

Using Solar Water Flat Plate Collector by the application of Taguchi ANOVA and Grey Relational Analysis method

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Abstract

Solar energy development is main concern of present research. Solar energy industries mainly focus on development of efficient, effective and economic "passive" solar system. Many researcher are trying to develop and modify various solar system which is presently used for this purpose are like flat plate solar collector, solar heating system etc. Solar energy is used for heating and cooking is older technology. The usability of solar energy is improve and developing new technology for cultivation of this renewable energy. Today solar energy is one of the most important sources of energy after thermal energy, many countries which are present in tropical belt are now mainly used this energy.

Keywords: Taguchi, ANOVA, Grey Relational Analysis.

1. Introduction

India's total energy consumption is fulfil by two major source are is thermal and second is solar energy. So that it is very important for India to developed new and advance technology which helps to cultivate more and more solar energy for this purpose over study is one of the important research for development and modify the flat plate solar collector with used of PCM. Conventionally used thermo syphon type solar water heater for water heating in this solar water heater it has collecting tank, bottom plates, tube and flow channel. In this conventionally solar water heater is not effective and efficient because it has some unavoidable losses of heat through temperature difference between system and surrounding by the made of conduction,

convention and radiation there is some more problem with this solar water heater is leakage and corrosion in the tube which also caused heat losses all this make system less effective and less efficient. In our research study we were trying to solve above problems with design and modification of this conventional solar water heater. We used flat plate solar water collector with PCM. For this modification we can make tube in sheet solar flat plate collector. In this tube water will be flow and PCM is surrounding this tube and modify the design as minimizing the heat losses by develops the effective Insulating box. Over main concern is improving the efficiency of collector with economic cost.

1.2 Design Procedure

Design of flat plate collector and manufacturing this collector with selected optimum process parameters like polymer tubes, iron tubes, iron box, copper sheet collector, insulating material, sealing glass cover and PCM.

Firstly we making water tank and collector tank is made by iron sheet metal shop and collector is also make with iron sheet in some sheet metal shape of workshop tank and collector is now arrange as the Water is flow smoothly from tank to collector and collector to outlet device.

Secondly we prepare flat plate collector as our requirement so that making collector with PCM with water tank. PCM is filled in collector tubes and then it make insulated by the use of suitable insulating material for preventing the heat losses.

2. Fabrication of Flat Plate Collector

2.1 Fabrication of Iron box with insulation

Firstly we collect all essential required material from market like iron sheet, polymer sheet, adhesive material, silver foil, point and toils then in sheet metal shope we can fabricate from box as per our required size and shape then make sufficient layer of coated primer and make sure the proper priming over box for giving highly surface finish of the box. Secondly we insulate the box by the used of insulating adhesive and make layer of theriacal sheet over it for preventing the heat loss from the box for make perfect reflection of solar radiation from the box we used silver foil and pasted it over the all side of box above theriacal sheet this silver foil make our box perfect for solar absorption and fabrication of iron box is done we check this box as it does not have any hole and it make defect free.

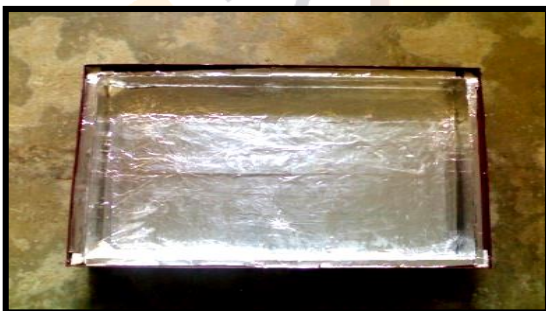


Fig.1 Fabrication of Iron box



Fig. 2 Surface model variations of machining responses

2.2. Fabrication of copper plate panel with tube work

Development of flat plate collector by the used of copper sheet ,size of collector $1000 \times 307 \times 8 \text{ mm}^3$ is fabricated in shape for making collector panel we used polymer tube with 7 mm dia 3800 mm long for making flat plate collector panel we arranged this polymer tube in 50 - 50 mm gap in the surface of copper plate collector we can also provide 25 - 25mm gap in side walls of collector from tubes the arrangement of collector plate and tube make some the proper flow of the water and preventing the heat losses from the tube and surface of collector walls.



Fig. 3 Copper plate panels with tube

2.3 Fabrication of copper plate with PCM

Copper plate panel is made by the tube and plate. In this panel there is two sets of the tube (concentric type tube) are making outer tube is made by iron and inner tube is made of polymer. This two tube is arranged as proper gap between iron and polymer



tube has the PCM material is properly filled in

iron tube and make sure the perfect sealing, this sealing is helping preventing the leakage and loss the PCM from the tube.

Fig: 4 copper plates with PCM

3. Taguchi Method

Dr. Genichi Taguchi, a Japanese quality management consultant developed the Taguchi Method. Taguchi method for performing statistical measurement of performance called Signal to noise ratio (S-N ratio). The S/N ratio is the ratio of the mean (Signal) to the standard deviation (Noise). It takes mean and variability both as parameter. To optimized, the S-N ratio mainly depends on quality characteristic parameters of flat plate solar collector. Taguchi S/N ratios mainly used as follows: Higher the Better (HB), Lower the Better (LB) and Nominal

is Best (NB). The parameter which has highest S-N ratio is taken as parameter for combination.

Larger-the-better is defined as follows:

$$SN = -10 \log_{10} \left(\frac{1}{n} \sum_{i=1}^n \frac{1}{y_i^2} \right) \quad (1)$$

Where:

y_i = quality measurement

n = the total of the measurements.

4. ANOVA (ANALYSIS OF VARIANCE)

ANOVA (analysis of variance) is a statistical method of collecting data of statistic models.

ANOVA is also collecting data of all procedures of method. In ANOVA, variable is collected and divided these variables in different-different variance of statistical models. In ANOVA analysis, it provided the statistical model of each variance in different level of variables. It does not provide the overall variable value of variance. For this evaluation ANOVA method is used. ANOVA method is also evaluate the signification effects of various process parameter of flat plate solar collector and also evaluates the error in experiments. The following procedure is used in ANOVA method as follows:

4.1 S/N (degree of freedom)

Number of possible movability of system is called degree of freedom. It can be calculated by subtracting 1 from total constraint value.

For each factor

$$n = \text{DOF of each factor level} - 1$$

For Total factor

$$n = \text{DOF of total experiment} - 1$$

Error in DOF

$n_e = \text{Total DOF} - \text{sum of DOF of each factor}$

5. Grey Relational Analysis

Grey analysis method is mainly used for information and data analysis. In grey analysis there is all sets of information which is related to operation or which is not related to operation are analysis for optimization. GRA (grey relational analysis) is the method which is used to analysis the various parameters and help to optimize our desired goal and make sure the getting quality output without compromising the experimental data and other variables which is essential for our research. In GRA result is rating out by Higher-the-Better criterion, the normalized data can be expressed as:

For Higher-the-Better (HB) criterion, the normalized data can be expressed as:

$$X_i = \frac{(y)_i - \min(y)_i}{\max(y)_i - \min(y)_i} \text{ where } i = 1, 2, \dots, n \quad (2)$$

Where:

$X_i = \text{value after the GRA}$

$\min (y)_i = \text{smallest value of } (y)_i$

$\max (y)_i = \text{largest value of } (y)_i$

$$G_i = \frac{L_{\min} + \epsilon L_{\max}}{L_i + \epsilon L_{\max}} \quad i = 1, 2, 3, \dots, n \quad (2)$$

Grey relation coefficient = ϵ

Grey relation coefficient = $0 < \epsilon < 1$ (i.e $\epsilon = 0.5$)

6. Measuring Equipment's

➤ **DATA Logger:** DATA Logger is device to measure and recorded the data of flat plate solar collector at various temperature level. DATA Logger is mainly two type, one is mechanical operated and second is digital logger. We can used USB-5001 digital type temperature data logger in our experiments for recording the temperature of system at various level.

➤ **Thermometer:** Thermometer is used for measuring the temperature of object with direct contact of object. Thermometer is made up of glass in different shape. The mercury is used as thermometric material in thermometers. The change in height of mercury in glass thermometer is recorded and measured the value of height by the scale which is drawn over thermometer. This recorded height value is put on the formula and then calculate the value of temperature of collector.

➤ **Pyranometer:** Pyranometer is device which is used for measuring the solar radiation over the earth on horizontal surface of hemisphere. Working principle of Pyranometer is that it show the sensitive surface towered the radiation. This sensitive surface is consisting of circular hot and cold junction. The cold junction is electrically insulated. Pyranometer is function on the basis of difference of temperature between hot and cold junction. This temperature difference of junction is due to radiation which is falling on the junction.

➤ **Beaker:** Water flow rate is measured by the used of beaker. Beaker is also used to main tend the flow rate of water in collector tubes. By the help of beaker collector tube maintain constant rate of water flow in flat plate solar collector i.e. 1 Lt/hr.

7. Conclusion

Reliability and checking of maximum effect of process parameters on flat plate collector. In this study is show that absorption membrane type is one of the main factors which affected the overall quality



and efficiency of flat plate collector. The optimum value of flat plate solar collector.

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