DESIGN AND ANALYSIS OF SOLAR POWERED WATER HEATER

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Abstract

With the rise in electricity expenses and environmental concerns, new technologies are being developed to extract the energy from every available source and store the excess energy generated for later usage. One such solution is provided by Thermal Energy Storage Systems. Nowadays, hot water is used for domestic, commercial and industrial purposes. Various Conventional energy resources like coal, diesel, gasoline etc, are used to heat water and for steam production. Solar energy is the chief alternative to replace the conventional energy sources. In the present project, the existing solar water heating systems were studied with their applications. The solar thermal water heating system is the technology to harness the plenty amount of free available solar thermal energy.The solar thermal system is designed to meet the energy demands and the size of the system depends on availability of solar radiation, temperature requirement of customer, geographical conditions and arrangement of the solar system, etc. Therefore, it is necessary to design the solar water heating system as per above parameters. The available literatures are reviewed to understand the construction, arrangement, applications and sizing of the solar water heating system.

Keywords:-Solar Water Heating System, Collector, Heat pipes, Solar Energy.

1. INTRODUCTION

Thesunhasbeenapowerfulpresenceandforce throughoutthehistory ofhuman existenceonearth. It hasbeen regardedby manyculturesas agodofone formoranother,andunderstoodbymosttobet heultimatesource of life onthisplanet.It hasalso been intentionally exploitedbymany clever means overthe centuries, inorder tobetter utilize this lifegiving energy. As far as renewable energy sources go, the sun representsthebestandmoststablewehave.Itis infinitewithrespecttoallpracticaltimescales, immensely powerful,understood and predictablein its overalltrendsandpatterns,andfortheforeseea ble futurebeyondanthropogeniceffects.Inshort, the perfect energy source; but it is not without difficulties.Solarheaterisa devicewhichis usedforheating the water forproducingthesteamfordomesticandindus trialpurposesbyutilizingthesolarenergy.Mo dern systems designed for capturing the suns energy and transferring it towater, either for immediate use or as astoragemedium, havebeenstudiedandputtousesincethe1970’s,whentheywerefirstusedforpoolheatinginCalifornia.Continuedresearchand innovationhasresultedinproductsfeasiblein muchcolderandlesssunnyclimatestoday.At present, hot water demands are met mainly by the use of electric heaters.Unfortunately, Rising energy cost, environmental concerns, and the depletingnature of the current primary energy sources in use have made electric heatersless attractive. This is because the primary energy sources of electric energyutilized are mainly the fossil fuels. In addition, the demand for electricity isgrowing rapidly; thus within those periods when hot water demand is highestthe electric energy facilities are often overstretched, resulting in some cases topowershadingespeciallyindevelopingcountries.Theseproblemscanbehandledbytakingofftheenergydemandforhotwaterpurposes fromelectricity. A solar water heater is a system that uses sunlight to heat water for use in homes, businesses, and other applications. The system typically consists of solar collectors, a storage tank, and a circulation system. Solar collectors are usually mounted on the roof and absorb sunlight to heat a fluid, typically water or a water-antifreeze mixture, which is then circulated through pipes to the storage tank. The storage tank is usually insulated to keep the water hot until it is needed, and a backup heating system is often used to ensure hot water is available on cloudy or rainy days.Fortunately,thetechnicalandeconomic feasibilitiesofSolarHotWaterSystems(SHWSs) are well established and they have found domestic and commercial applications. These systems use solarenergytogeneratehotwater.Thetechnologyemployedhasbeenreasonablydeveloped andcanbeeasilyimplemented at a low cost. Several configurations exist for this purpose. Theseconfigurations may be grouped into two, namely, the Passive Solar Hot WaterSystems (PSHWS) and the active SHWS. The solar collectors employed in theseconfigurationscouldbeflatplate,concentrating,orevacuatedtubetypes.However, the flat-plate-type solar collector appears to be the most commonlyused. Its low cost and ease of design and construction are basically responsiblefor this. They are often used for low and medium temperature applications butmaybeappliedonhighloadsituationbyusingmorethanonecollector,connectedinseries.The concentrating and evacuated tube collectors are used for industrial orcommercial applications where high load temperatures of up to 100 °C arerequired. In this work we review the current works on SHWSs with a view tobringing into focus their expected specific applications, cost, and ranges ofperformance.There are two main types of solar water heater systems:- passive and activesystems.Activesystemsintegratepum psandrotaryelementsandarethereforeveryex pensive.Passivesystemsusenaturalwatercir culation,gravity,andpressurized water systems. Passive solar water heater systems are much lessexpensivethantheir activecounterpartsandareeasier to maintainandrepair.

2. PROBLEM FORMULATION

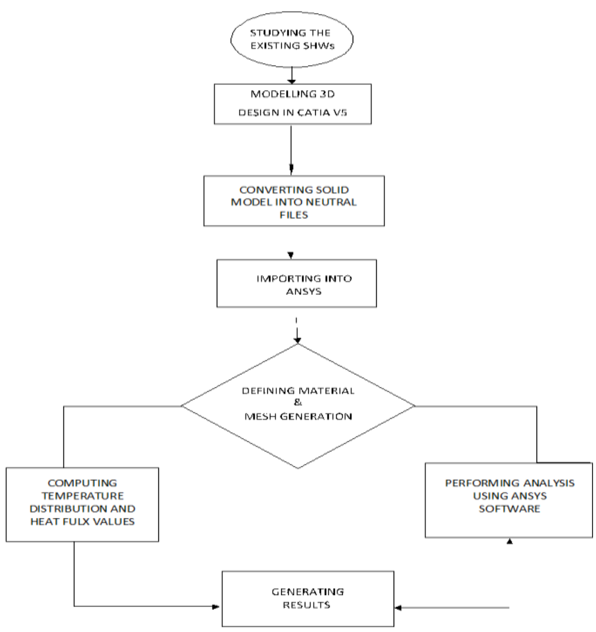
There is always a gap between supply and demand of electricity in ourareas especially during peak summer & winter seasons . The situation furtherworsen during early hours in peak winter season when enormous heating loadisswitchedON.Thisasbeenaconsistentpr oblem,IftheheatingloadisswitchedtoRenew ableEnergySourcefromConventionalEnerg ySourcethenthegapcanbebridged considerably.The use of 1000Solar Water Heating (SWH) systems of 100 liter capacity cancontributetopeakloadsavingofaprx.1M Welectric energyandalsoeachSWHcanpreventemissio nof1.5TofCO2peryear.

LimitationsofusingConventionalWaterHea ters:-

- Susceptibletopoweroutages
- Highoperatingcost
- Traditionalwaterheatersusuallyl astforfewyears(lesslifespan)
- Indirectlycausesenvironmentalp ollution
- Useofconventionalheatersleadst o exhaustofnaturalresources.

Objectives

- ✓ Tofindoutthe bestmaterial to beusedformaximumpossibleefficie ncyofSWHsystem.
- ✓ Applyingdifferenttypesofmaterials.
- ✓ Applyingdifferenttemperaturecondi tions.
- ✓ ApplyingThermalanalysisondiffere ntmaterials.
- ✓ Generat



3. EXPERIMENTATION

CATIA MODEL

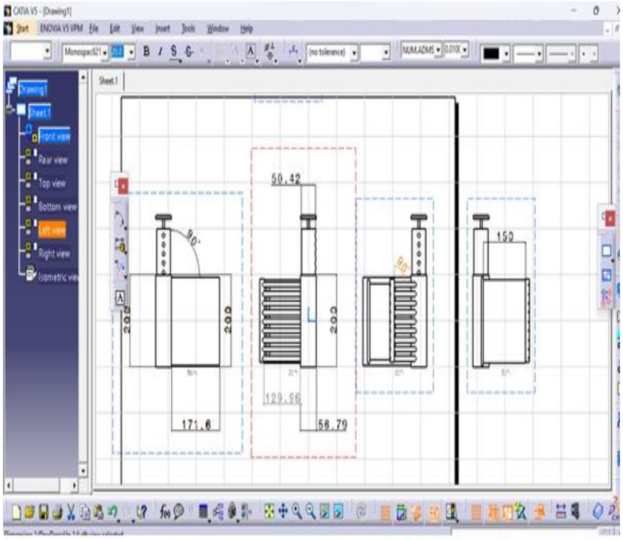


Figure.1: 2D Sketch

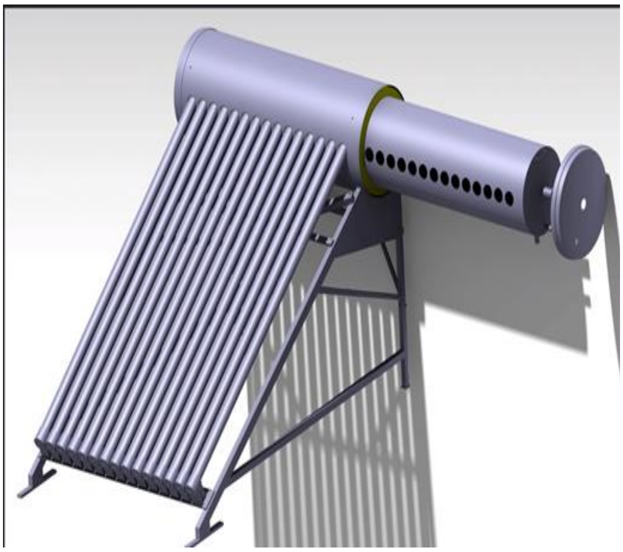


Figure.2: 3D Design

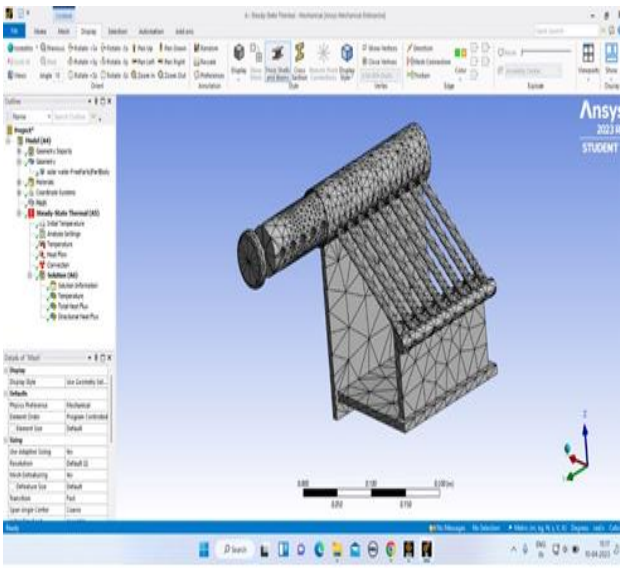


Figure. 3:Mesh model

Tabulation OfResults

After performing the thermal analysis the reults (Heat flux values) obtained are listed below according to the different materials.

Material	Temperature	Total Heat Flux	Directional Heat Flux
ALUMINIUM ALLOY	80	49795	35385
MAGNESIUM ALLOY	80	49630	35299
COPPER ALLOY	80	53484	37522

Material	Temperature	Total Heat Flux	Directional Heat Flux
ALUMINIUM ALLOY	60	32524	23128
MAGNESIUM ALLOY	60	32516	23127
COPPER ALLOY	60	35041	24583

Material	Temperature	Total Heat Flux	DIRECTIONAL HEAT FLUX
ALUMINIUM ALLOY	100	67168	47695
MAGNESIUM ALLOY	100	66744	47471
COPPER ALLOY	100	71926	50461

Comparisonof Results

From the above results we can say that the one which has highest heat flux has the best heat transfering and holding capacity.Comparsion between the three materials (i.e., Copper, Aluminium, Magnesium) has been carried out to find the best material which observe and hold heat for long time with economically.

Graph 1 Heat flux v/s temperature

Comparing the heat flux values to find the best material which has more heat transfer rate atdifferent temperatures (60 ^{0}C, 80 ^{0}C, 100°C) using Line graph:

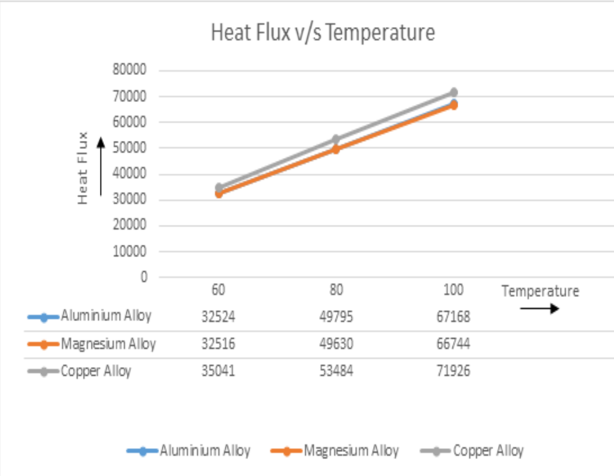
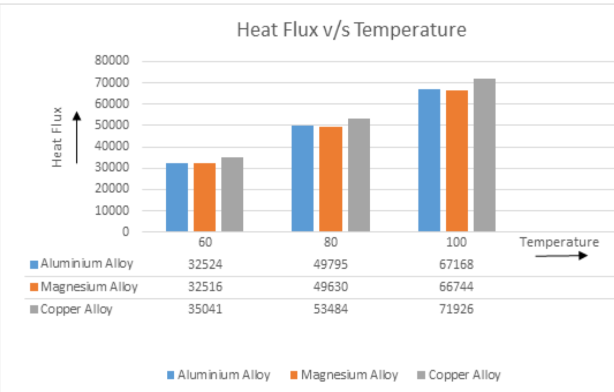


Fig no-4 Heat flux v/s temperature (Line Graph)

From the above graphwe can say that, thebest material which has more heat flux compared to other materials is copper alloy. During analysis the Heat Flux value of Copper alloy was 35041 W/m², 53484 W/m²& 71926 W/m² at 60°C, 80°C, & 100 °C respectively.

Graph 2: Heat flux v/s temperature

Comparison of heat flux valuesof different materials at 3 temperatures (i.e.,60°C, 80°C, 100°C) to get the best material which has more heat transfer rate using Bar graph:



Figno- 5 Heat flux v/s temperature (Bar Graph)

From the above bar graph the best performance is observed inCopper alloy (with a heat flux value of 71926 W/m² at 100°C)compared to other materials.

4. RESULTS AND DISCUSSION

Copper alloy is a popular choice due to its high thermal conductivity and corrosion resistance. This makes it an ideal material for the absorber element in solar collectors. Magnesium alloy is another material that is gaining popularity due to its lightweight and corrosion-resistant properties, but has less efficiency than copper. It is particularly useful for portable solar water heaters or in areas with high levels of humidity.Aluminum alloy is also commonly used in the construction of solar collectors due to its low cost, lightweight, and excellent thermal conductivity. However, it is less resistant to corrosion compared to copper or magnesium alloys.

Ultimately, the choice of material will depend on several factors, including cost, availability, and the specific needs of the application. The design and analysis of solar power water heaters can help determine the most appropriate material for the collector and ensure optimal performance and efficiency. Overall, solar powered water heaters can offer significant benefits in terms of energy efficiency, cost savings, sustainability, and independence from non-renewable energy sources.The graph shows the different heat flux values based on the different temperatures (60, 80, 100°C)applied to different materials at different stages.

5. CONCLUSION

In the present course of work, we have designed the Solar Powered WaterHeaterusing CATIA V5. We have taken three different materials namely Aluminum,Copper, and Magnesium and performed Thermal analysis using ANSYS software.The obtained results were comparedto find best suitable material to design Solar Heating System DifferentFrom the comparison we can say that the Copper is the one which suits best for this system. Copper is yet another good conductor of heat, absorbs quickly and holds it for a longer period of time besides this it is also corrosion-resistant. Because of its versatility while Magnesium and Aluminum can also be used for water heater tanks, they may not provide the same level of thermal conductivity, corrosion resistance and durability as copper. As a result, Copper is the most preferred material for solar water heater than others.

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