critical operating conditions such as pumps start/stop, operating pumps tripping and pumps tripping on total power failure. The below tables show the values at various conditions:

Table - 1: Summary of Transient Pressures

Condition: Power failure to all duty pumps simultaneously-Without air valves

Sl No.	Description	PDV closure time									
		45 sec		60 sec		75 sec		90 sec		No Valve Closure	
		Head (m)		Head (m)		Head (m)		Head (m)		Head (m)	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	Pumps 2100DN (pump discharge line)	51.5	Vac	51.5	Vac	42.3	Vac	33.8	Vac	16.7	Vac
2	CW Inlet - 3600 DN (@ beg. of buried pipe)	58.2	Vac	50.5	Vac	42.2	Vac	35.1	-6.4	24.2	-6.4
3	Condenser (beg.)	23.1	Vac	13.0	Vac	10.2	Vac	8.3	Vac	7.0	Vac
4	CW Outlet - 3600 DN (@ beg.)	32.4	Vac	22.6	Vac	20.0	-7.0	18.1	-7.0	11.8	-7.0

Table-2: Summary of Pump parameters during transient condition

Sl. No.	Case	Pump maximum reverse speed (rpm)
1	Power failure to one out of two working pumps with PDV closure of 90 sec	320 (97% of Nr)
2	Power failure to all working pumps with No valve closure	300 (91% of Nr)

Table - 3: Summary of Transient Pressures

Condition: Power failure to all duty pumps simultaneously-with column separation simulation

	PDV closure time	60 sec		75 sec		90 sec	
Sl. No.	Description	Head (m)		Head (m)		Head (m)	
		Max	Min	Max	Min	Max	Min
1	Pumps 2100DN (pump discharge line)	169.13	Vac	122.13	Vac	106.13	Vac
2	CW Inlet - 3600 DN (@ beg. of buried pipe)	76.10	Vac	71.48	Vac	60.08	Vac
3	Condenser (beg.)	56.80	Vac	56.50	Vac	50.60	Vac
4	CW Outlet - 3600 DN (@ beg.)	78.68	Vac	59.60	Vac	55.20	Vac

The report recommended minimum setting time for closure for the closure of the discharge valve in case of normal and emergency operations including shut down and power failure. Based on this valve closure time, the number and location of ARVs were accordingly recommended.

Mitigation Options:

Option # 1:

The entire forces acting on the structure and piping needed to be recalculated in view of the transient operating conditions of the system. Subsequent to the revised loads, the structures needed to be strengthened.

However, considering the construction stage of the project (unit was ready for synchronization), it was opined that this may not be an optimal solution.

Option # 2:

Since the root of the problem is the surge (formation of pressure wave disturbance in the piping system), it was decided to mitigate the disturbance during surges. The disturbance in the piping system occurred because of the closure of the valve in a very short span of time compared to the recommended value in the transient analysis, thereby not allowing sufficient time for dissipation of the pressure wave disturbance.

The surge wave can be dissipated without affecting the structure in a normal condition from the duct, if enough time and suitable passage is made available for its release from the pipe header. Installation of addition ARVs was recommended.

Action Taken:

The following modifications were carried out in the piping systems to take care of such disturbances:

- Additional air release valves were installed at the header on jetty, at the place where maximum disturbance was created
- Discharge valve closure period adjusted as recommended in the transient analysis report
- The saddle contact area with the pipe was increased from 120 degrees to 180 degrees, for proper distribution of load
- Cleaned the surfaces of PTFE bearings and ensured the required contact area between insert plate and PTFE bearing

Fig-3

Fig-4

Major operational challenge:

The major challenge encountered during the operations are the bio-fouling, which comprise of both micro fouling and macro fouling. Bio fouling consist of barnacles, tube worms, mussels and debris, which grow and colonize in circulating water system. Of these, M. Sallei is the most dominant, which grows at very rapid rate – deposit of 30 mm in 15 days. About 100 kg/Sq.M of fouling debris accumulates per annum.

High turbidity and high aquaculture, depending on the behavior of the sea like high tides, heavy rains, low depressions, etc., also is affecting the operations.

Consequence:

The greatest hazard of these marine fouling is that they grow, detach and block condenser tubes, cause reduction in efficiency.

Marine fouling along with high turbidity, silt and aqua-culture is causing choking of ultra-filtration system in desalination plant, ACW self-cleaning strainers and debris filters at condenser inlet, thereby affecting the availability and efficiency of the equipment.

The result of these fouling has direct impact on desalination plant output. As there was no other source of fresh water to the plant, there were occasions of unit stopping because of the decreased output of desalination plant due to choking of ultrafiltration units during commissioning phase.

Mitigation Measures:

Marine fouling is being controlled by using chlorine as biocide. Initially it was used to prevent the growth of slime on the inside of condenser tubes. This slime greatly reduces the heat transfer capacity of the condenser.

Bacterial slime can be controlled by injecting chlorine at 2-3 ppm for 15 min every 6 hour. But this had little effect on mussels as they close up when the chlorine is on, and open up and start feeding as soon as the chlorine is switched off. Later, the schedule was revised to continuous dosing and intermittent shock dosing to maintain a minimum free residual chlorine (FRC) of 0.5 ppm.

A modification in hypochlorite dosing system was made to ensure equi-distribution of Hypo Chlorite across the caisson to prevent entry of aqua-culture.

To control the entry of aqua-culture and silt in the feed water of desalination plant, settling chambers were introduced. Later, hydro cyclone separators were introduced to further minimize the ingress of silt in the ultra-filtration system.

Between hydro cyclone separator outlet and ultra-filtration units, auto self-cleaning filters were introduced to reduce the turbidity.

As an additional source, ash water recovery clarifier output was modified to supply feed water to desalination plant during the times of high turbidity.

All these measures helped in improving the availability of desalination plant and reliability of the Station.

Conclusion:

TOPIC: POST COMMISSIONING AND STABILIZATION ISSUES OF NEW PLANT

The contemporary India demands water intensive industries to be located in coastal areas so that they can utilize seawater to meet their water requirements. Such plants erect massive civil super structures like jetty, large size ducts, duct support pedestals, pumps etc. While designing the structures of such large magnitude, special emphasis must be given for all the dynamic scenarios to the system during any operating conditions.

It should be the endeavor of the system integrator to ensure a seamless integration of all the packages. During such integration, the terminal points should be clearly defined and the system integrator should ensure that design input data is appropriately considered by various package vendors.

Reference:

CW System Design basis report

CW System Transient Analysis Report

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