DESIGN AND FABRICATION OF WASTE HEAT RECOVERY SYSTEM

MINI PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

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BONAFIDE CERTIFICATE

Certified that this project report **"DESIGN AND FABRICATION OF WASTE HEAT RECOVERY SYSTEM"** is the bonafide work of

G. AGORAMOORTHY, M. ASWIN, D. SUNDARAPANDIAN and M. SURESH,

Who carried out the project under my supervision.

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PROJECT GUIDE

Department Of Mechanical Engineering

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INTERNAL EXAMINER

EXTERNAL EXAMINER

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ABSTRACT

It is obvious that the know resources of fossil fuels in the world are depleting very fast and by the end of the century, we will have depend upon renewable source of energy like wind energy, ocean energy, energy from bio-mass, solar energy etc.

Solar energy is available around the year. It is available in plenty at no cost. It's potential is 178 billion mega watts which is about 20000 times of the world demand.

To make effective use of solar energy available perennially in tropical countries like India, a hybrid solar heating system was designed. The area of the collector was determined based on the requirement of heat energy.

Along with the design of the system, details of solar radiation, measurement of solar radiation are also explained in various chapters.

The detailed fabrication of the various components of the system along with the dimensions and materials of constructions and cost estimation of the system has also been given.

The performance test was conducted on the system for three days and various parameters like water temperature, glass plate temperature were measured. Solar intensity was measured with a pyranometer.

The heat available in the system, solar intensity and the efficiency are calculated and tabulated. These results are presented in form of various graphs.

The remarks based on performs analysis are given in the system is also incorporated along with the concluding remarks.

INTRODUCTION

INTRODUCTION:

Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy especially when other sources in the country have depleted.

Energy comes to the earth from the sun. This energy keeps the temperature of the earth above that in colder spaces, causes current in the atmosphere and in ocean, causes the water cycle and generates photosynthesis in plants.

The solar power where the sun hits the atmosphere is 1017 watts, whereas the solar power on earth's surface is 1016 watts. The total worldwide power demand of all needs of civilization is 1013 watts. Therefore, the sun gives us 1000 times more power than what we need. If we can use 5% of this energy, it will be 50 times what the world will require.

The energy radiated by the sun on a bright sunny day is approximately 1 KW/m^2, attempts have been, made to make use of this energy in raising steam which may be used in driving the prime movers for the purpose of generation of electrical energy. However on account of large space required, uncertainly of availability of energy at constant rate, due to clouds, winds haze etc., there is limited applications of this source in the generation of electric power.

The applications of solar energy, which are in most success to do, are :

1. Heating and cooling residential building.
2. Solar water heater.
3. Solar distillation on a small community scale.
4. Salt production and evaporation of sea water or inland brines.
5. Solar drying of agriculture and animal products.

6. Solar cookers.
7. Solar furnace.
8. Bio conversion and wind energy, which are the indirect, source of solar energy.
9. Food refrigeration.
10. Solar engines of water pumping.
11. Waste heat recovery system.

WASTE HEAT RECOVERY SYSTEM

WASTE HEAT RECOVERY SYSTEM:

This project is based on Thermal energy storage especially Latent heat storage. **Thermal energy storage** may refer to a number of technologies that store energy in a thermal reservoir for later reuse. They can be employed to balance energy demand between day time and night time. The thermal reservoir may be maintained at a temperature above (hotter) or below (colder) than that of the ambient environment. The principal application today is the production of ice, chilled water, or eutectic solution at night, which is then used to cool environments during the day.

Thermal energy storage technologies store heat, usually from active solar collectors, in an insulated repository for later use in space heating, domestic or process hot water, or to generate electricity. Most practical active solar heating systems have storage for a few hours to a day's worth of heat collected.

Energy storage has great potential for providing the means for efficient use of various forms of energy being wasted in the industry, homes, and large building to use renewable energy sources, which includes solar, wind, geothermal, and tidal. In addition, energy storage systems provide efficient means for matching of power generation and demand, and the energy is recovered during low load periods and the energy is recovered during peak load periods. The storage of thermal energy as latent heat of fusion has attractive features over the sensible heat due to its high storage density and isothermal nature of storage process at melting point temp. Solid-liquid transformation is most commonly utilized and the energy stored could be discharged at a constant crystallization temperature. However, most of the solid phase materials usually have low thermal conductivity. Therefore, during the discharging process, as a material solidifies onto the heat transfer surface, high thermal resistance is obtained.

PCM:

A **phase change material** (**PCM**) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage (LHS) units.

PCMs latent heat storage can be achieved through solid-solid, solid-liquid, solid-gas and liquid-gas phase change. However, the only phase change used for PCMs is the solid-liquid change. Liquid-gas phase changes are not practical for use as thermal storage due to the large volumes or high pressures required to store the materials when in their gas phase. Liquid-gas transitions do have a higher heat of transformation than solid-liquid transitions. Solid-solid phase changes are typically very slow and have a rather low heat of transformation.

Organic PCMs

Paraffin (CnH2n+2) and Fatty acids (CH3(CH2)2nCOOH)

Advantages

1. Availability in a large temperature range
2. Freeze without much super cooling
3. Ability to melt congruently
4. Self nucleating properties
5. Compatibility with conventional material of construction
6. No segregation

7. Chemically stable

8. High heat of fusion

9. Safe and non-reactive

10. Recyclable

Disadvantages

1. Low thermal conductivity in their solid state. High heat transfer rates are required during the freezing cycle.

2. Volumetric latent heat storage capacity is low

3. Flammable. This can be easily alleviated by a proper container

4. Due to cost consideration only technical grade paraffins may be used which are essentially paraffin mixture and are completely refined of oil

Inorganic

Salt hydrates (MnH2O)

Advantages

1. High volumetric latent heat storage capacity

2. Low cost and easy availability

3. Sharp melting point

4. High thermal conductivity

5. High heat of fusion

6. Non-flammable

Disadvantages

1. Change of volume is very high

2. Super cooling is major problem in solid-liquid transition

3. Nucleating agents are needed and they often become inoperative after repeated cycling.

Selection Criteria

Thermodynamic properties:

Melting temperature

High latent heat of fusion per unit volume

High specific heat, high density and high thermal conductivity

Congruent melting

Kinetic properties:

High nucleation rate to avoid super cooling of the liquid phase

High rate of crystal growth,

Chemical properties:

Chemical stability

Non-corrosiveness

Non-toxic, non-flammable and non-explosive materials

Economic properties

Low cost
Large-scale availabilities

DESIGN OF SOLAR COLLECTOR

CALCULATION OF SOLAR ISOLATION:

Solar isolation on horizontal plane is given by:

H_o= 24/ π *I_{sc} [1+0.033 cos[360n/365]].[(cosα cosδ sin W_s)+2π W_s/360[sinα sinδ]

Where,

I_{sc} = solar energy constant/hr= 1353 W/m^2

N= day of the year

$W_{s=}$ sun rise hour angle= $\cos^{-1}$[-tan Y+ tan δ]

α= altitude= 11^0

δ= declination=4^0

W_s= $\cos^{-1}$[-tan (11) + tan (4)]

= $\cos^{-1}$[-0.013592395]

Ws=98.78^0

N= 31+28+20= 74 days.

Ho=24/π * 1353 * [(1+0.0096)] * [0.979145249+0.021]

=24/π * 1353 * [1.0098]

Ho=104380.4046 J

H_{av}= (Ho.a) + (b.(n/N))

Where

H_0= Average horizontal solar radiation for a clear day

N= Maximum daily hours of bright sunshine for same period

N= Average daily hours of bright sunshine for same period

a= 0.3 b= 0.5

H_{av}= 104380.40466 [0.3 + 0.5 (6/12.1038)]

= 104380.40466 [0.5528]

= 5770.47849 W/m^2

H_{av}= 5.77 KW/m^2

Area of the collector:

The area of the collector is given as:

A= L * B

Where

L= 900 mm B= 600mm

A= 540000 mm^2= 0.54 m^2.

EXPERIMENTAL SETUP

EXPERIMENTAL SETUP:

1. GLASS COVER:

The glass cover is 3 mm thick and allows the solar rays to penetrate into the box.

2. ABSORBER PLATE:

The purpose of the absorber plate is to absorb solar radiation in the form of heat energy. Usually aluminium plates are coated with dull black paint, which act as an absorber. The absorber Plate attached to the horizontal rows of tubes.

3. INSULATION:

The bottom portion of the collector should be insulated perfectly to avoid heat dissipation. The insulation materials such as wood, thermo Coles are used.

4. STORAGE TANK:

The storage tank must be placed be placed height relative to top of the collector to prevent the revenue circulation during off-shine hour. The hot water of the storage tank can be either under city water pressure or cold water storage tank pressure. The water holding capacity of the tank was designed to 4 liters.

EXPERIMENTAL MODEL:

Glass plate thickness= 3 mm

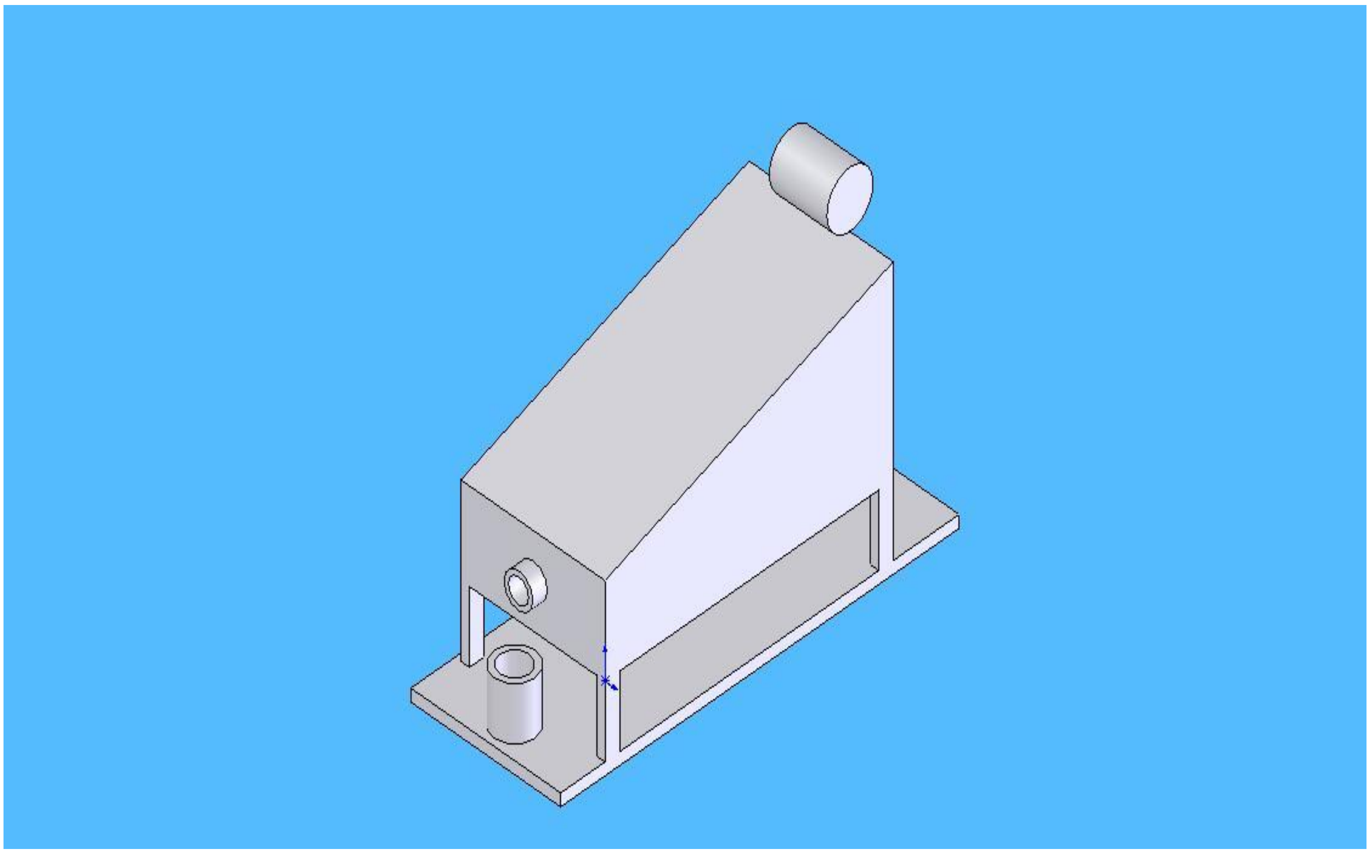
Pipe diameter:

Inner dia= 12 mm

Outer dia= 19 mm

Collector area= 0.31 m^2

Insulation thickness= 20 mm



PRINCIPLE OF OPERATION:

The principle of operation of multipurpose solar waste heat recovery system is illustrated. The solar rays penetrate through the glass covers and get absorbed by blackened metal tray kept inside the collector. The solar radiation entering the box is of short wavelength. This shorter wavelength gets converted to longer wavelength after penetrating the glass cover.

The re-radiation from absorber plate to outside the box is minimized by providing the glass cover. The loss due to convection is minimized by making the system air-tight by providing a rubber strip all around the glass cover. With this type the system is placed in the sun, the blackened surface starts absorbing the sun rays and the temperature inside the box starts rising to the required level. The temperature attained is 60 ^{0}c and the time taken is about 1hour.

The heat is stored by the PCM (paraffin wax) through out the day. After the sunset the heat stored in the PCM is utilized by means of supplying water through the collector and hot water is obtained. The PCM material is packed inside the solar collector by means of aluminium tubes. This is how the waste heat from wax is utilized by means of solar energy.

COST ANALYSIS:

MATERIAL	COST
Body frame	600
Glass plate	200
Sheet metal	400
Aluminium pipes	300
Thermocole	250
Storage tank	350
Welding work	450

TOTAL: Rs. 3000

CONCLUSION:

The fabrication of waste heat recovery system tested in our houses for 2 days. The system gave the encouraging results. The parameters such as water temperature, absorber plate temperature and glass cover temperature were taken.

If we consider small towns and villages, people are using kerosene, LPG, electricity and charcoal. To meet the alternative in the heavy demand of such fuels, the possible solution is that the effective utilization of solar energy. It would cost only the investment and useful throughout the year as India is the country having 240-300 days of sunny days. If the solar energy is utilized, then it will reduce the other fuel demands.

BIBLIOGRAPHY:

1. NON-CONVENTIONAL ENERGY SOURCES by G. D. RAI
2. A. Pasupathy, R. Velraj and R.V. Seeniraj, Renewable & Sustainable Energy Reviews (2008)
3. POWERPLANT ENGINEERING by G. D. RAI
4. MACHINE DESIGN by JOSEPH SHIGLEY

WEB RESOURCES:

1. www.howstuffworks.com
2. www.engineeringtoolbox.com
3. www.mechanialengineeringideos.tv

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