

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 3, March 2019

# Integrated Solar and Thermal Desalination Using Diesel Engine Exhaust Waste Heat

K.Mahesh Kumar<sup>1</sup>, M.Dharanraja<sup>1</sup>, G.Nagarajan<sup>1</sup>, S.Palani Vel<sup>1</sup>, K.S.Maheswari<sup>2</sup>

U.G. Student, Department of Mechanical Engineering, Francis Xavier Engineering College, Vannarpettai,, Tirunelveli,  
Tamil Nadu, India<sup>1</sup>

Associate Professor, Department of Mechanical Engineering, Francis Xavier Engineering College, Vannarpettai,  
Tirunelveli, Tamil Nadu, India<sup>2</sup>

**ABSTRACT:** The aim of this work is to utilize the heat energy wasted in exhaust gas of an IC engine of low capacity for desalination using a horizontal tube straight pass evaporator and a condensing unit, without aid of any external energy and integrate with solar energy is used to this desalination process. Producing Fresh water from sea water using the heat wasted in flue gas of a diesel engine is the project. The work proven that 1.8 liter/hr of saline water can be desalinated from the 5 HP Engine Exhaust gas, without affecting the performance of the engine. We also recover the heat energy removed in condenser which uses the water as a cooling element . That's also taken into the process of desalination using solar still. The global warming is also reduced considerably.

## I.INTRODUCTION

Although India occupies only 3.29 million km<sup>2</sup> geographical area, which forms 2.4% of the world's land area (Rakesh Kumar et al 2005). India has 16 % of the world's population and four % of its fresh water resources. The fresh water crisis is already evident in many parts of India, varying in scale and intensity at different times of the year. Multiple-effect distillation (MED) is a distillation process often used for sea water desalination. It consists of multiple stages or "effects". In each stage the feed water is heated by steam in tubes. Some of the water evaporates, and this steam flows into the tubes of the next stage, heating and evaporating more water. Each stage essentially reuses the energy from the previous stage. Direct sunlight has been utilized long back for desalination of water. Solar distillation plants are used for supplying desalinated water to small communities nearby coastal remote areas. Solar stills are easy to construct, can be done by local people from locally available materials, simple in operation by unskilled personnel, no hard maintenance requirements and almost no operation cost. But they have the disadvantages of high initial cost, large land requirement for installation and have output dependent on the available solar radiation. If there is no sunshine, the productivity is almost zero for conventional basin type model. However, from the simplest basin type models of solar still in earlier days, researchers have progressed a lot to increase its efficiency. Suitable modification of solar still can produce high output using minimum areas of land and even in cloudy days. One of such upgraded version is capillary stills, which are gaining popularity for their high output. The heart of capillary still is a fabric (woven or non- woven) which facilitates rapid evaporation of water at minimum heating

## II LITERATURE REVIEW

### **K.S.Maheswari, R.Samuel Hansen and S.Ananth (2016)**

In their study they have utilize the heat energy wasted in exhaust gas of an IC engine, of low capacity for distillation desalination using a submerged horizontal tube straight pass evaporator and a condensing unit, without aid of any external energy use for pumping system. In this work a Horizontal tube Straight pass evaporator designed fabricated and experiments were conducted. The performance of the SHTE analyzed under various load

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 3, March 2019

condition. The work proven that 1.8 liter/hr of saline water can be desalinated from the 5 HP Engine Exhaust gas, without affecting the performance of the engine. By utilizing the heat energy in addition to increase in overall efficiency the thermal Pollution is also reduced considerably .

### **Anderson L.Z. and Robert Nation H. (1982)**

In their study they have fabricated a shell and finned tube heat exchanger integrated with an IC engine setup to extract heat from the exhaust gas, and stored the thermal energy in a storage tank. They have conducted their experimental study in twin cylinder, four stroke, water cooled, Kirloskar make diesel engine (Specifications-bore 87.5 mm, stroke 110 mm, rated power 7.4 kW at 1500 rpm). The energy recovered from the exhaust gases can be stored in the form of sensible heat of a solid or liquid medium or latent heat of a phase change substance. Sensible heat storage (SHS) units have very low heat capacity per unit

### **Hiroshi Tanaka and Chang-Dae Park (2010)**

utilize the waste heat from portable electric generator to increase the productivity of desalinated water in Solar stills. In their paper, they numerically analyzed a vertical multiple-effect diffusion still utilizing energy from waste gas from a portable electric generator by means of a heat-pipe to determine the basic behavior of distillation and the productivity of the still in steady-state.

They concluded that the proposed still using waste heat from portable generator in addition can produce 20kg of distilled water with about 3, 5 and 9h-operation at flow rates of waste gas of 40, 20 and 10 m<sup>3</sup>/h, respectively, and this amount of distillate is equivalent to the maximum daily productivity of the solar still obtained in outdoor experiments.

This steam is then condensed to hot water, which is still hot, and is then employed as the heat source to the preheater of subsystem C. The circulated jacket water is primarily used as the energy source to heat the seawater in the preheater, and the evaporators operate under low pressure.

### **Cohen J, Janovich I. and Muginstein A. (2001)**

In their work design a low-cost evaporator. The new type of evaporator suggested by him is of the spray-type, i.e., spraying the seawater into fine droplets to evaporate the water. The evaporator is designed based on the theory of cooling towers. They increased the production rate of solar stills by their method.

Initially the sea water is heated in solar stills and made to spray in the evaporator, one side of the evaporator is designed with condenser which cools the evaporated water. They used two pumps to circulate the water, one in the sea water side and the second in the brine side.

From their experiment the rate of evaporation is mainly influenced by the droplet size and temperature, i.e., the evaporation is enhanced by having small-diameter and high temperature water droplets. Also it is desirable not to operate the systems with temperatures higher than 70°C. The annual production of a unit with a collector area of 1 m<sup>2</sup> is 11.2m<sup>3</sup>, which is a satisfactory value, much better than the best enhanced solar stills.

### **Hung.T.C. and Shai.M.S. (2003)**

Hung et al (2003) in their study deals with the utilization of the waste heat streams, jacket water and exhaust gas from a Diesel engine as the heat source for desalination of seawater.

Waste heat is generated in a process by the way of fuel combustion or chemical reaction, and then dumped into the environment even though it could still be reused for some useful and economic purpose.

The exhaust gas from the engine is allowed to flow either to the heat exchanger or to the atmosphere by using valves. Castor oil is circulated through tube side of the heat exchanger using gear pump and is passed through thermal

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 3, March 2019

energy storage tank. At full load condition the maximum heat extracted is around 3.6 kW which is very high when compared to all other engine load conditions due to very high heat release rate from the engine at maximum load.

### III. EXISTING MODEL

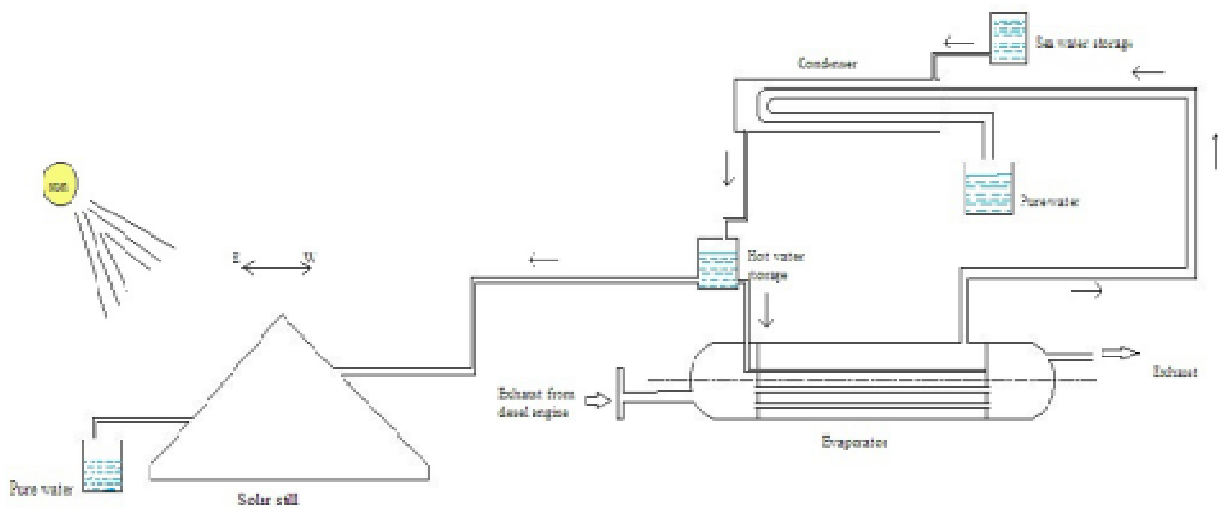


Fig 1 design of desalination process

Similar to the first system this experimental setup also consists of an evaporator, storage tanks for storing the saline and potable water, the difference is the air cooled condenser is replaced with a water cooled condenser. The exhaust gas from the engine is passed through the evaporator, the saline water which is in the evaporator gets the heat from the engine exhaust and evaporated. The steam then passed through the water cooled condenser and condensed. The condensed water is of potable quality.

To calculate the performance of the evaporator for its efficiency of producing pure water from the input saline water, parameters like inlet and outlet temperature of water, velocity and mass flow rate of distilled output water are to be measured.

### IV. EVAPORATOR

The evaporator needs additional space for the evaporation of water, at the same time as the heat energy available is low so that the heat extraction arrangement is also made in the same evaporator itself. So a shell and tube evaporator consists the tubes at the bottom was designed so that the saturated vapour collected above the top of the liquid level.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 3, March 2019

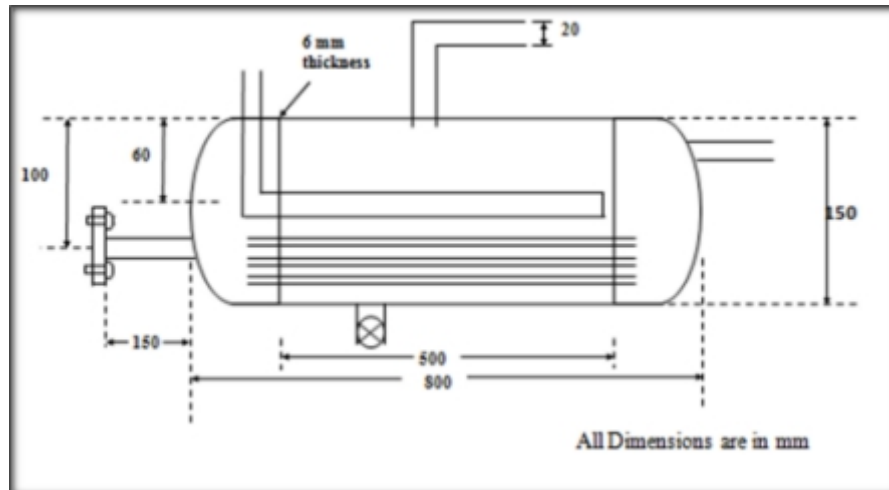


Fig2 : Shell Dimensions

## V. WATER COOLED CONDENSER

Water cooled condenser designed based on vapour output from evaporator. We got productivity 1.8kg/hr vapour, when we used evaporator and air cooled condenser, in this system the feed water temperature to evaporator is 30°C only. To increase the productivity I have decided to introduce the water cooled condenser. In this system feed water to evaporator is preheated to 60°C in water cooled condenser and we got productivity as 3kg/hr vapour. For designing water cooled condenser the following assumptions were made.

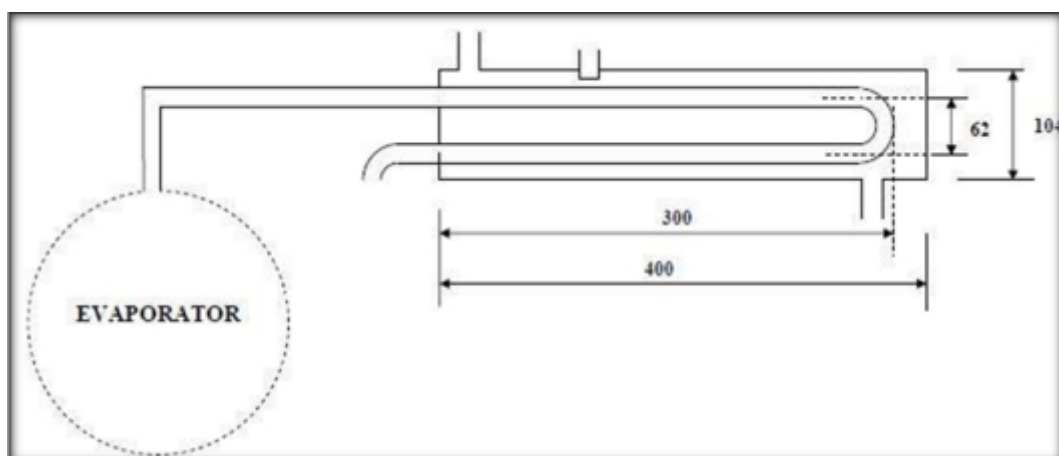


Fig 3 Condenser

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 3, March 2019

### VI. SOLAR STILL

A solar still operates on the same principle as rainwater: evaporation and condensation. The water from ocean evaporates, only to cool, condense, and return to earth as rain. When the water evaporates, it removes only a pure water and leaves all contaminants behind.

Solar still has to cover made of glass, with an interior surface made of water proof membrane. This interior surface uses a blackened material to improve absorption of the sun's rays. Water to be cleaned is poured into the still, which is mostly absorbed by the blackened base. The glass cover allows the solar radiation to pass into the still, which is mostly absorbed by the blackened base. The water begins to heat up and the moisture content of the air trapped between the water surface and the glass cover increases. The base also radiates the energy in the infra-red region which is reflected back into the still by the glass cover trapping the solar energy inside the still. The heated water evaporates from the basin and condenses on the inside of glass cover, In this process salts and microbes that were in the original water are left behind. Condensed water trickles down the inclined glass cover to an interior collection trough and out to storage bottle. There are no moving parts in solar still and only the sun's energy is required for operation.

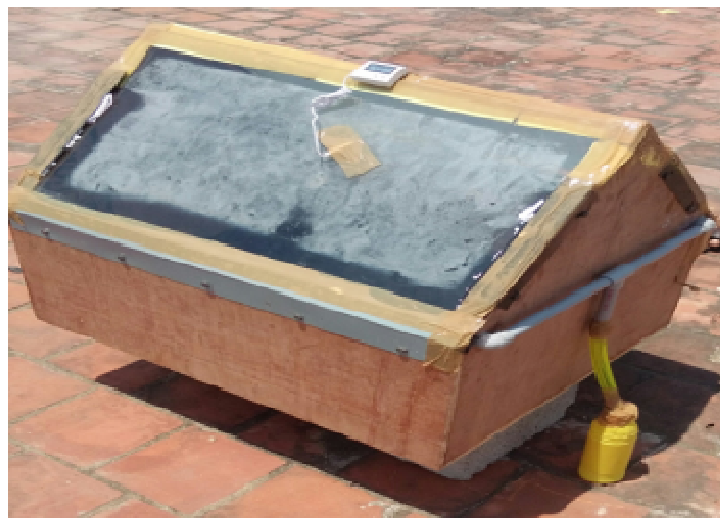


Fig 4 solar still setup

### VII. CONCLUSION

The aim of this work is to utilize the heat energy wasted in the exhaust gas of IC engine for Desalination. A Horizontal tube Straight pass Evaporator is used to absorb the heat energy from IC Engine. The steam from the evaporator is passed through the water cooled condenser and the fresh water is collected. For cooling the steam from the evaporator the saline water itself is used and it is stored and fed to evaporator.

The experimental setup was designed, fabricated ( Evaporator, air cooled condenser, water cooled condenser without and with preheating) and connected to the 5 Hp Kirloskar make single cylinder Diesel engine. The evaporation rate of water is varied by changing the engine load conditions were analyzed. The results are summarized below. The desalinated water output is higher for water cooled condenser than air cooled condenser. Similarly the desalinated water output is considerably increased while using water cooled condenser with preheating than water cooled condenser without preheating.

# International Journal of Innovative Research in Science, Engineering and Technology

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 3, March 2019

## REFERENCES

1. K.S.Maheswari, R.Samuel Hansen and S.Ananth (2016) 'Desalination through diesel engine exhaust waste heat' International Journal of Research in Advanced Technology Vol 1.
2. Anderson L.Z. and Robert Nation H. (1982) 'Waste heat recovery system for an internal combustion engine' United States patent Vol.155 pp.4351.
3. Brandon, Moore A. and Eiki Martins 'Waste to water: a low energy water distillation method' Desalination Vol. 220 pp. 502-505
4. Chyu M.C. and Bergles A.E. (1987) 'An analytical and experimental study of falling film evaporation on a horizontal tube' Trans. ASME J. Heat Transfer Vol. 109 pp. 983-990.
5. Cohen J, Janovich I. and Muginstein A. (2001) 'Utilization of waste heat from a flue gases up stream gas scrubbing system' Desalination Vol. 139 pp. 1-6.
6. Cooper M.G. (1984) 'Saturation nucleate pool boiling-a simple correlation' Int. Chem. Eng. Vol. 86 pp. 785-792.
7. Corrado Sommariva (2008) 'Utilisation of power plant waste heat steams to enhance efficiency in thermal desalination' Desalination Vol. 222 pp. 592-595
8. Danilova G.N., Burki V.G and Dyundin V.A. (1976) 'Heat transfer inspray-type refrigerator evaporators' Heat Transfer e Soviet Vol. 8 pp. 105-113.
9. Desai AD and Bannur P.V (2001) 'Design, fabrication and testing of heat recovery system from diesel engine exhaust' J Inst Engrs Vol. 82 pp. 111-8.
10. Dincer Ibrahim (2002) 'Thermal energy storage as a key technology in energy conservation' Int J Energy Res Vol. 26 pp. 567-88.
11. El-Dessouky H.T. and Ettouney H.M. (1999) 'Multiple-effect evaporation desalination systems: thermal analysis Desalination Vol. 125 pp. 259-276
12. Fujita.Y and Tsutsui M. (1998) 'Experimental investigation of falling film evaporation on horizontal tubes' Heat Transfer e Jpn Vol. Res.27 pp. 609-618.
13. Hafizur Rahman, Hawlader M.N.A. and Male.A. (2003) 'An experiment with a single-effect submerged vertical tube evaporator in multi-effect desalination' Desalination Vol. 156 pp. 91-100
14. Hiroshi Tanaka and Chang-Dae Park (2010) 'Distillation utilizing waste heat from a portable electric generator' Desalination Vol. 258 pp. 136-142
15. Hung.T.C. and Shai.M.S. (2003) 'Cogeneration approach for near shore internal combustion power plants applied to seawater desalination' Energy Conversion and Management Vol. 44 pp. 1259-1273