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Study on Performance Enhancement of Solar Ejector Cooling System

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Abstract: Cooling sector is dominating by vapor compression cooling sector which uses refrigerant which are harmful to environment. The solar ejector cooling system is alternative for vapor compression cycle which uses solar energy to give heat to the generator, which is a viable method for heat generation. The solar ejector cooling system not only fulfills cooling requirement but also helps in energy conservation and protection of environment. It reduces the generator work and decrease the throttling losses. Maintenance requirement and cost is low for ejector cooling system .In this paper, theoretically study is done on enhancement of the performance of solar ejector cooling system. Various system configuration are presented with detailed design. This system still needed a lot of research work to make it alternative for vapor compression cycle based cooling system completely.

Keywords: Ejector, Cooling system, Solar system, Ejector design.

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I. INTRODUCTION

Now a days, Air cooling systems in the world are dominated by vapor compression machines, which consumes more electricity and gives high load during summer season. Solar cooling systems are classified into two parts, solar electricity driven and solar thermally driven processes.[1] Most commonly used in solar electricity driven is vapor compression based cooling system, driven by a photovoltaic system(PV). These are used for small application and requires low maintenance[2], But PV solar cooling system is only limited to daytime. Whereas in solar thermally driven cooling system, the solar collector produces heat which is converted into mechanical power required to compress the refrigerant.Ejectors can be classified into two types one is constant pressure mixing ejector and another is constant area mixing ejector[3]. In constant pressure mixing ejector, the incoming flow in the mixing chamber from nozzle and evaporator is equal[4,5]. And mixing starts with constant pressure. In constant area mixing ejector, the incoming flow in the mixing chamber from nozzle and the evaporator is happen at constant area section[6,7]. Solar ejector cooling system can be an alternative for cooling system as it can produce 5-10°C evaporator temperature from low grade energy input[8]. However, disadvantage of this system is that it has moderate C.O.P(Coefficient of Performance)[9,10]. For high C.O.P pilot scale steam ejector with generator temperature of 200°C is used[11]. Constant pressure mixing ejector gives better performance than constant area mixing ejector because of generation of high compression ratio for the same C.O.P[12]. Supersonic ejector can give better result than normal ejector as it reduces the shock from the ejector[13]. An experimental investigation found that ejector-to throat area ratio is also a main parameter in design of ejector[14]. A variable geometry ejector is used to counter with unstable heat source[15]. A special consideration is taken to avoid the formation of liquid droplet so superheated of the refrigerant are done. In some studies it is found that in transferring of heat water has some great advantages in solar ejector cooling system[16,17,18]. And its low cost and safety use make water good alternative as a working fluid in the ejector system[19]. Environment-friendly refrigerant become the hot topic in ejector cooling system[20].

On the basis of cooling system, vapor compression system are same as of ejector cooling system but the only difference ejector cooling system use generator with an ejector. The simple solar ejector cooling system consists three loop, solar loop which provides heat to the generator shown in fig 1. in generator the working fluid become vapor of high temperature end high pressure vapor. Then it enters into ejector where it pass through nozzle the high pressure vapor accelerates. At the end of nozzle the pressure of vapor decreases as its velocity increases. Due to low pressure at the end of nozzle than the evaporator, it draws vapor from the evaporator and mixed with primary flow in mixing chamber in ejector. The mixture from the mixing chamber enter into diffuses where its pressure become high and this high pressure and high temperature vapor refrigerant enters into condenser and in condenser vapor refrigerant is converted into liquid refrigerant by giving heat to the surrounding. Some part of liquid pump to the generator and remaining part enter into evaporator through expansion value. In expansion value, the pressure of refrigerant decreases and this refrigerant enters the evaporator and in evaporator the heat is taken from space where cooling is required and liquid refrigerant is converted into vapor and enters to the ejector.

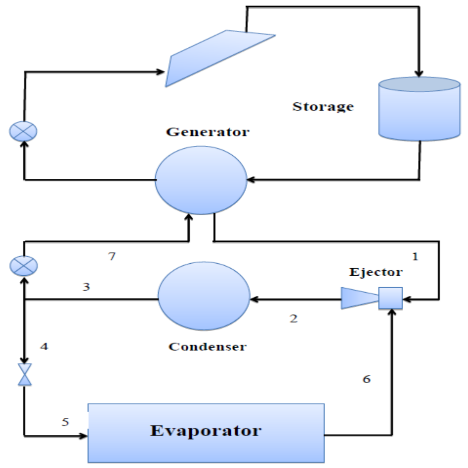

Fig 1

Design of Ejector

There are three main parts of each ejector; a nozzle, a mixing chamber and a diffuser shown in fig 2. The nozzle has geometry of converging venture whereas geometry of the diffuser is diverging venture. The ejector, fluid properties and stream flow rates dimensions explain the ejector capacity and performance[21]. The operation parameters are generator temperature(Tg), evaporator temperature (Te) and condenser temperature (Tc) Sankarlal and Mani [22] study says that by increasing the value of Tg; the COP increases. If condenser pressure is below the critical back pressure. Then COP will be constant and if condenser pressure is more than critical back pressure then he entrainment ratio and COP will decreases. The COP of solar ejector cooling increases with increase in Te. Pridaswes and Landquist [23]concluded that for higher efficiency high temperature solar collectors hot needed. Huang et al. [24] concluded that single glazed collector is best suited for solar collector.

The design factor which have most influence on performance of solar ejector refrigerant is working fluid.

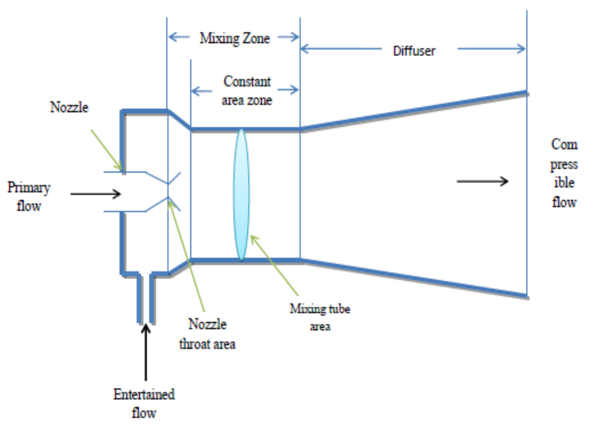

Fig 2

Performance Enhancement of Ejector Cooling System

To enhance the performance of solar ejector cooling system, the conditions of ejector is to be improved. But ejector only designed for particular conditions, it does not perform on other condition. So a parallel array of ejector with different dimension is placed shown in fig 3. The selection of ejector from parallel array of ejector is done by condenser pressure.

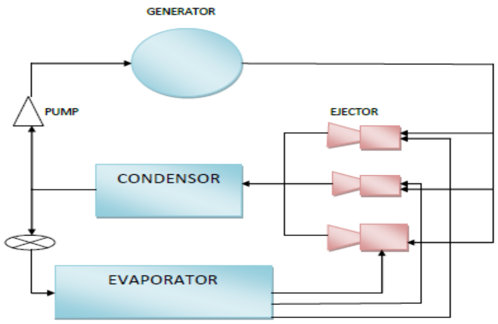

Fig 3

A solar ejector cooling system with booster can be used to enhance the performance of simple solar ejector system shown in fig 4. Booster increases the pressure of vapor after evaporator. Inter cooler are placed between the booster and ejector, which helps to increases the mass flow rates so that more vapor can be sucked into ejector and it maintains the intermediate pressure. This results increases the COP and 60% decrease in solar collector area.[25]

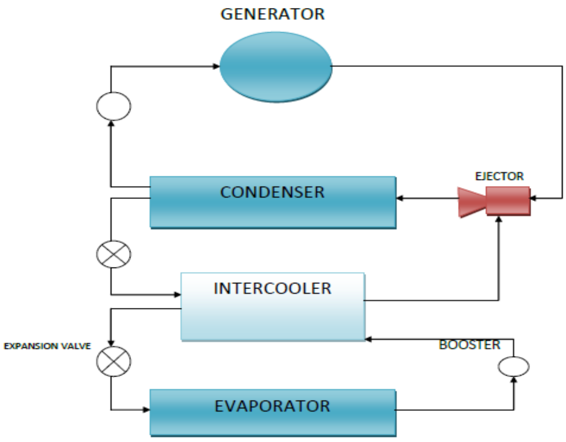

Fig 4

A solar ejector vapor compression cascades system is shown in fig 5. In this condenser work as evaporator for ejector system, by doing this COP of cycle is increased and low evaporator temperature can be achieved. [26,27]

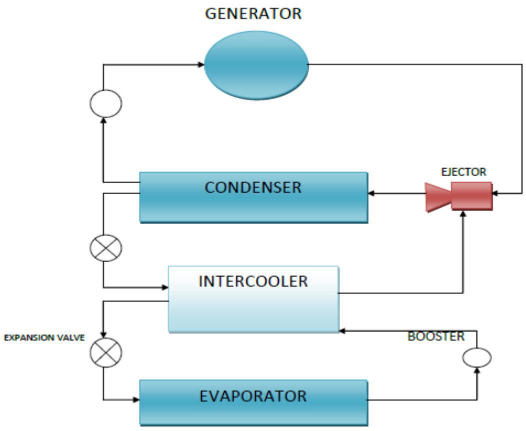

Fig 5

A combined ejector absorption system is shown in fig 6 it is divided into two parts, one is ejector system another is absorption cooling system in this ejector is used to decrease the pressure of refrigerant while entering into absorber[28,29]. This arrangement helps to achieve low temperature at evaporator which increases the COP of system.

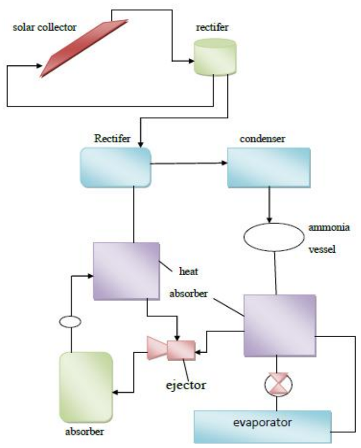

Fig 6

An ejector cooling system shown in fig 7 with regenerator is used to decrease the work of generator and help to suck more vapor in the ejector. By reducing the generator work COP of system is increased.[30]

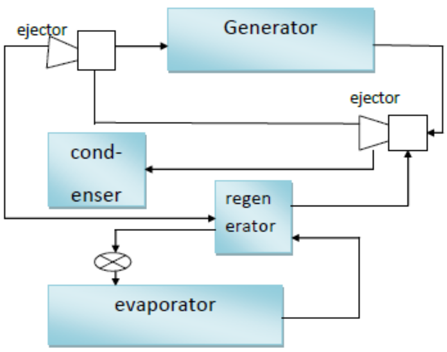

Fig 7

A bi-ejector cooling system is shown in Fig 8. One ejector is placed between evaporator and condenser, it helps to suck vapor from evaporator and second ejector is used to pump the refrigerant from condenser to generator it reduces the work of generator and produce low temperature in evaporates, COP of this system is higher than the conventional ejector cooling system[31].

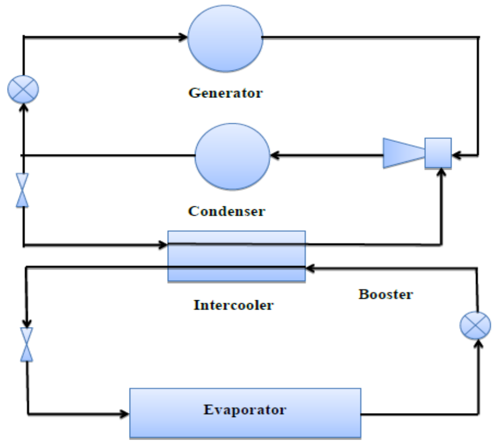

Fig 8

CONCLUSION

This paper presented some alteration in solar ejector cooling system to enhance the performance of conventional ejector cooling system. There are various system configuration for ejector-cooling system which can increase the COP and performance of ejector cooling system. By using adjustable ejector, we can modify the system as per condition. Introducing booster after evaporator can increase the mass flow rate of vapor flowing into the ejector, which produces low possible evaporator temperature. Booster can be placed before generator to decrease the generator work. A jet pump can also be placed before generator to increase the temperature of working fluid before entering into the generator.

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