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PERFORMANCE ANALYSIS OF SOLER WATER PURIFICATION SYSTEM BY TAGUCHI PARAMETRIC OPTIMIZATION TECHNIQUE

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ABSTRACT

Solar water purification system is new concept in thermal industry .It is vary nearer to the natural purification of water which include vaporization and condensation of water. Solar energy is used to make vapour from stored water .Vapour particles collects on inclined glass and flew down following the condensation process. Condensed water is collected in the container .Performance of purification depends upon many controllable and uncontrollable factors in which water temperature, ambient temperature ,glass plate temperature ,inclination of glass ,humidity and water quantity are some factors. Recent economics research has focused on developing the reliable machinery database to ensure optimum design. In this research process parameters have been optimize for best performance of solar water purification system by Taguchi optimization technique. Larger is better option has been taken for the analysis three parameters water temperature (WT),glass plate temperature (GT) and quantity of water (QW) are taken and level of parameter are three (Lower, Medium, High). Degree of freedom of parameter is six which is suitable for L_9 orthogonal array for three independent parameter. Performing with all nine set of parameter amount of TDS have been observed. The study includes selection of parameters, utilizing an orthogonal array, conducting experimental runs, data analysis, determining the optimum combination. Finally the experimental verification has been done. Experimental results are provided to illustrate the proposed approach. Finally we derived a mathematical model for maximum performance with the help of MATLAB software. After the whole work comparative analysis of results from different theories has been done in which we found that all results are approximately similar. Hence author concluded that the values of parameters can be selected for other vital experiment on the basis of mathematical model generated by this research

Key words : Solar water ,Taguchi, Water Temperature, Glass plate temperature, Quantity of water , TDS,

INTRODUCTION

Necessity of purified water leads to the requirement of purification system There are many processes available for purification of drinking water like Chlorine tablets , Pot chlorination of wells, Slow and rapid sand filters, Fluoride removal , Reverse osmosis plants, etc .In this project, we are making a water purifier which works on solar energy] We are using solar energy which is a renewable source, abundant and cheap. In case of power failures, this purifier will continue to work as solar energy can be stored This purifier can be used in remote and rural areas where there is no electricity. It can also be used in places affected by natural disasters. It also reduces the salt content in sea water. It provides pollution free operation .Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic's, solar thermal energy, solar architecture,.

TAGUCHI METHODOLOGY

Taguchi is a methodology which gives the optimum combination of independent parameter which has a significant role to change the value of dependent parameter. The prime objective of the method is to design best quality product at least cost of manufacturer. This method was generated by Dr. Genichi Taguchi of Japan .This method has designed to investigate how various parameters significantly affect the mean and variance of parameter pertaining to main characteristic and quality of process .The orthogonal arrays is the prime tool which arrays to organize the parameters affecting the process and the levels at which they should be varies. Taguchi method tests pairs of combinations in place of all possible combinations .This provide the necessary data to identify the significance of factors affecting product quality with a minimum recourses and time. The arrays are selected on the basis of degree of freedom of parameter which depends on the no of parameter and their level. The data from the arrays can be analyzed by visual analysis.

Philosophy of the Taguchi Method

(a)Quality of product depends on the process by which it has been produced . One can improve the quality by optimising the parameter affects the process.
(b) Best quality can be achieved by minimizing uncontrollable environmental factor which leads to deviation from a target.
(c)The cost of quality should be measured as a function of deviation from the standard and the losses should be measured system wide.

Procedure and Steps
Step-1: Selection of the quality characteristic

There are three types of quality characteristics in the Taguchi methodology, such as smaller-the-better, larger the-better, and nominal-the-best. For example, smaller-the-better is considered when measuring fuel consumption of fuel in automobile or roughness in surface finish. The goal of this research was to find the effect of parameters and achieve maximum performance of water purifier

Step–2: Selection of noise factors and control factors

In this step, the controllable factors are water temperature (WT), Glass plate temperature (GT) and Quantity of water (QW) which were selected because these are the factors which affect the Performance of water purifier

Step–3: Selection of Orthogonal Array

There are 9 basic types of standard Orthogonal Arrays (OA) in the Taguchi parameter design. Selection of arrays depends on the degree of freedom of selected parameter. Degree of freedom of all three parameter is 6 . An L_9 Orthogonal Array is selected from for this work. The layout of this L_9 OA is as mentioned in Table 1.

Experiment	P1	P2	P3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 1: L_9 Orthogonal Array

Step–4: Conducting the experiments
Experiment has been conducted at various level .Observation are shown in fig 1

Step–5:Predicting Optimum Performance

Using the mentioned data, one could predict the optimum combination of parameters for maximum value of purification level (TDS). With this prediction, one could conclude that which combination will creates the better result. A confirmation of the experimental design was necessary in order to verify the optimum variables combination

EXPERIMENTAL SETUP: As the literature suggested, the experimental setup is constructed for the various factors and their levels are chosen, which affect the performance of Heat Exchanger

S.No.	W.T. ^{0}c	G. T. ^{0}c	Q.W. (ml)	TDS
1	33	35	100	25
2	33	45	1000	19
3	33	55	2000	12
4	50	35	1000	15
5	50	45	2000	11
6	50	55	100	16
7	68	35	2000	12
8	68	45	100	15
9	68	55	1000	8

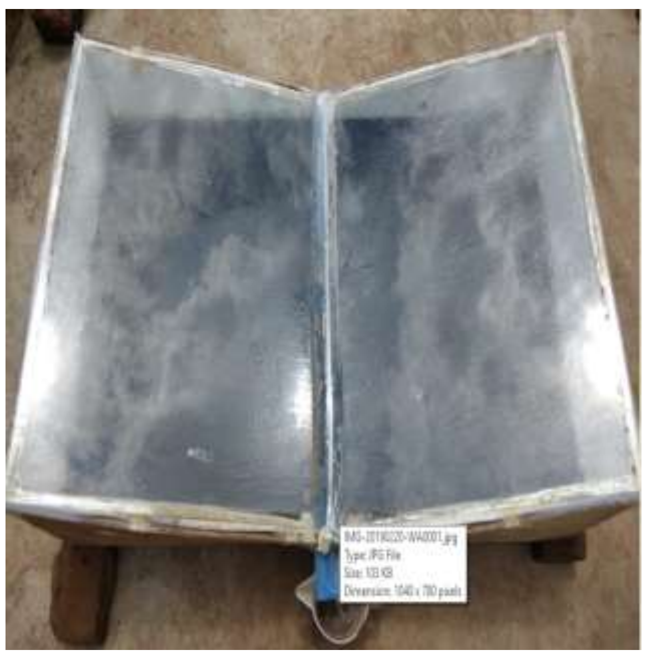

Figure -: 1 solar water purifier.

S.No	**Parameter**	**Levels**		
		Low	**Medium**	**High**

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1.	WT (ºC)	33	50	68
2.	**GT** (ºC)	35	45	55
3.	**QW** (ml)	100	1000	2000

Table- 2: Level of Factors

Table- : Observation Table

Stepwise MATLAB calculation is as follows:

Step -1

Input parameters and output parameters were converted into natural log terms.

```
X=[1 3.49 3.55 4.60;1 3.49 3.80 6.90;1 3.49 4.00 7.60;1 3.91 3.55 6.90;1 3.91 3.80 7.60;1 3.91 4.00 4.60;1 4.21 3.55 7.60;1 4.21 3.80 4.60;1 4.21 4.00 6.90]

X =

    1.0000    3.4900    3.5500    4.6000
    1.0000    3.4900    3.8000    6.9000
    1.0000    3.4900    4.0000    7.6000
    1.0000    3.9100    3.5500    6.9000
    1.0000    3.9100    3.8000    7.6000
    1.0000    3.9100    4.0000    4.6000
    1.0000    4.2100    3.5500    7.6000
    1.0000    4.2100    3.8000    4.6000
    1.0000    4.2100    4.0000    6.9000

>> Y=[3.21;2.94;2.48;2.70;2.39;2.77;2.48;2.70;2.07]

Y =

    3.2100
    2.9400
    2.4800
    2.7000
    2.3900
    2.7700
    2.4800

    2.7000
    2.0700
```

```
>> X'

ans =

  Columns 1 through 6

    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    3.4900    3.4900    3.4900    3.9100    3.9100    3.9100
    3.5500    3.8000    4.0000    3.5500    3.8000    4.0000
    4.6000    6.9000    7.6000    6.9000    7.6000    4.6000

  Columns 7 through 9

    1.0000    1.0000    1.0000
    4.2100    4.2100    4.2100
    3.5500    3.8000    4.0000
    7.6000    4.6000    6.9000

>> X'*X

ans =

    9.0000   34.8300   34.0500   57.3000
   34.8300  135.5769  131.7735  221.7510
   34.0500  131.7735  129.1275  216.7850
   57.3000  221.7510  216.7850  379.5900

>> inv(X'*X)

ans =

   68.8672   -4.9312  -12.4044   -0.4308
   -4.9312    1.2742   -0.0000   -0.0000
  -12.4044   -0.0000    3.2787   -0.0000
   -0.4308   -0.0000   -0.0000    0.0677

>> A=ans
A =

   68.8672   -4.9312  -12.4044   -0.4308
   -4.9312    1.2742   -0.0000   -0.0000
  -12.4044   -0.0000    3.2787   -0.0000
   -0.4308   -0.0000   -0.0000    0.0677

>> B=X'*Y
```

B =

23.7400
91.3738
89.5785
148.9870

>> A*B

ans =

8.9830
-0.6371
-0.7798
-0.1460

$C_{0=}$ Antilog 8.98 =$7.94x10^3$
C_1= -0.63
C_2= -0.77
C_3= -0.14

TDS = 7.94 * 10^3 $(WT)^{-0.63}$ * $(GT)^{-0.77}$ $(QW)^{-0.14}$

RESULTS AND ANALYSIS

The values obtained from the result are plotted to visualize the effect of the three factors at three levels. Graph 1 shows the influence of each factor. Water temperature (A) Glass plate temperature (B) Quantity of water (C) as the higher TDS value is a better performance characteristic.

Table- 4: Optimum Level of factors

Symbol	Controllable Factors	L	M	H
A	**WT**	**18.66**	14.0	11.66
B	**GT**	**17.33**	15.0	12
C	**QW**	**18.66**	14.0	11.66

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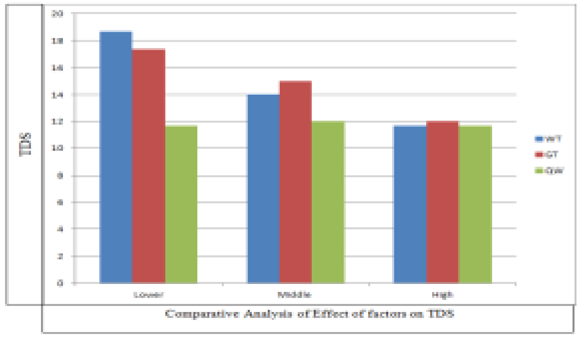

Graph-1 Factors Effect for Mean TDS

Table-:5 Comparative Analysis of results

S. No.	WT ^{0}c	GT ^{0}c	QW	TDS	From Formula	Diff.
1	33	35	100	25	29.91	+4.91
2	33	45	1000	19	17.85	-1.15
3	33	55	2000	12	13.83	+1.13
4	50	35	1000	15	16.61	+1.61
5	50	45	2000	11	12.42	+1.42
6	50	55	100	16	16.19	+0.19
7	68	35	2000	12	12.42	+0.42
8	68	45	100	15	15.57	+0.57
9	68	55	1000	8	9.66	+1.66

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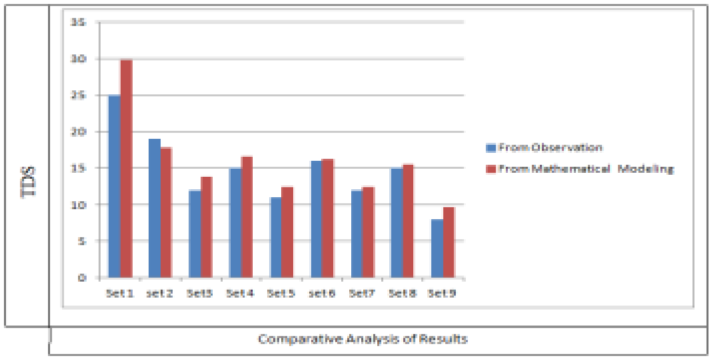

Graph-2 Graph for Comparative Result of Experiments & Mathematic Model

CONCLUSIONS

Experiments conducted and subsequently analysis performed by using the Taguchi Method. The optimum characteristics for TDS operation are identified and mathematical formula had generated with the help of MATLAB, then the results obtained have compared with the result of above said optimization methods. It conclude that

Level I for Water temperature WT_1 =33 ^{o} C indicated as the optimum situation in terms of mean value.

(a) Level I for glass plate temperature GT_1 =35 ^{o}C indicated as the optimum situation in terms of mean value.

(c) Level I for Quantity of water QW_1 = 100 ml, indicated as the optimum situation in terms of mean value.

(d) Value of TDS for any combination of parameter can be calculated from generated formula.

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