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Energy Audit And Conservation By Balance Cooling Potential Utilization of Cooling water System of A Combined Cycle Power Plant - Case Studies

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ABSTRACT: *The Energy is most important Element of every Human activity . However the amount of energy required for certain work depends upon the technology of uses. Therefore in developed and developing Countries, same product and services require different amount of energy due to use of different Technology. Further the same Technology can not be suitable for all Geographical Locations. The present paper analyzes one such aspect where adaptation of a technology designed for one geographical location failed to performance when used without modification at another location .The paper also highlights one such solution to modify the technology for adaptation to given geographical Location with available resources without creating additional infrastructure ,design Modification and cost.*

Nomenclature:
PHE : Plate type heat Exchanger
ACW : Auxiliary Cooling water
CW : cooling water
T : Temperature
P : pressure
ECW : Equipment Cooling water System
GT_PHE : Plate Type heat Exchanger installed in Gas Turbine
STG-PHE : Plate Type Heat Exchanger Installed in Steam Turbine

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I. Introduction

A typical combined cycle Power plant consists of provisions of operation of units in Combined cycle when both gas Turbine and Bottoming Cycle steam Turbine are in Operation. However for certain duration; Plant operates in open cycle ie only Gas Turbine is operated . In case of only gas Turbine Operation , in most of the design , the cooling system is equipped with fined – fan assisted cooling system. The cooling water is required in gas Turbine for scanner cooling, Lube oil Cooling , Turbine leg Cooling and Generator cooling etc. The Fined fan coolers are not suitable in peak summer months for climatic Conditions similar to national Capital of India. This results in frequent tripping of Gas Turbines due to variation of Parameters ,as cooling water does not get cooled up to desired temperature in Peak summer Months due to high Ambient Air temperature reaching up to 45 ^{o}C.

The present paper is one such case study where the in effectiveness of fin fined coolers were handled by utilization of Balance Cooling potential of Existing steam Turbine water cooling system of waste heat Recovery plant. The General arrangement of cooling water of Gas turbine was earlier as per figure-1. The Cooling was being done with the help of six numbers fans ,each of 30 KW motor capacity supplying air to fined tube water –air heat Exchanger . The Gas Turbines were designed to operate at 32.2 ^{0}C average Temperature.

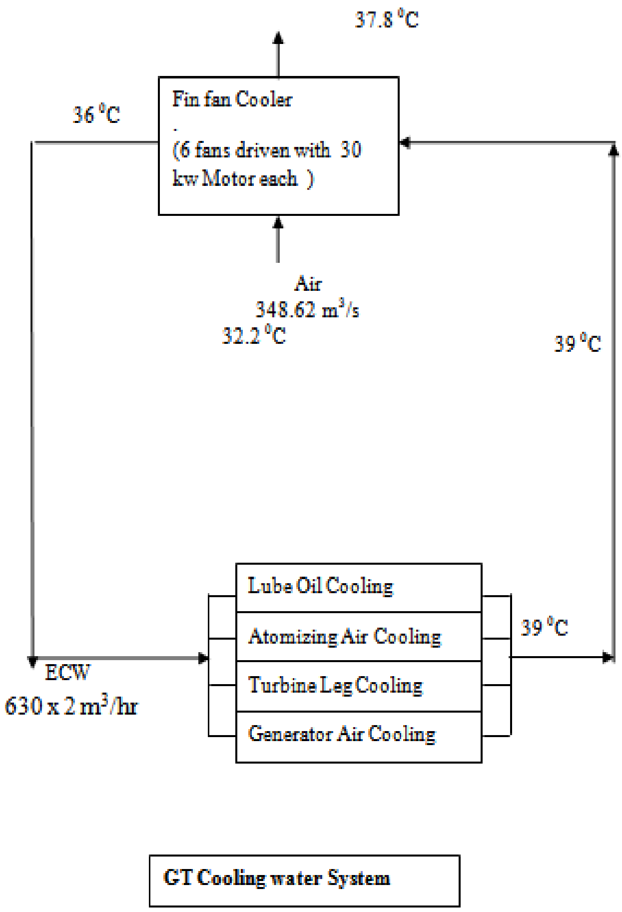

Figure-1: Initial Arrangement of GT Cooling Water System

However during peak summer, the air temperatures of National Capital of India remains above 45^{0}C during the day time. During this period the cooling of cooling water with above arrangement becomes in effective. This results in inability of Gas turbines to operate due to increased lubricating oil and Generator winding Temperature. Thus the gas Turbines could not generate when there is Maximum demand of power due to increased Air Conditioning Load of the city. A careful analysis of layout and design of the plant indicates that the plant is designed to operate in combined cycle mode with separate arrangement of Steam Turbine Lubricating oil. The general arrangement of cooling water system of bottoming steam Turbine is as per figure-2.

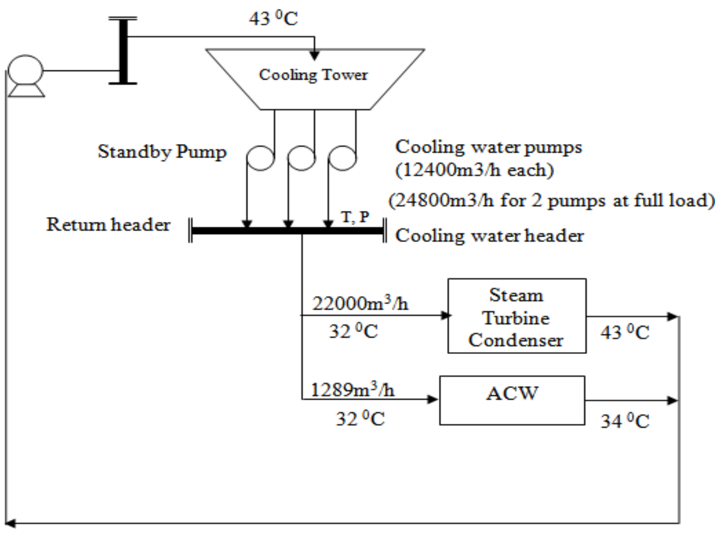

Figure-2: Initial Arrangement of Cooling Water system of Steam Turbine

The total cooling water flow in the system is 24800m3/Hr , which is used for cooling the steam in steam turbine Condenser by maintaining a flow of 22000m3/Hr. The balance quantity around 1289 m3/Hr is used in cooling of lubricating oil system of steam Turbine , in a PHE where de mineralized water is cooled by this water, which in turn is used for cooling Lubricating oil cooler. The condenser and PHE both are designed for a Temperature rise of 10^{o}C, however in case of Auxiliary cooling water system, there is hardly a temperature rise of 2^{o}C in all seasons . Thus ACW cooling water has the potential of further taking the heat up to designed temperature rise of 10^{o}C.

Therefore in order to further explore the potential of use of balance cooling capacity of ACW water , the PHE out let temperature and drop in pressure was recorded for all seasons . The study concluded that there was only 2^{o}C Temperature rise in ACW water and pressure drop was negligible. Thus PHE out let water has potential to further take the heat load of 1400 kcal/second ,though the heat load of gas turbine is only 538.86 kcal/second. Thus availability of ACW water of 1289m^3/Hr matched the cooling water requirement of two Numbers of Gas Turbines of 630m^3/Hr each. However given the potential of balance cooling capacity of ACW water ,even half of the flow of ACW water is sufficient

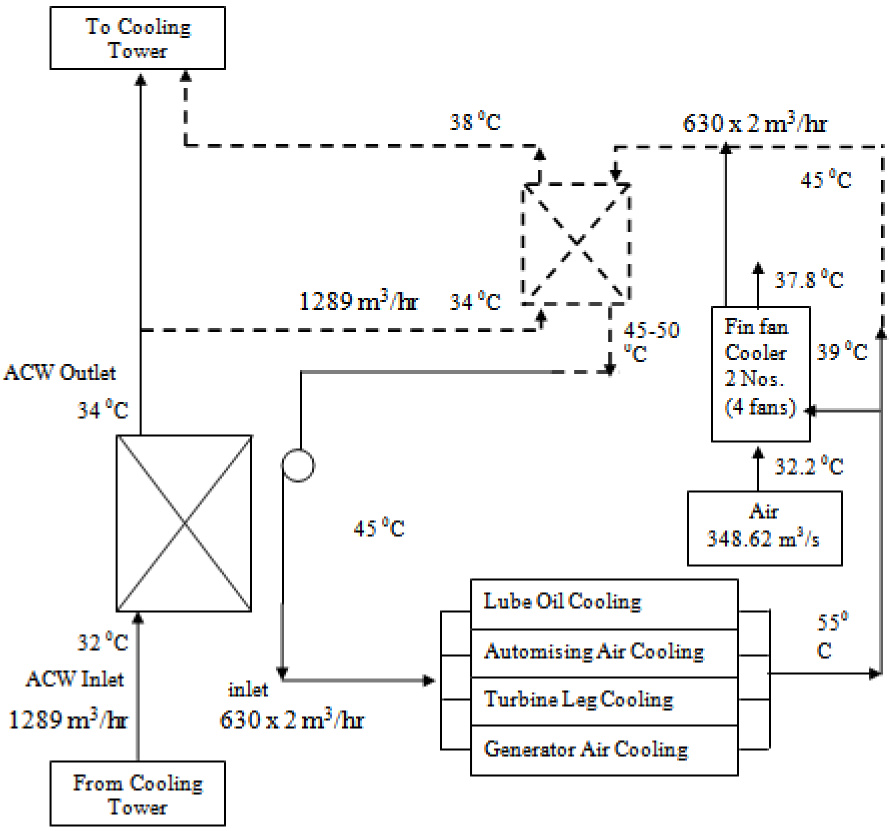

Figure-3: Integrated arrangement of cooling water System

To take heat load of both gas Turbines. Therefore cooling water arrangement of both Steam and Gas Turbines were integrated as per figure-3.The above integration and balance cooling water capacity utilization needed no additional pumping and major modification in the existing cooling water system of both steam Turbine and gas Turbine. The total cost of modification and system integration involved the cost of valves, piping, PHE including civil work. This is about INR 8000000.00 . The implementation of the system has resulted in saving of 360kw Electrical power of fans of fin –fan coolers of gas Turbines for all seasons in combined cycle operation. The total annual energy saving computes to INR 12614400 @ Electricity cost of INR 4/kwh. The pay back period is 7.6 months. Further assuming 1o % of saving is used to meet the operation and maintenance expenditure in terms of cleaning of PHE, attending valves, pipes for any leakage and mall functioning and 12% of discounting of fund flow, then for 10 years of initial PHE life ,the fund flow of the energy conservation is as per table -1:

Energy rate(Rs/kwh)	**Internal rate of return (IRR) in %**	**Net present Value (NPV in INR**
2	**63.39%**	**20866040.21**
3	**95.67%**	**35299060.32**
4	**127.69%**	**49732080.43**
5	**159.64%**	**64165100.54**
6	**191.58%**	**78598120.64**
7	**223.51%**	**93031140.75**
8	**255.44%**	**107464160.9**

Table-1. Economics of Modification with Sensitivity of Fuel price variation

Thus the energy conservation option is feasible even at vide variations of Energy input cost , the pay back period being less than a year.

II. Conclusion

The above implementation with minimum modification in conventional design of gas turbines by using balance cooling capacity of already existing cooling water system, is an excellent example of the Energy and resource conservation by system integration . The utilization of balance cooling capacity results in saving of 360 Kw of Electrical energy . This is excellent example of Energy conservation by way of process Integration at operational stage of the plant without much modification. The case study can be replicated in similar organizations with similar set of design and operational problems in cooling water system . The idea can also be replicated in any climatic condition for any cooling water requirement where balance cooling capacity of one system is sufficient to replace the cooling water system of another facility within the organization or other adjacent organization with financial settlement.

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