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Study of Thermal Performance of Absorption Refrigeration Cycle

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ABSTRACT:

Vapour Absorption Chillers (VAC) find application in summer air-conditioning whereas heat pumps are used in winter air-conditioning. These systems operate on heat (low grade energy) whereas conventional Vapour Compression Chillers (VCC) consume electricity (high grade energy). In addition to the above, some hybrid systems have also been developed by engineers. The chillers based on vapour absorption are environmental friendly as they use chemical compounds which have low Global Warming Potential (GWP) and also low Ozone Depletion Potential (ODP). The common working pairs used in absorption cycles are LiBr-water and NH_3-water. Properties of working pairs have been the centre of attraction besides the configuration of the cycle. It is observed that although absorption cycle has a low coefficient of performance but their running cost is low and are environmental friendly.

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INTRODUCTION:

Vapour absorption chillers are heat operated systems and are systems of green energy and technology [1] as they use environmental friendly chemical working pairs like LiBr-water, ammonia-water, LiCl-water , ammonia - $LiNO_3$,etc. The Second World War saw the booming period of Absorption Technology , especially in USA where heating , ventilating and air-conditioning (HVAC) industry was the beneficiary[2]. In India this technology is pioneered by THERMAX, VOLTAS and BLUE STAR etc. In Japan, Hitachi, Kawasaki, Mitsubishi, Sanyo etc are pioneers. Among applications of these systems , solar cooling and combined cooling , heating and power (CCHP) for residential (small capacity) and industrial (large capacity , 2000-3000 tons) like hospitals, school buildings are recent ones. These machines use negligible electrical energy for running the pump which can be neglected for finding the performance parameter (COP). Some machines are pump-less which use Bubble pump for their operation. Thermax has recently commissioned Triple effect vapour absorption chiller. In these systems LiBr-water find application for air-conditioning whereas ammonia- water find application in refrigeration also. Some nano-materials when added along with these working pairs also improve COP, as they effect the heat transfer rates.. Some surfactants also find application for improving heat and mass transfer. Among the different sources of thermal energy added to the generator, solar is beneficial . Geothermal, Biomass, Natural gas, exhaust from internal combustion engines and steam bled from steam turbines in thermal power plants are the other alternatives .The heat pumps operating on VACs are also used for heating the space. Heat transformers are also used to obtain the temperature lift . As far as selection criterion of working pairs is concerned, major one is separation of the pure refrigerant from the strong solution and secondly the crystallization of the absorbent. Both single and multi-effect heat pumps are used at large tonnage scales. Attempts are being made to commercialize these systems on a small tonnage operated by solar or liquefied petroleum gas. Also new working pairs are sought after which are sustainable, cheap, easily available and do not disturb the regulations of the Kyoto Protocol and the Montreal Protocol.

MODELS: Several models have been developed to improve the performance. These include double effect, triple effect, quadruple effect and the hybrid ones [5].

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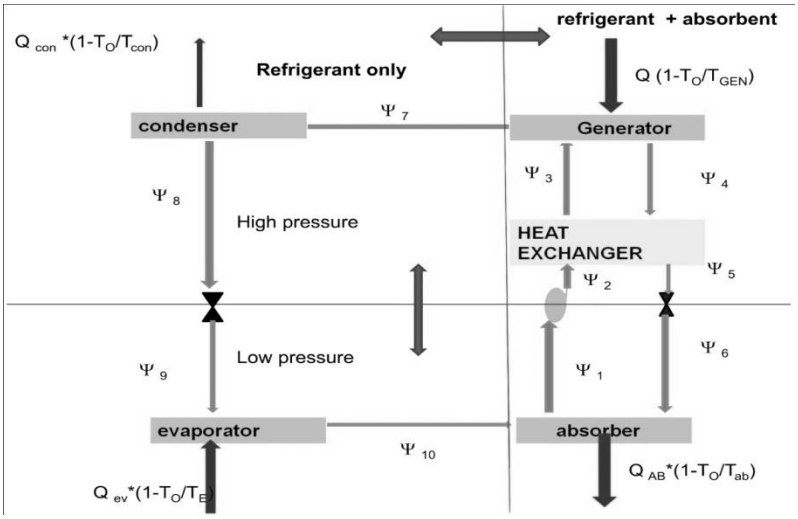

Fib1: LiBr-water Absorption Airconditioning Chiller

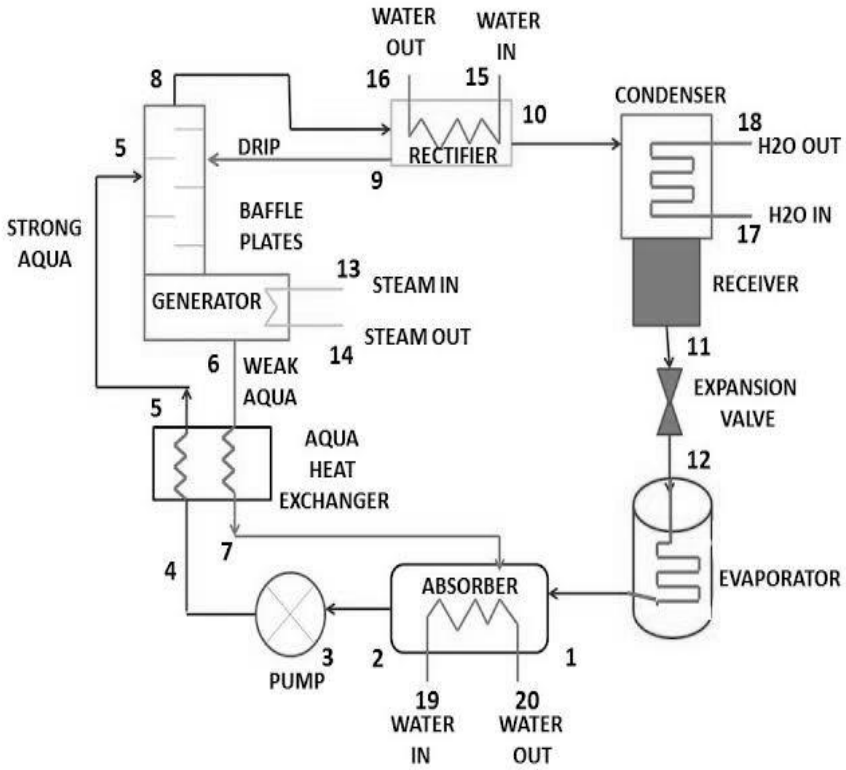

Fig.2 Ammonia-water Refrigeration Chiller Incorporating Rectifier.

Both parallel and series configurations have been modeled with COP in the vicinity of 0.8 to 1 for double effect to 1.2-1.4 for triple effect [5]. In the double effect, there are two generators and in the triple effect , there are three generators. Series and parallel configuration can be developed for both double effect and triple effect. For research purposes as observed in the literature , quadruple and higher effect models have been studied. The maximum COP keeps on increasing as the number of effects are increased. Major problem is that these systems occupy large space , there initial cost is high , but the biggest advantage is that there running cost is low and there maintenance is also negligible as there are few moving parts. . Hybrid model involves combination of

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compression and absorption cycle together[6]. LiBr-H_2O and R134a are used in combination in figure given below . LiBr-H_2O and CO_2 based cascade chillers are also used

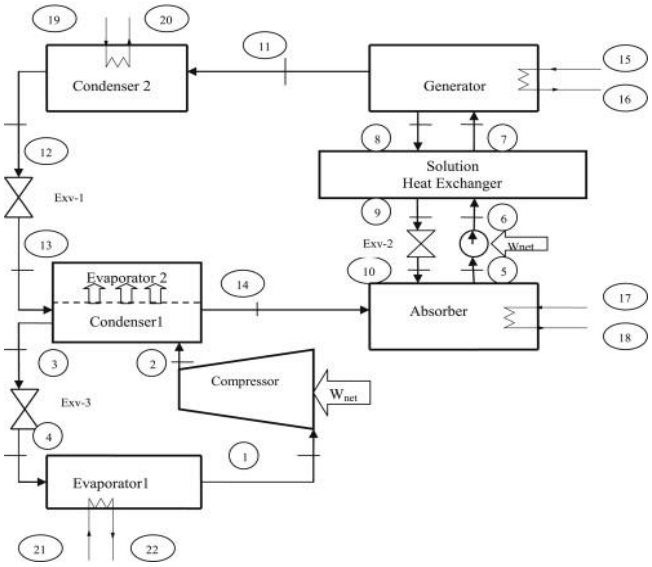

Fig. 3. Cascade Compression and Absorption Cycle

DIFFERENT WORKING PAIRS:

Different working pairs are selected on the basis of thermal and chemical stability including minimum crystallization levels and corrosion issues. Crystallization is a major issue which should be avoided [3]. On this classification basis there are more than 150 absorbents such as Li-Br, Li-Cl, organic chemicals etc and more than 40 refrigerants such as H_2O, NH_3 , R134a/R12/R22, Methanol, n-propanol, Methyl chloride , CO_2, etc. [3,4]

Ammonia is used as a refrigerant mainly for refrigeration purposes whereas water is used as a refrigerant mainly for air-conditioning purposes as it freezes at lower temperatures. Rectifier is needed in ammonia-water systems whereas no rectifier is needed in lithium- bromide water systems. Carbon-dioxide gas , although being a greenhouse gas is again making inroads for air-conditioning both for compression and absorption cycle and also in hybrid systems involving a combination of vapour absorption and vapour compression cycle.

RESULTS:

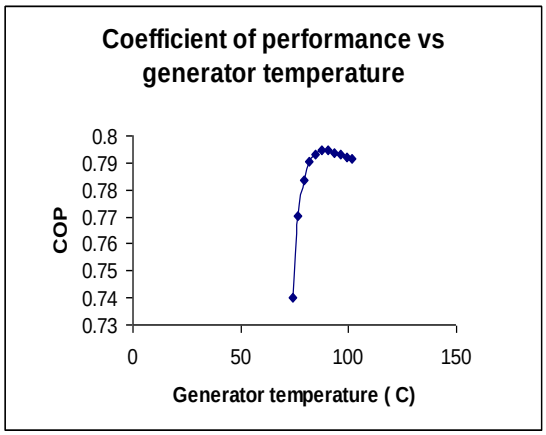

Fig. 4: Typical Variation of COP with Generator Temperature

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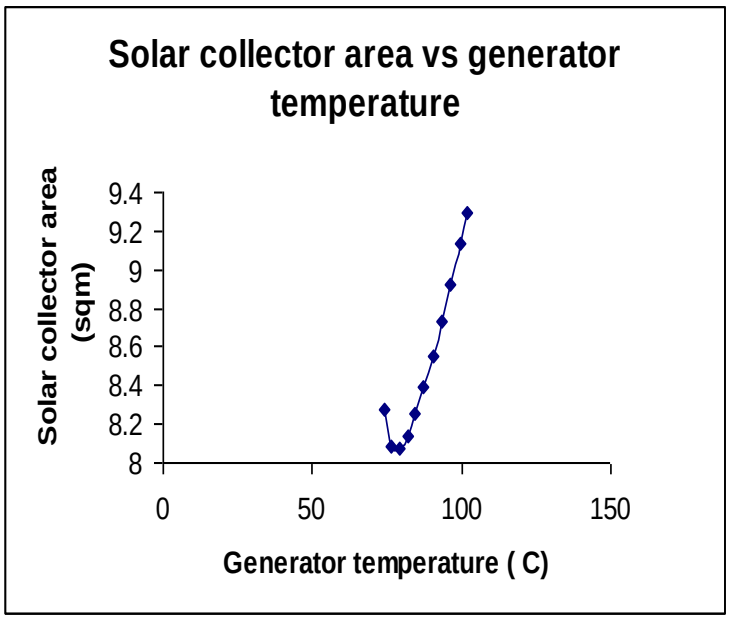

Fig.5. Typical Variation of Collector Area with generator temperature

The above figures show that the cost is effected by working conditions , mostly by the generator temperature and indirectly the heat source temperature. Fig 6 [13] shows the variation of generator temperature with that of evaporator. Fig. 7. Shows the variation of flow rate ratio with evaporator temperature.

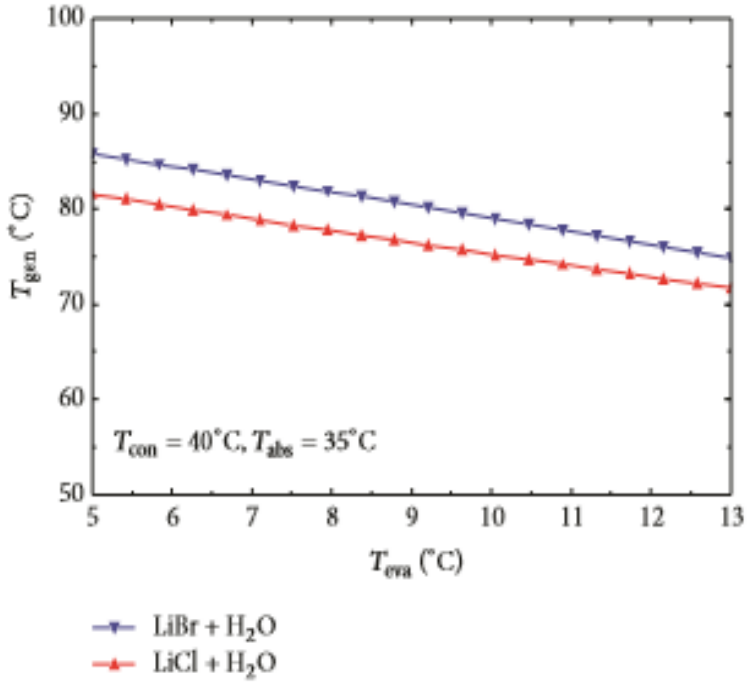

Fig. 6. Effect of evaporator temperature on generator temperature[13]

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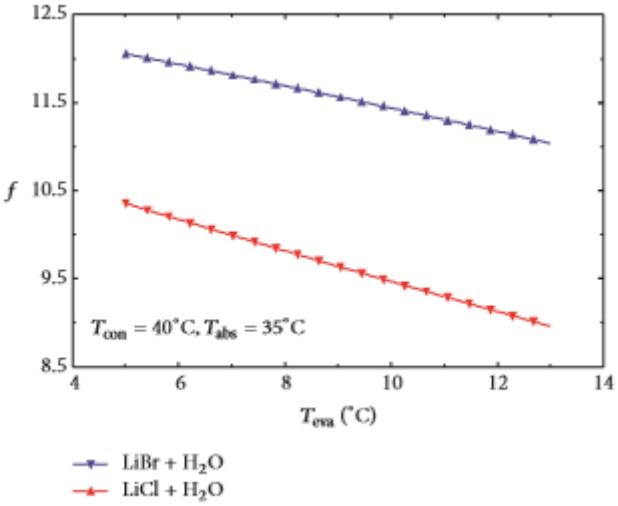

Fig. 7. Effect of evaporator temperature on flow rate ratio[13].

CONCLUSIONS:

1. In the literature overview, it is observed that coefficient of performance increases as the number of stages increases from half-effect to triple effect.
2. It is found out from numerical study that coefficient of performance increases and than becomes stagnant and then reduces as we increase the desorber temperature.
3. The economics of vapour absorption chiller is also affected by working parameters especially the generator temperature. The solar collector area first decreases , then reaches minima and again increases.

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