DESIGN AND FABRICATION OF SPIRAL SOLAR HEAT PIPE

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ABSTRACT

The reduction of energy consumption has become a priority for all countries in the world. This fact is due to the limitation of Earth's natural resources, global warming and the increasingly high costs of energy consumption. Wastewater, from drains, represents a waste heat source which is untapped so far. The recovery of heat from wastewaters would reduce the dependencies on fossil fuels, the greenhouse gas emissions and would increase the energy independence. This paper presents a research on the use of heat pipe heat exchangers in the recovery of waste heat from urban wastewaters. And a solar heat pipe is a device that efficiently transports thermal energy from its one point to the other. It utilizes the latent heat of the fluid instead of the sensible heat. Heat pipe consists of a sealed container, a wick structure and a small amount of working fluid that is just sufficient to saturate the wick and it is in equilibrium with its own vapour. As the future progresses, many companies and industries are striving to achieve a "greener" approach to energy production by using solar energy. Solar panels that use PV cells (semiconductor devices used to convert light into electrical energy) are popular for converting solar power into electricity. One of the problems in using PV cells to extract energy from sunlight is the temperature effect on PV cells. As the solar panel is heated, the conversion efficiency of light to electrical energy is diminished. Because solar panels can be expensive, it is important to be able to extract as much energy as possible. This thesis proposes cooling methods for the panel in order to achieve optimum efficiency.

Keyword: - *heat pipe, heat exchanger, wastewater, waste heat.*

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1. DESIGN AND FABRICATION OF SPIRAL SOLAR HEAT PIPE

A heat pipe is used as a device which efficiently transfers thermal energy from one point to another. As results there is effective thermal conductivity it may be several orders of magnitudes higher than that of solid conductors. It consists of a container, a wick structure, a small amount of working fluid that is just sufficient to saturate the wick and it is in equilibrium with its own vapor. And heat pipe will be divided into three parts viz. evaporator section, adiabatic section and condenser section. But in a standard heat pipe, the inside of the container is lined with a wicking material.

1.1 PRINCIPLES OF OPERATION

The all operations of heat pipes easily understood by using a cylindrical geometry. However, the heat pipes can be of any size or shape. The components of a heat pipe are a sealed container (pipe wall), a wick structure, and a small amount of working fluid. Different types of working fluids such as water, glycerin + water; transformer oil, rice bran oil, ammonia or sodium can be used in heat pipes based on the required operating temperature. The heat pipe can be divided into three parts: evaporator section, adiabatic (transport) section and condenser section. A heat pipe may have different heat sources or without adiabatic sections depending on specific applications and design. Heat applied externally to the evaporator section of heat pipe is conducted through the pipe wall and wick structure, where it vaporizes the working fluid. And there is resulting temperature rise in the condenser. And the capillary pressure created by the menisci in the wick pumps the condensed fluid back to the evaporator section.

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1.2 TYPES OF HEAT PIPES

There are different types of heat pipes it have been designed and built with various types of cross-sectional areas as par requirements and operations to be performed. All heat pipes having an evaporator and condenser section where the working fluid evaporates and condenses, respectively. Working fluids is in the tubes, which is circulated by capillary forces in a wick. Following are different types of heat pipes.

- Two-Phase Closed Thermosyphons
- Capillary-Driven Heat Pipe
- Annular Heat Pipe
- Vapor Chamber
- Rotating Heat Pipe
- Gas-Loaded Heat Pipe
- Loop Heat Pipe
- Pulsating Heat Pipe
- Capillary Pumped Loop Heat

2. Design & Fabrication

Analysis of the performance of spiral solar heat pipe is done using computational fluid dynamics method. For this geometry is modeled in 2D in as shows in fig. in previous chapter schematic diagram of the geometry is shown in fig. The length and the diameter of the channel (here channel instead of pipe is said as model is in 2D) 9 mm O/D 8 mm I/D and 1524 cm long respectively and the pipe is assumed to be made of copper. Water and oils are taken as the working fluid which flows in the channel.

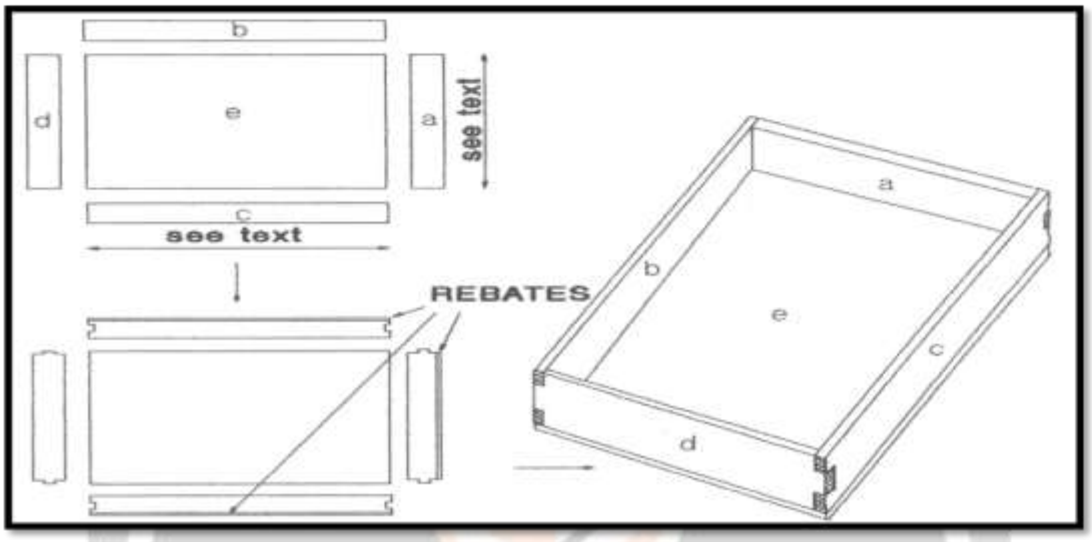

Fig -2: block diagram of wooden box

2.1 Box

a. Take a large plywood sheet with t = 2 cm
b. Mark on it dimensions 86.36 x 84x 12.7 cm
c. Cut the plywood in required dimensions
d. Prepare a sure wooden box from it
e. Place a glass of the same dimensions above it
f. Make the tube in spiral form.
g. Make two drills on the box on its both sides for inlet & outlet of copper tube.
h. Fix the copper coil in box be means if clips and plastic tie.
i. Paint the box and spiral copper tube with black color.
j. 4 side mirrors are attached inner of box. For max efficiency.

2.2 Copper Tube

a. Taking hollow copper tube of length 1524cm with 8 mm internal diameter and outer diameter 9 mm
b. Spiral the copper tube in following dimensions

Length: 1524 cm

Distance between coils: 3-4 cm

Curve radius: increasing from centre to outward

c. Diagram of copper tube is shown as follows

2.3 Input Parameters

Input Parameters

Sr. No	List of Components	Quantity
1.	Wooden Box	1
2.	Copper Tubes	1
3.	Transformer Oil	6lit
4.	Rice Bran Oil	6lit
5.	Glycerin	1kg
6.	Table Stand	3
7.	mirror	3
8.	Glass	1
9.	Copper Sheet	3
10.	Colorimeter	1
11.	Thermometer	3
12.	Screw	50gm
13.	Handle	1
14.	Coating	250ml
15.	Black spree	2
16	Inner mirrors	4

Table -2.2: Input Parameters

3. Fluid Properties

3.1 Properties of water

Water is the chemical substance with chemical formula H2O; one molecule of water has two hydrogen atoms covalently bonded to a single oxygen atom. Water is a tasteless, odourless liquid at ambient temperature and pressure, and appears colourless in small quantities, although it has its own intrinsic very light blue hue. Ice also appears colourless, and water vapour is essentially invisible as a gas.

Water is primarily a liquid under standard conditions, which is not predicted from its relationship to other analogous hydrides of the oxygen family in the periodic table, which are gases such as hydrogen sulphide. The elements surrounding oxygen in the periodic table, nitrogen, fluorine, phosphorus, sulphur and chlorine, all combine with hydrogen to produce gases under standard conditions. The reason that water forms a liquid are that oxygen is more electronegative than all of these elements with the exception of fluorine. Oxygen attracts electrons much more strongly than hydrogen, resulting in a net positive charge on the hydrogen atoms, and a net negative charge on the oxygen atom. These atomic charges give each water molecule a net dipole moment. Electrical attraction between water molecules due to this dipole pulls individual molecules closer together, making it more difficult to separate the molecules and therefore raising the boiling point. This attraction is known as hydrogen bonding.

The molecules of water are constantly moving in relation to each other, and the hydrogen bonds are continually breaking and reforming at timescales faster than 200 feta seconds (2×10^{-13} seconds). However, these bonds are strong enough to create many of the peculiar properties of water, some of which make it integral to life.

The dissociation constant for this dissociation is commonly symbolized as K_w and has a value of about 10^{-14} at 25 °C; see here for values at other temperatures

Properties	
Chemical formula	H2O
Molar mass	18.01528(33) g/mol
Appearance	White solid or almost colorless, transparent, with a slight hint of blue, crystalline solid or liquid
Odor	None
Density	Liquid: 0.9998396 g/mL at 0 °C 0.9970474 g/mL at 25 °C 0.961893 g/mL at 95 °C Solid: 917 kg/m^3 = 0.917 $tonne/m^3$= 0.917 kg/l = 0.917 g/cm^3 ≈ 57.2 lb/ft^3

Melting point	0.00 °C (32.00 °F; 273.15 K) [a]
Boiling point	99.98 °C; 211.96 °F; 373.13 K [4][a]
Vapor pressure	3.1690 kilopascals or 0.031276 atm
Acidity (pK_a)	13.995
Basicity (pK_b)	13.995
Thermal conductivity	0.6065 W/m·K
Refractive index (n_D)	1.3330 (20°C)
Viscosity	0.890 cP
Specific heat capacity (C)	75.375 ± 0.05 J/mol·K
Std molar entropy (S°_{298})	69.95 ± 0.03 J/mol·K
Std enthalpy of formation ($\Delta_f H^{\circ}_{298}$)	-285.83 ± 0.040 kJ/mol
Gibbs free energy ($\Delta_f G^{\circ}$)	-237.24 kJ/mol

Table -3.1: Properties of Water

3.2 Properties of Rice bran oil

Rice bran oil is the oil extracted from the hard outer brown layer of rice after chaff (rice husk). It is notable for its high smoke point of 232 °C (450 °F) and its mild flavour, making it suitable for high-temperature cooking methods such as stir frying and deep frying.

Properties	
Food energy per 100 g (3.5 oz)	3,700 kJ (880 kcal)
Smoke point	232 °C (450 °F)
Iodine value	99-108
Acid value	1.2
Saponification value	180-190
Unsaponifiable	3-5
Density (15-15 °C)	0.913-0.920
Moisture	0.1-0.15%

Table -3.2: Physical Properties of Rice bran oil

3.3 Properties of Transformer oil

Transformer oil or insulating oil is oil that is stable at high temperatures and has excellent electrical insulating properties. It is used in oil-filled transformers, some types of high-voltage capacitors, high-voltage capacitors, fluorescent lamp ballasts, and some types of high-voltage switches and circuit breakers. Transformer oil is most often based on mineral oil, but alternative formulations with better engineering and/or environmental properties are growing in popularity.

Transformer oil's primary functions are to insulate and cool a transformer. It must therefore have high dielectric strength, thermal conductivity, and chemical stability, and must keep these properties when held at high temperatures for extended periods. Typical specifications are: flashpoint 140 °C or greater, pour point −30 °C or lower, dielectric breakdown voltage 28 kV (RMS) or greater. To improve cooling of large power transformers, the oil-filled tank may have external radiators through which the oil circulates by natural convection. Very large or high-power transformers (with capacities of thousands of kVA) may also have cooling fans, oil pumps, and even oil-to-water heat exchangers.

Large, high voltage transformers undergo prolonged drying processes, using electrical self-heating, the application of a vacuum, or both to ensure that the transformer is completely free of water vapour before the cooling oil is introduced. This helps prevent corona formation and subsequent electrical breakdown under load.

Oil filled transformers with a conservator (oil reservoir) may have a gas detector relay (Buchholz relay). These safety devices detect the build-up of gas inside the transformer due to corona discharge, overheating, or an internal electric arc. On a slow accumulation of gas, or rapid pressure rise, these devices can trip a protective circuit breaker to remove power from the transformer. Transformers without conservators are usually equipped with sudden pressure relays, which perform a similar function as the Buchholz relay.

3.4 Properties of Glycerin

Glycerine is a simple ploy compound. It is a colourless, odourless, viscous liquid that is sweet-tasting and non-toxic. The glycerol backbone is found in all lipids known as triglycerides. It is widely used in the food industry as a sweetener and humectants and in pharmaceutical formulations

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Properties	
Chemical formula	$C_3H_8O_3$
Molar mass	92.09 g·mol^{-1}
Appearance	colorless liquid hygroscopic
Odor	Odorless

Density	1.261 g/cm^3
Melting point	17.8 °C (64.0 °F; 290.9 K)
Boiling point	290 °C (554 °F; 563 K)
Solubility in water	Miscible
Vapor pressure	0.003 mmHg (50°C)
Magnetic susceptibility (χ)	-57.06·10^{-6} cm^3/mol
Refractive index (n_D)	1.4746
Viscosity	1.412 Pa·s
Flash point	160 °C (320 °F; 433 K) (closed cup) 176 °C (349 °F; 449 K) (open cup)

Table -3.4: Physical Properties of Glycerine

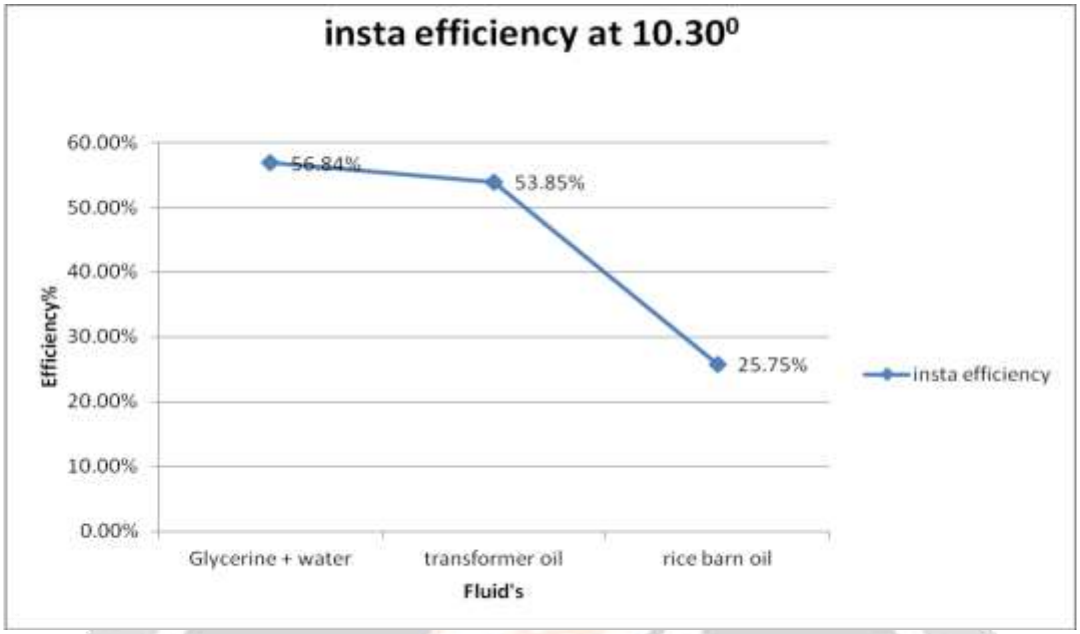
3.5 Observation Table

Sr. No	Ø	altitude	δ	LAT	hr angle	ω (w/m2)	ϴ	r_b	r_d	r_r	I_t	S
1	19.87	75.34	20.45	11 HR 28 min	8	1040	13.11	0.9823	0.969	0.0063	1252.35	1000
2	19.87	75.34	20.45	11 HR 28 min	8	1190	13.11	0.9823	0.969	0.0063	1400.64	1117.3
3	19.87	75.34	20.45	11 HR 28 min	8	1520	13.11	0.9823	0.969	0.0063	1726.9	1377.6

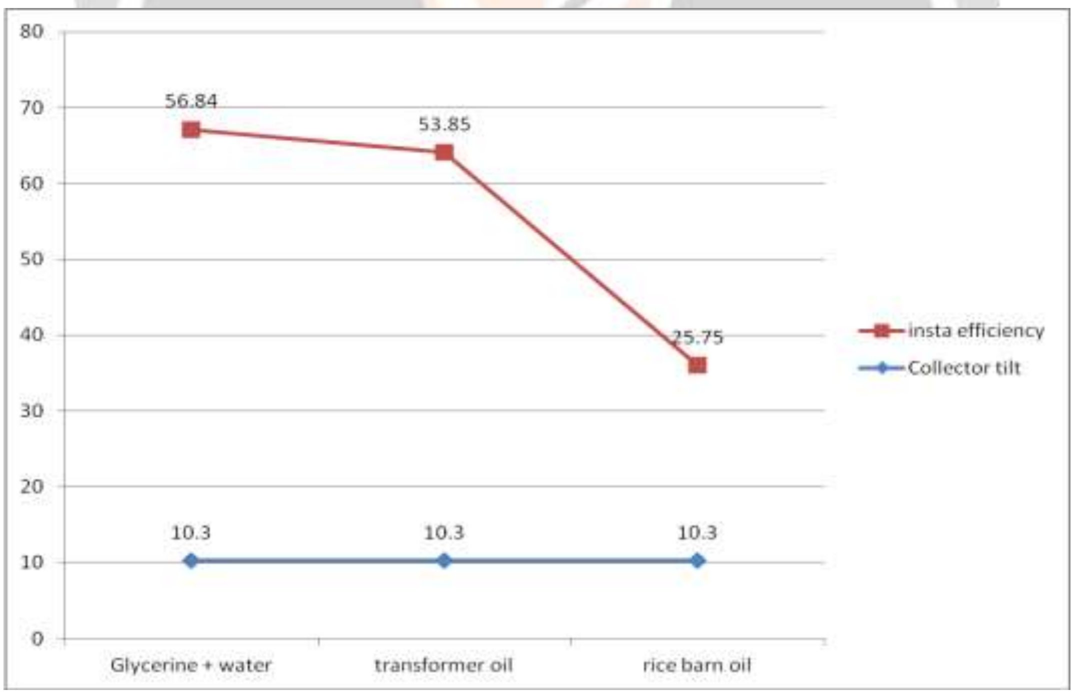
F'	(Fr)	q_u	ql	T_{pm}	T_{fo}	ηi	Fluid	β
0.8701	0.835	1584.2	375.8	358.93	338.46	56.84%	Glycerine + water	10.3 degree
0.8701	0.383	802,7	1387.21	488	552.34	25.75%	rice bran oil	10.3 degree
0.8701	0.799	2069.7	630.39	391.42	377.62	53.85%	transformer oil	10.3degree

Table -3.5: Observation Table

3.6 Graphs



Graph -3.5: Instantaneous Efficiency



Graph -3.5: Instantaneous Efficiency at 10.30^0

4. CONCLUSIONS

Short and long term performance tests were conducted on natural and force convection spherical -tube and heat pipe evacuated tube solar heaters. The test procedures employed enabled comparative performances of solar water and different types of fluids heating systems to be made even when they were tested at different times of the year. The experimental results showed that the natural convection heat pipe system was capable of heating fluids up to 100 degree C. and performed best among the systems tested.

1) There is pressure variation in the tube because of increase in volume of the working fluid by absorbing heat at one end which causes the transport of vapor slug and liquid.

2) After a certain time of interval, the oscillating behavior of working fluid becomes more frequent which causes oscillation in heat flux at the output that means at some moment cooling effect will be more and at some time it will be less.

3) Alcohol attends frequent oscillation earlier as compared to water which signifies that Fluid with lower specific heat will give cooling effect much earlier than the fluid with higher specific heat.

4) For higher the value of input heat flux, the oscillation starts in lesser time as compare to the lower value of heat input.

5. ACKNOWLEDGEMENT

With a profound feeling of immense gratitude and affection, I would like to thank my Project guide **Prof. K. T. PATIL** for his continuous support, motivation, enthusiasm and guidance. His encouragement, supervision with constructive criticism and confidence enabled me to complete this project.

I also wish to extend my reverences to **Prof. G. S. DHAGE**, Head of Mechanical Engineering Department for motivating me to put my best efforts in this project work.

I express my deep gratitude towards **Dr. R. S. PAWAR**, Principal for constant motivation and providing necessary infrastructure.

I express my admirations for **Prof. K. T. PATIL** (Project Coordinator) for his valuable advice and support throughout this venture.

Finally, graceful thanks to family, friends, colleagues and everyone who has directly or indirectly contributed to make this project a success.

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