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Design and Development of Fog Condenser

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Abstract— **As the world's population as well as demanding of fresh water increases, new water resources are needed. During the researching for the new resources, it was recognised the fog is the mixture of air and moisture. Along with, Fog water harvesting is a being investigated as a sustainable alternative water resource for drinking water. Another problem we have identified is fog reduces visibility, limit contrast, distort perception and causes many auto accidents each year. To avoiding such disasters and accidents without harming the environment a device was designed which extract moisture from natural fog and condense it in purified drinkable water.**

In this project, construction and working of "Fog Condenser" it proposed. The device works on the Gay Lussac's law. The design has two main objective those are 1) Extract 1 lit of drinkable water from fog. 2) Light and portable device. An orifice is used as a pressure reducing element, due to which temperature also reduce. Because of this reduction in temperature fog cools down to its dew point temperature and water is extracted from fog because of surface condensation through a net provided inside the system.

Keywords—Fog Condenser, Fog analysis, Purification of Fog Water, Ansys of Fog, Circuit Design Water Tank.

I. INTRODUCTION

Water shortage has become a critical issue due to growth of world's population and issues like climate change, hydraulic fracturing, increased demand in agriculture, and pollution of water sources caused by rapid and uncontrolled industrial development and increase in household water usage. Several studies have demonstrated that different regions of the world are already experiencing the first symptoms of water scarcity.

Formation of Fog:

Generally, fog formation and existence are in the strong influence of local orographic factors, the actual synoptic situation and the atmospheric circulations where average relative humidity is near to 100%. It can be formed everywhere over land and water surfaces and most of the time in the hilly regions where relative temperature is low i.e., hill stations. Particularly due to its local character of formation, its capability of reducing the temperature amplitude, and the fact it is directly related to humid parameters.

Natural fog as a form of condensed water existing in the atmosphere, has a significant impact on many components of the environment, such as the global and regional climate, the atmosphere's thermal and radiative budget, air quality, waters, flora and fauna, air surface interaction. At the same time, as resulting in reduce visibility, fogs can perturb and affect severely the societal life and functionally (e.g. - air, surface and water transport) causing an impressive number of injuries and fatalities

Depending on the physical and chemical nature and the composition of the droplets, fogs can also have direct and indirect adverse effects on human health (respiratory and radiation diseases, skin and eye damages, secondary health effects etc).

Representation of fog and eco-system/logical role. Fog, the presence of suspended liquid water droplets in the air at ground level, is a natural part of the global water cycle. Fog droplets diameter typically range from 1 to 50 μm and originated from water lost through evapotranspiration, creating masses of humid air over land or sea. Advection fog formation often occurs over the ocean, where moist air passes over cooler waters forming low altitude clouds that are then blown towards the coast by the wind. Radiation fog occurs overnight as the cooling ground causes the condensation of water vapour in the air above it.

Regardless of the type of fog, there must be the presence of humid air along with a drop in temp. below the dew point for fog formation to occur. Environmental conditions such as high dew point temperatures, high humidity, and high elevation are known to favor fog formation. Due to geological factors, fog formation is usually highest among mountain areas near the coast.

Fog forms when the difference between air temperature and dew point temperature is less than 2.5 degree Celsius.

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Fog begins forms when water vapour condenses into tiny water droplets that are suspended into air. Some examples of ways that water vapour is added to the air are by wind convergence into areas of upward motion. Precipitation or virga falling from above.

Fig. 1 Formation of fog

Daytime heating evaporation water form from the surface of oceans, water bodies, or wet land. Transpiration from plants. Cool or dry air moving over warmer water, and lifting air over mountains. Fog, like elevated cousin stratus, is a stable cloud deck which tends to form when a cool, stable air mass is trapped underneath a warm air mass.

Working Principle of Fog Condenser:

Fog Condenser works on the principle of Gay Lussac's law. It states that, at a constant volume, the pressure of a given amount of a particular gas is directly proportional to its Kelvin temperature.

It can be written as:

- $P \propto T$, or
- $P/T = k$ where k is a constant, or
- $P1/T1 = P2/T2$

II. PROPOSED DESIGN

A. Objective :-

- To extract one litre of water from fog.
- To make system light and portable.

B. Construction

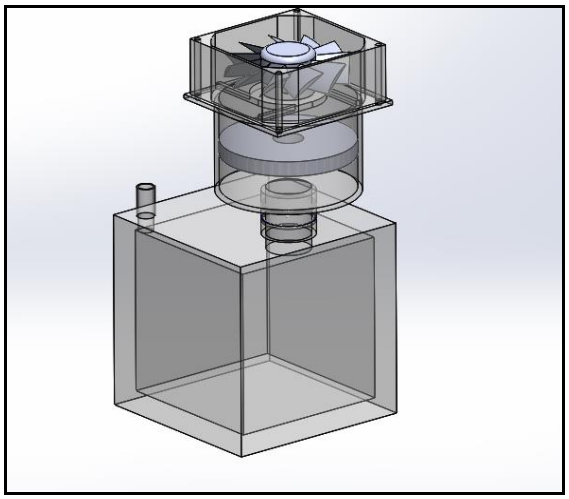

Fig. 2 Fog Condenser (Full Section)

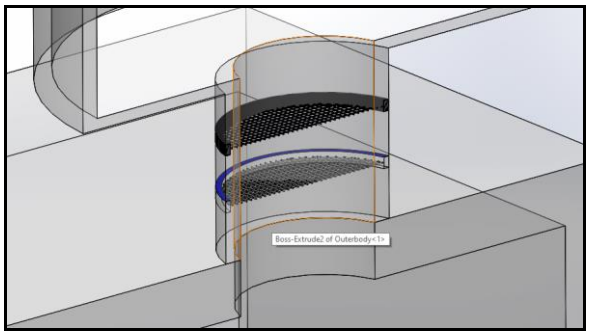

Fig. 3 Fog Condenser (Half section)

Components of Fog condenser:

12 V Relay	Battery
Outer shell	Vent
Resistor	Transistor
Orifice	Storage tank
Push Button Switch	LED
Net	Case Fan

C. Python program for finding out the orifice dimensions: -

```
t1=18#C
p1=101325#pa
d1=0.090#mm
d2=0.02#mm
z1=0.09
z2=0.06
A1= ((22/7)/4) *(d1*d1) #mm2
A2= ((22/7)/4) *(d2*d2) #mm2
g=9.81#m/s
rho=1.223
cfm=202.82
Q=0.00047194745*cfm#m3/s
print(("Discharge"),Q)
v1=Q/A1
```

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```
print (("Velocity 1"), v1)
v2=Q/A2
print (("Velocity 2"),v2)
h=((v2*v2)/(2*g)) -((v1*v1)/(2*g))
p2=-(h-((p1/(rho*g)) +z1)-z2) *(rho*g)
print(("pressure 2"),p2)
t2=(p2*t1)/p1
print(("temperature 2"),t2)
```

Result:

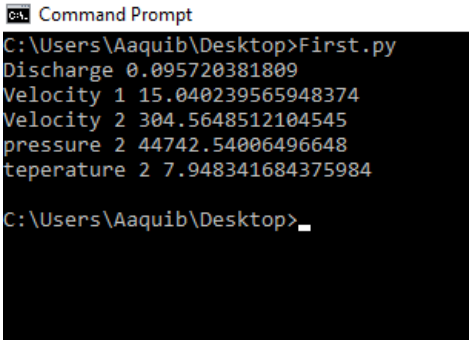


Fig. 4 Results for Program

III. WORKING

Fog Condenser works on the principle of Gay Lussac's law, as the pressure abates, temperature also decreases. Using above relation, the system was designed to reduce the pressure which will relatively reduce temperature. When the push button is actuated system starts running and electric supply starts flowing from battery to case fan. Due to which the fog from outer environment starts flowing in the outer shell. The fog it passed through the orifice placed inside the first section of outer shell, which reduces the pressure of fog from atmospheric pressure i.e., 101325 Pa to 44742.6 Pa. As the pressure drops the temperature of fog is also decreases (from 19 ºC to 8 ºC) due to which dew point temperature is reached. This cooled fog enters in the second section of outer shell where two nets are placed 30 mm apart. The cooled fog flow through the net and the dews are formed on the strings of net. These dews are then collected the storage tank provided below. The access air flows out of the system. When the tank gets completely filled with water and reaches the maximum limit specified by the water level sensor, the sensor sends a signal to the transistor and relay. Hence, these signals complete the circuit and turns off the electric supply to the fan. The typical circuit diagram is shown below:

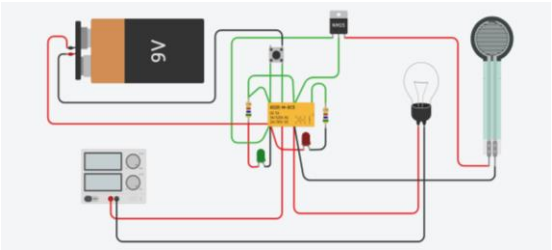
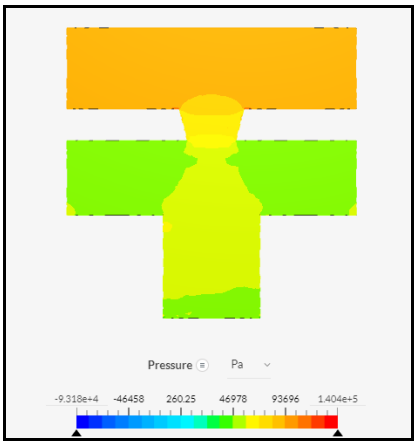


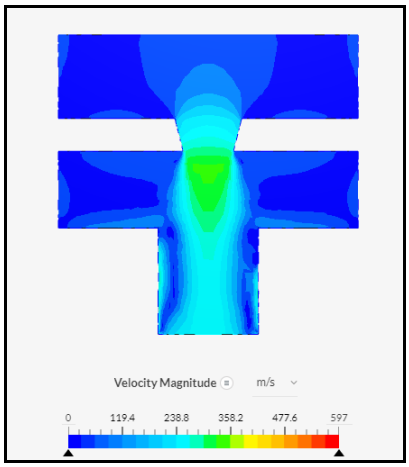
Fig. 5 Circuit Diagram

IV. CFD ANALYSIS

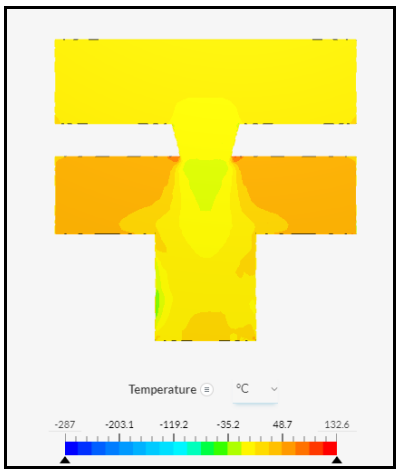
CFD analysis for transient flow was carried out using Simscale. The purpose of the CFD analysis was to verify the working of system for fog. Main aim was to determine the change in temperature. Following figures shows the results of the simulation:



(a)



(b)



(c)

Fig. 6 (a) Change in Pressure, (b) Change in Velocity and (c) Change in Temperature

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CFD analysis of orifice, which was performed using Simscale to simulate its working in dynamic condition. A transient flow simulation was carried out on the air which turbulent factor as k-epsilon. The simulation was conducted on moist air at atmospheric pressure and temperature. Fig. 6 (a) depicts the change in pressure at the end of the orifice. Through this simulation it was found at the exit of orifice the pressure was reduce through 43,000 Pa approximately. As our system works on Gay Lussac's law, the temperature of air was respectively reduced to 8 ^{o}C from ambient temperature shown in fig. 6 (c) with increasing air velocity shown in fig. 6 (b).

V. CONCLUSION

The purpose of this project is to give a precise solution for world's leading problem "water scarcity". In this project, we have proposed a design of "Fog Condenser", a device that extracts water from moisture content of fog, which can be used as potable water. It can be concluded the proposed design satisfies the primary objectives and provides a new promising source of potable water.

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