Research On Implementation Of Solar Water Heater In Silk Reeling Industry

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ABSTRACT - *Solar energy has a silver lining in that it helps to reduce the greenhouse effect, which helps to restore ecological balance in our environment. Solar energy has a lot of potential in the high-energy silk business. Because it is a cottage industry, it relies on firewood and different forms of agricultural leftovers for energy, which has serious environmental consequences and deprives the soil of critical nutrients and organic conditioning material. Cocoon heating is a critical phase in the reeling process, as it is during this step that the silk is extracted. As additional components for the silk reeling unit, a new system for energy efficient management of the silk reeling process has been developed, which incorporates heat recovery unit and flat plate collectors. The energy consumption for cooking, reeling, and re-reeling activities was calculated and compared to a standard method. For the production of 20 kg multivoltine raw silk in a 10 basin silk reeling unit, 1000 , 500 , 400 and 100 L of water are consumed on average for cocoon cooking, reeling, re-reeling, and boiler operations, respectively, resulting in a significant amount of firewood to generate thermal energy for cocoon preparation.. With the combined use of solar water heating, a heat recovery unit, and a boiler, the new, energy-efficient management technique produces 52 percent saving in firewood consumption with a payback period of a 50-year return on investment when compared to the old technique.*

***Key Words*: Cocoon cooking, firewood, heat recovery unit, insulated hot water tank, silk reeling, solar water heating system.**

INTRODUCTION

The unwinding of filaments from a bunch of cocoons in a hot water bath onto a reel is known as silk reeling. There are two types of reeling: direct reeling on normal reels and indirect reeling, which involves preparatory reeling on small sized reels and moving reeled silk directly from the reels to standard sized reels on re-reeling machines. The cocoons are only heated until the shell becomes wet on the floating system. Still impermeable to water, allowing them to float in water when placed in the reeling basin. Cooked cocoons dip in water during the reeling process in this technique. This technique involves dipping cocoons in water during the reeling process. This method not only cooks the shell, but it also fills the cocoon with water to a level of 97 to 98 percent, causing the cocoon to become heavy and sink in the reeling water. Raw silk is converted into standard-sized hanks by re-reeling. Grant reeling is useful for recovering broken thread ends and knotting. Grant reeling divides the hank into many portions that are maintained separately by lacing. The bevel ratio determines the width of the diamond. For finer denier silk, teeth must be utilized in higher numbers. The pace of re-reeling is approximately twice that of reeling. As a result, one re-reeling end will be sufficient to manage the input from two reeling ends. Using an upgraded multi-end basin reeling mechanism. It's a Cottage Basin variant that's powered up. The ends of cocoons should be rounded and strong, with no sharp edges. Well-pointed ends are simple to recognise because of their form. Steam is used for cooking, reeling, and cocoon suffocation in specialized steam rooms, thanks to the construction of boilers. The selection of cocoons must be done with care, as any lapse in this area could result in significant losses for the struggling business. Selective cocoon buying on the open market is difficult and imperfect, especially in the lack of established cocoon quality standards and acceptable methods of testing for grading cocoons.

1.1 REELING

The optimum temperature of 40-45°C of hot water , more effective for reeling. During reeling, the capacity of each basin comprises roughly 40 L of water at 40-45°C. A total of 400 L of water is required for ten basins. To bring the entire water in the reeling basins to reeling temperature and keep it there during reeling, steam energy is necessary. In all of the basins, hot water is naturally cooled, and steam is employed to enhance the cooling effect. The cooling of heated water at 45°C is measured as a loss of 0.07 kcal/L/min heat energy. The concentration of dissolved sericin in basin water increases as cocoons are reeled indefinitely, altering the color of the raw silk produced. It is practiced to avoid the turbidity effect by ten basins, and the reeling temperature is kept at 45°C for eight hours each day. The energy needed by a 10 basin reeling machine in the traditional technique of producing 10 kg raw silk per day is determined.

There are two types of reeling i.e.Direct reeling on standard reels and Indirect reeling on small sized reels and moving the reeled silk straight from the reels to standard sized reels on re-reeling equipment. Is a mechanical operation in the automatic reeling machine. The size of the raw silk is controlled by the size detector & enables reeling silk yarn of uniform size. The machine has several devices such as the variable speed motor, traverse , cocoon conveyor , stop motion of small reel , rotation calculator etc. which makes the machine efficient.. The semi-automatic reeling machine can be operated with poor quality cocoons. The main distinction between a semi-automated and an automatic reeling machine is that the cocoon end groping, cocoon end plucking, and cocoon transporting are all done manually.

1.2 SOLAR WATER HEATER

A solar flat plate collector is made out of a big heat-absorbing plate, which is commonly made of copper or aluminum since they are both strong heat conductors, and is painted or chemically etched black to absorb as much sun radiation as possible for best efficiency. Because of their simpler design and production, flat plate collectors are less costly than evacuated tubes. From one collector to the next, flat plates are less costly. Despite the fact that evacuated tubes cost 10-15% more than flat plates, their processing costs are dropping. Flat plate collectors can only heat water to a temperature of 250°F, therefore there's no danger of it overheating. In contrast, evacuated tubes can heat water to well over 170-180°F. As a result, they're considerably more likely to overheat than evacuated plates . For this reason, it's usually best to oversize your storage tank rather than undersize it if you're utilizing flat plate collectors. In colder climates, Flat plates are also more common since they are more effective than evacuated tubes in extremely cold temperatures. Flat plate collectors have a high risk of overheating in particularly hot areas, so be cautious if you're in one.

2. LITERATURE REVIEW

Brown Eri W et al. [1], discussed the purpose of the reeling process to know about renewable energy resources like solar energy. Rama Kumar B, Raghu K, Anjaneyulu K S R & Sujatha P et al. [2] , discussed the purpose of non- conventional energy for silk industry - renewable energy. Soteris A.Kalogirou et al.[3] address a survey conducted in 2004 that looked at several types of solar thermal collectors and applications. Solar water heating systems include thermosyphon, integrated collector storage, direct and indirect systems, and air systems; space heating and cooling systems include space heating and service hot water, air and water systems, and heat pumps; and industrial process heat systems include air and water systems. B Sivaraman and N krishna Mohan et al.[4] , represents experiments on the effect of L/d ratio of heat pipe on heat pipe solar collector in 2005 with a different L/d have been designed and fabricated. A heat pipe with stainless steel wick replaces the transport tubes of the solar collector. Hussain Al-Madani et al.[5] , studied a batch solar water heater in 2006 Bahrain consisting of an evacuated, cylindrical glass tube. Water runs through copper coils, which act as collectors, located within the glass tube.

Dharamvir Mangal, Devander Kumar Lamba,Tarun Gupta, Kiran Jhamb et al. [6] , purpose the one of the latest solar water heater in 2010 which is based on the thermosiphon principle used for heating water for domestic purposes in household by utilizing solar radiations. K.S. Ong and W.L. Tong et al.[7] , presents a System performance of solar water heaters in 2011 depending upon collector and storage tank design and sizing and weather conditions. The experimental results showed that the natural convection heat pipe system was capable of heating water to 100°C and performed best among the systems tested. Dhingra Sunil et al .[8] , discussed the purpose of producing raw silk in 2006 which is a case study of the silk industry . Chen, Y., Li, B., Shen, W., Wei, Z., Xu, Y et al .[9] , summarized the Low temperature cocoon cooking method for mulberry cocoon with little sericin. Hisashi N et al.[10] , discussed the process of frozen fresh cocoon which is used in reeling of frozen fresh cocoon. Naik, S. V. & Somashekar, T. H. et al .[11] , described the Effect of degree of cocoon drying and cocoon cooking conditions on reeling performance and quality of raw silk of Indian bivoltine hybrid cocoons. Prasad, B. C., Pandey, J. P., & Sinha, A. K. et al . [12] , Observed the mylitta cocoonase and use in cocoon cooking and studies on Antheraea mylitta cocoonase and its use in cocoon cooking.Tsukasa, H. & Takashi, Y. et al . [13] presents about the Extracting solution and method for modifying fiber or fabric. M.K. Mansour et al .[14], analyzed the thermal of a novel minichannel-based solar flat-plate collector in 2013 .

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Wang, Z. Quan, L. Wang, D. Yu et al .[17] , investigated the performance for the novel flat plate solar collector with a micro-channel heat pipe array conducted in 2013. W.S. Sarsam, S.N. Kazi, A. Badarudin et al .[18] , reviewed studies on using nano-fluids in flat plate solar collectors in 2015 . J. Jyothi, H. Chaliyawala, G. Srinivas, H.S. Nagaraj, H.C. Barshili et al . [19] , designed the absorber for high temperature in 2015 which is a spectrally selective tandem absorber for high-temperature solar thermal power applications . C.D. Del, A. Padovan, M. Bortolato, M. DaiPre, E. Zambolin et al . [20] , performing the flat plate solar collectors with sheet-and-tube and roll-bond absorbers in 2013 .

A.M. El-Sawi, A.S. Wifi, M.Y. Younan, E.A. Elsayed, B.B. Basily et al .[21] discussed the uses of folded sheet metal in flat bed solar air collectors in 2010 .S. Kumar, S.C. Mullick et al .[22] , discussed the purpose of Wind heat transfer coefficient in solar collectors in outdoor conditions . J. Vestlund, M. Ronnelid, J. Dalenback et al . [23] , discussed the purpose of thermal performance of gas filled flat plate solar collectors in 2009 . N. Akhtar, S.C. Mullick et al . [24] , affecting the absorption of solar radiation in glass cover on heat transfer coefficients in upward heat flow in single and double glazed flat -plate collectors .X. Zhang, S. You, H. Ge, Y. Gao, W. Xu, M. Wang, T. He, X. Zheng et al .[25] , performing direct - flow coaxial evacuated - tube solar collectors with and without a heat shield , energy on 2014 .T. Beikircher, P. Osgyan, M. Reu, G. Streib et al . [26] , proposed the methodology of flat plate collector for process heat with full surface aluminum absorber, vacuum super insulation and front foil, International Conference on Solar Heating and Cooling for Buildings and industry. P. Henshall, P. Eames, F. Arya, T. Hyde, R. Moss, S. Shire et al .[27] , induced the stresses in evacuated enclosures for high performance flat plate solar thermal collectors .H. Bhowmik , R. Amin et al. [28], proved the Efficiency improvement of the flat plate solar collector using a reflector .A.J.N. Khalifa, K.H. Suffer, M.S. Mahmoud et al .[29] , purposed the methodology of solar water system with a back layer of phase change material in 2013 . E.B.S. Mettawee, G.M.R. Assassa et al .[30] , discussed the purpose of experimental study in 2006 of a compact PCM solar collector .

3. MATERIALS AND METHODS

The material is chosen based on the solar water heater's intended use. Below are the requirements or aspects that influence the solar water heater's performance, and a thorough investigation was conducted before selecting the material.

3.1 PHYSICAL PROPERTIES

- The incident solar energy was absorbed by the black surface.
- The glazing cover acts as a transparent cover that transmits radiation to the absorber and also limits radiant and convective heat loss from the surface.
- Heat is transferred through the heat transfer fluids from the collectors through the tubes.
- The support framework makes the components fixed.
- To reduce heat loss, an insulated plate is fixed inside the absorber plate.

3.2 MECHANICAL PROPERTIES

The increased thermal efficiency is in the region of 50 to 78 percent. SWH achieved a thermal efficiency of up to 78 percent by using vibration to promote heat transport. This discovery was made using a flat plate solar collector. Heat transfer fluid, absorber coatings, Insulation material, raiser, heat transfer pipes. Maintaining turbulence in the flow, enhancing fluid mixing in the tube for higher temperature uniformity, and increasing the heat-transfer area and heat capacity account for the majority of the improvements.

3.3 CORROSION RESISTANCE

- Most industrial boilers and feedwater systems are made of carbon steel. Many have copper alloy and/or stainless steel feedwater heaters and condensers. Stainless steel is used in several superheaters.
- Feedwater heaters, economizers, and deaerators are successfully protected against corrosion when boiler feedwater is treated.
- To lower costs, it is necessary to understand the operating requirements for all critical system components.

3.4 EASE OF MAINTENANCE

- Collector maintenance and upkeep
- Maintenance and maintenance of heat storage system
- Maintenance and upkeep of piping systems
- Solar system cleaning and descaling method

Table -3.4 : Physical parameters of flat plate collector

PHYSICAL PARAMETERS	VALUE
Length of the fluid tube *L*	2m
Outer diameter tube of the fluid tube *do*	00.11m
Inner diameter tube of the fluid tube *di*	0.01m
Width between the tube *2W*	0.4m
Insulating thickness *Xins*	0.05m
Insulating conductivity *kins*	$0.04W/m^2$
Average thickness of the adsorber *tpm*	0.5mm
Adsorber (copper) conductivity *kp*	$385W/m^2$
Adsorber (copper) conductivity α	0.9
Adsorber (copper) emissivity εp	0.17
Viscosity of Silicone fluid	(1.000–5.000 cs)
Specific heat capacity of Silicone fluid	4.18 J/gK @ 20 °C)
Density of Silicone fluid	$970 kg/m^3$

4. DESIGN

The design of solar panels and solar water heaters has been carried out to get the maximum concentration of sunlight on solar panels and solar collectors. The closed solar water heater system has been designed for the maximum heat generated by the heat transfer fluid. The solar collectors and solar panels are properly installed on the open terrace with the unshaded region to get the maximum efficiency. The complete setup was designed and design parameters were undertaken for the tilting angle of solar collectors, how much solar collectors required for the 1000 lpd storage tank, how many solar panels required for the particular reeling sector has been analyzed and considered for the design. The 72 cell solar panel is used for the design to get more concentrated solar radiation on each cell. The boiler, solar collectors, storage tanks, expansion tanks and pump stations are designed as conceptual. The complete setup made the solar water heater complete and different analyses have been carried out for the selection of components. The total design was carried out in Fusion 360 with the advancement features available in the CAD software.

Fig 4- 3D model of solar water heater

5. ANALYSIS

The solar water heater was tested using Fusion 360 Simulation Software. Various studies had to be done on the coils and Storage tank for the high temperature and thermal stress acted on the storage tank . With the help of thermal analysis, the design is iterated to get the higher efficiency of the coil and storage tank. The theoretical calculations concluded how the design of the solar panel , flare plate collector , boiler and pump should be and the software analysis concluded the deformation of the setup during the water or fluid setup .

5.1 THERMAL ANALYSIS

Thermal analysis is a discipline of materials science that studies how materials' properties vary as temperature changes. Several approaches are routinely employed, each of which is distinguished by the attribute being measured: Thermal analysis of dielectrics: dielectric permittivity and loss factor.

A thermal analyst must examine difficulties like overheating and excessive thermal strains while dealing with heat transmission. Thermal analysis may be used to estimate the model's temperature distribution, temperature gradient, and heat flow, as well as the heat exchanged between the model and its surroundings.

This study is based on two components .

- Helical coil
- Storage water tank

These components experience different studies like applied temperature, Radiation, internal heat which defines the practical possibility of the manufacturing.

5.2 ANALYSIS OF HELICAL COIL

- When the heat transfer fluid is heated to 200 degrees Celsius, it transmits the heat via the coil.
- The water is heated to a maximum temperature of 170.3 degrees Celsius.
- The fluid cannot be heated evenly along the coil.
- The coil may reach a minimum temperature of 120 degrees Celsius.

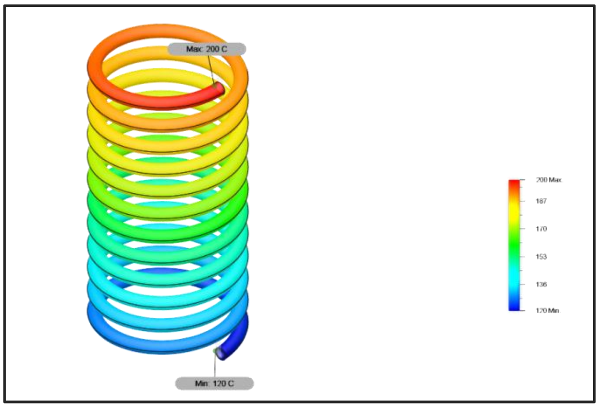

Fig 5.2 - Analysis of helical coil

5.3 ANALYSIS OF STORAGE TANK

- At the heat recovery unit, there was a storage tank. The heat transfer fluid inside the helical coil has already been heated to a maximum temperature of 200 C.
- The heated heat transfer fluid goes through the coil, which warms up and heats the water, resulting in convection.
- Water is heated to a continuous temperature of 170.3 degrees Celsius and a minimum of 80 degrees Celsius to provide warm water for cooking and reeling devices.
- Cooking and reeling cocoons at a temperature of 70-110 degrees Celsius.

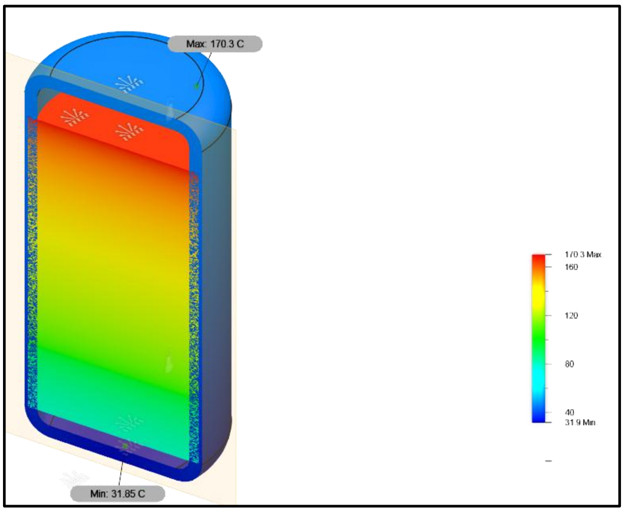

Fig 5.3 - Analysis of storage tank

5.4 ENERGY PRODUCED BY SOLAR PANEL

Solar panel	2
Solar panel size	5ft * 7ft
Solar cells	72
Energy generate	400 W
Watt produced per solar cell	5.55 watt
72 cell solar panel	Solar cell * watt produced 72 * 5.55 = 400W

6. IMPLEMENTATION

1. Centrifugal pumps transport regular water from the usual storage tank to the solar collecting tanks.
2. Silicone fluids are started and flow across the solar collectors to absorb as much heat as possible.
3. The collector tanks with the copper coiled tubes receive heated silicone fluid and transfers the heat from the copper tube to water.
4. This system acts as a heat exchanger and the hot water is pumped out from the collector tanks and stored in the fused storage tanks.

5. The fused storage tanks can accommodate both the hot water ie) primary source and secondary source.

6. The electric hot boilers are used as a secondary source of heat to get the required temperature at the time of process.

7. The Solar panels installed in the terrace acts as an electric source for the boiler and other electric supply units involved in reeling sectors.

8. The solar panels can produce only DC current which is converted into AC with the help of inverters.

9. The excess electric supplies are stored in the batteries.

10. The Fused storage tank supplies the required hot water to the cooking and reeling sectors.

11. As the heat requirement of reeling is low compared to cooking, the water used by the cooking sector is enough for reeling.

12. The consumed water is later received by the recycling sector for the recycle purposes.

13. The recycled sector supplies the normal water for the solar storage tank for another cycle.

14. The remaining hot water in solar storage tanks is also transported to other departments rather than reeling sectors.

15. Hence the process is completely utilized and there is no wastage in both water and electricity.

In the reeling industry, the installation method is simple. In terms of production and management, this results in significant savings and advantages.

3. CONCLUSIONS

The hot water requirements are really needed in textile industries and reeling sectors. The small scale based industries are using firewoods and fossil fuels as their heat source to get the hot water for their different applications. The major part of manufacturing cost must be used in improving the quality of making products and should not be in buying raw materials for manufacturing. As the solar radiation is adequate and abundant, we can use them as a source for production. The implementation of solar water heaters can give enormous benefits in the production needs. The implementation of solar water heaters eradicated the buying of firewoods and fossil fuels for the reeling sectors. This discourages deforestation and makes an impact on the environment. The solar panel with required amount of capacity satisfies the reeling sector needs and also saves the electricity for the future use. The saved electricity can be used for other departments involving other than reeling sectors. The research makes the role model to other textile industries to implement solar water heaters and solar panels to save electricity, improve manufacturing costs for other processes, to discourage deforestation.

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