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Feasibility of Working of Evaporative Condenser cum Thermal Desalination System

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***Abstract*- Water is considered as most precious and scarce resource for recent and upcoming era, especially in the area where fresh water is not available with an ease. In most of the countries and cities situated near sea shore pure fresh water resources are insufficient even for drinking purpose and it is not viable for using water in big power plants for cooling purpose in condenser and cooling tower circuit. However big evaporative type or dry air cooled condensers are used in such power plants. In such cities desalination is also carried out on large scale for fresh drinking water demands. When it comes to thermal desalination, weather high heat energy is to be provided or vacuum is to be maintained in order to generate steam out of salty water and further condensing it to get pure desalinated water. Both of the above mentioned process are costly and consumes either good amount of low grade energy in form of heat or high grade energy in consumed in vacuum pumps, a minor defect caused in such systems lead to significant losses and may affect the thermal efficiency to higher extent. In present study a combined set up of evaporative condenser cum thermal desalination system is proposed with working diagram. the efficiency and pure water recovery from the proposed system may not be as high as conventional systems, but it is beneficial as it is working on waste heat recovery principle and very less running cost is incurred leading towards fuel saving and ecofriendlyness ,which is need of the hour.**

Index Terms- thermal desalination, dry air cooled condensers, evaporative condenser cum thermal desalination system.

I. INTRODUCTION

Water is one of the most basic and essential component for human life and other living beings. About 70 % of planet surface area is covered by water bodies and about 97.5 % of this available water is salt water in form of oceans and salty lakes, Out of remaining 2.5 a major portion is locked up in glaciers. Hence less than 1 % of the world's fresh water (~0.007%) of all water on earth is accessible for direct human uses. Even less than 1 %(small fraction) is believed to be adequate to support all life's on earth but due to problems like global warming, water pollution, and unequal distribution of water resources, fresh drinking water is a great problem of many areas , and there are many cities situated on sea shore having abundant of salty water but Fresh and pure drinking water in abundance is still a great problem.

Desalination is a process in which salt of water is removed in order to make it suitable for domestic and industrial purposes. It is also called as desalting or desalinization. Desalination is very common and popular process nowadays used specially for treatment and obtaining pure water out of sea water (containing 3-5%) of salt and very abundant in nature.

Desalination can be done in a number of ways depending on source such as sea water or brackish water also the available energy to get pure water

Presently there are three main types of desalination processes, namely- distillation, reverse osmosis and electro dialysis. The selection of right process depends on factors such as initial capital investment, plant capital, operation and maintenance costs etc. scientists and research scholars all over the world are constantly working in developing economical process so as to generate fresh water on large and economical sales. During last three decades the combination of R & D work and operating experience favours distillation (thermal desalination) and reverse osmosis method as most promising method of various process of desalination.

In above mentioned conventional processes of desalination, a huge amount of high grade or low grade or mix of both energy consumed in order to obtain pure desalinated water. Other than renewable energy, more energy consumption is directly proportional to environmental pollution. It is really unfortunate to waste large amount of precious energy just for very basic need of human being, in form of water. The use of renewable energy like solar heating at higher or lower temperatures to generate steam, with or without evacuation is desired, but availability of renewable energy is not uniform and it varies according to seasons and climate, moreover storage of renewable energy is a big challenge and one of the most highlighted topics of modern research. The waste heat utilization from big capacity plants and systems, and using this waste heat for obtaining pure desalinated water out of salty water is one of the best solutions to this problem. The main benefits associated with waste heat recovery systems is uniformity in operation with very less fluctuations in output and very less operation cost , which increase efficiency of overall system and indirectly reduces pollution to the environment.

In present study , a model is proposed in which waste heat rejected in evaporative condensers , at lower temperatures are used to increase the humidity and temperature of air flowing through outer walls of steam carrying pipes surrounded by sprayed salty water. The hot and humidified air at the exit of the evaporative condenser is again cooled below its dew point temperature in order to gain condense desalinated water, used for drinking purpose. A small modification is required in conventional evaporative condenser systems in order to prevent outer surface of pipe from salt deposition and relative fouling that is also discussed in this study.

II. LITERATURE REVIEW

As most of the condensers working temperature is less than 100°C , and only few degrees more than ambient temperature for better thermal efficiency of plants and even at this temperatures steam is almost dry due to vacuum is maintained inside condensers.

Hence the temperature at which latent heat of condenser is recovered is less , so literature review is performed on low temperature desalination systems and combined results are discussed .

Tay at el.(1996,[1]) studied the feasibility of a vacuum based desalination system operating at a vacuum of 0.1-0.7 bar evaporating water at 40-90°C heated using waste heat from a steam turbine.

Lourdes & Carlos et al.(1999,[2]) concludes that the use of solar energy could compete with a conventional energy supply in MSF distillation processes depending on the climatic conditions.

Lalzad et al. (2007,[3]) conducted experiments on barometric vacuum desalination system and demonstrated that a flat plate collector of area 4 m2 with an efficiency of 50 % can provide 14-17 kg of distillate per day, which is enough for the basic water needs of an average family in the areas facing severe drinking water problems.

I.W.Eames et al.(2006,[4]) confirmed the technical feasibility of a solar-powered barometric desalination system, in which the vacuum produced in the vaporizer, was due to the elevation of the vaporizer above mean sea level. It is estimated that a solar panel with a area of 4.727m2 would be sufficient to provide 30 liters of fresh water per day, which is considered as the minimum requirement of one person.

Joseph et al. (2005,[5]) developed a single stage solar desalination system using flat plate collectors. The performance of the system was 3 times higher than the yield of a solar still yielding 8.5 liters of fresh water per day .

Shaobo hou et al.(2008,[6]) presented a two stage solar multi effect humidification de-humidification desalination process plotted from pinch analysis. The sketch of two stage multi effect humidification dehumidification desalination process is given. The solar evacuated tube collector is employed in the desalination system, multi effect (HDD) process are plotted in two different temperature range according to pinch technology. The higher temperature range is from 60- 80° C and the lower is from 30 – 60 °C. the mass flow rates of dry air in the two stage desalination units are different. The pinch analysis chart is given. According to pinch chart, the energy recover rate could higher according to working temperature range.tha research proves that the multi-effect HDD has much room to be improved.

K.S Reddy and K Ravi Kumar et al. (2012,[7]) has developed a novel multi-stage solar desalination system by utilizing latent heat recovery. A transient model is proposed for the solar desalination system.

The effect of various design an operating parameter on the system performance is studied to optimize the configuration. The distillate yield increases initially due to in hence evaporation caused by the presence of thin layer water in the stages. The distillate yield decreases with increase in salinity of water due to an increase in ion activity and the reduction of thermodynamically spontaneous change from liquid to vapour the optimum number of stages, gap between the stages and the supplied mass flow rate for the system were found to be 4100 mm and 55kg /m2/day respectively throughout the year the overall thermal efficiency of the system is found to be 53.9 % and 29.6% for the month march and December respectively in India the maximum yield of 53.2 kg/m2/day is found in march at an operating pressure of 0.03 bar. The multi-stage evacuated solar desalination system is a viable option to meet the needs of rural and urban communities.

For study of waste heat recovery at lower temperatures some literature review are discussed here.

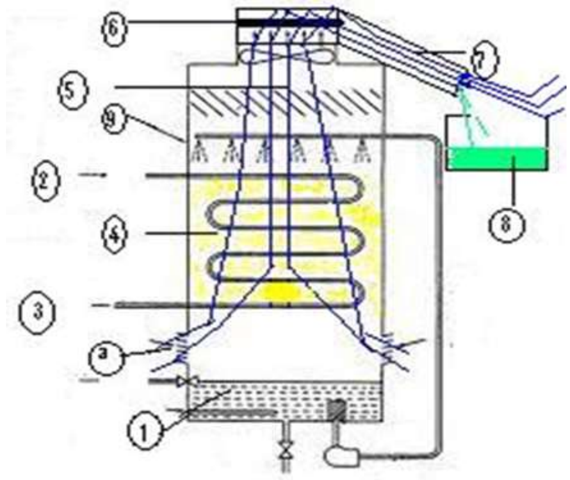
Jain et al.(2013,[8]) used waste heat of an air conditioning system to heat the feed water r of boiler plant and accounts to increase efficiency from 76.33% to 76.53% which reduces fuel cost from Rs. 8, 04,000 to Rs. 8, 01,934 per day

Weerasiri et al.(2014,[9]), 2014 worked on increasing efficiency of a 100 MW, DG SET power generation system, which was accomplished by utilizing waste heat of flue gas in making steam and further used to drive steam turbine. From the chosen steam turbine, 12884.4 MJ of energy was recovered per hour. This amount is 21.89% of recoverable total energy of flue gas per hour basis.

Almost no work is recorded on waste heat recovery on evaporative condenser, the idea of it's working set up is suggested in this study.

III.WORKING PRINCIPLE

The main parts of proposed evaporative condenser cum thermal desalination system are given as: 1) salty water storage and recirculation pump 2)steam carrying pipes 3) steam exit condensate tank 4) metals scrap grid surrounding outer surface of steam carrying pipe 5) air outlet fan 6) cooling or dehumidifying coil 7)cold dehumidified air exit ducts 8) desalinated water condensate collection tank 9)salty water spraying nozzles. A schematic working diagram is presented with mentioned parts



Fig(3.1): schematic of evaporative condenser cum desalination system

In the schematic diagram, air flow is represented by blue color, desalinated water obtained in collection tank is represented by green color, and yellow color shows the waste metal scrap which traps and atomize the salty water sprayed.

Unsaturated air enters the system by forced convection, obtained by forced or induced draught type fans, this air is passed through metal scrap grid present at the outer surface of the steam carrying pipes, where it comes in contact with atomized hot salty water (sprayed by nozzles) which gradually increases humidity and temperature of air to some extent and tends to reach towards wet bulb temperature. The latent heat released by steam is used in increasing temperature and humidity of air, by pushing more evaporated atomized water in air. The humidified air is then passed through cooling coil where temperature is maintained below dew point temperature of air and air is dehumidified resulting in moisture recovery in form of desalinated pure water. The main function of the metal meshed grid is to atomize the salty water sprayed by nozzles which helps in hot water evaporation from grid surface; also this surface is removed easily and replaced by new grid after some cycles of operation as salt is trapped in the grid led to fouling and decreasing heat transfer coefficient. The metal scrap grid is another novelty proposed in this system in place of grilled outer surfaces of pipe provided to maintain baffled air flow and to act as fin. Grilled surfaces however cannot be used in this type of systembecause we are using salty water here which led to salt deposition on grilled surfaces and it cannot be replaced repeatedly, where as metal scrap grid provides the same function of grilled outer surface and it can be replaced easily as it is fixed to outer surface and not welded. Also better waste management of metal scraps is obtained.

Fig (3.2): metal scraps produced from machining processes, used for making outer surface grid

V. CONCLUSION AND DISCUSSION

Waste heat recovery played a great role in working of many energy conservation based project as discussed earlier. In this set up also waste heat will be recovered and utilized for desalinated water production out of salty water. A uniform amount of desalinated water is produced with very low operation and maintenance cost in comparison to conventional systems where vacuum pumps are used. In this system only metal scrap buying and changing, as well as cooling coil operation cost is incurred. The desalinated water output may vary depending on climatic conditions like relative humidity and dry bulb temperature.

VI. FUTURE SCOPE

Prototypes and realistic working models can be tested and compared with conventional systems on various parameters like water yield, operation an maintenance cost, seasonal fluctuation in yield and life of the system etc. due to waste heat recovery principle idea looks promising for future scope.

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