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IMPROVING ITS EFFICIENCY BY CHANGING SHELL TUBE PARAMETERS

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Annotation

To solve such an optimization problem, the Taguchi method is used in the present work to screen experiments and determine the critical critical parameters that affect the performance of shell-and-tube type heat exchanger. Prefix parameters (tube diameter, mass flow rate, and step length) are used as input parameters, and the output parameter is the maximum temperature difference of the shell and tube heat exchanger. Nine different models are created in Solid Works 2012 and CFX analysis is performed in ANSYS 12.0. Minitab 16 software is used for Taguchi analysis. The results of the Taguchi analysis show which combination of design parameters gives the minimum outlet water temperature. The parameter that most affects the water temperature is the pipe diameter, pitch length and mass flow rate determined by Taguchi analysis.

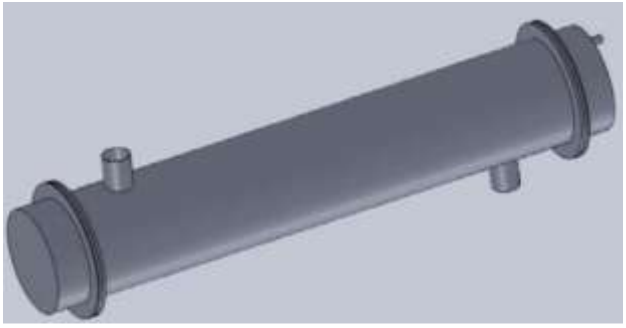
Keywords

Heat exchanger, ANSYS 12.0, Minitab 16, Solid works 2012, Taguchi method.

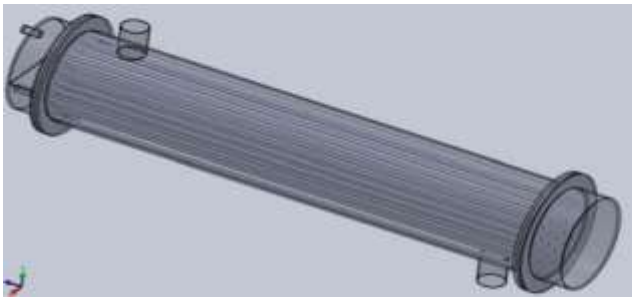
Introduction

Taguchi experimental design methods provide a simple, efficient, and systematic approach to optimizing the performance quality and cost of experimental designs. The main goal of the Taguchi method is to reduce process variation through robust design of experiments. The experimental design proposed by Taguchi involves the use of orthogonal arrays to regulate the parameters affecting the process and the degrees to which they should vary; It allows you to save time and resources with minimal experiments to collect the necessary data to determine which factors have the greatest impact on product quality.

Selection of process variables. From researching past literature, we have discovered that several factors affect the efficiency of a heat exchanger. Shell and tube heat exchanger is widely used in industry, so it is taken for analysis. The efficiency of a shell and tube heat exchanger depends on many parameters, such as the diameter of the tube, the length of the tube. Longitudinal pitch, mass flow rate, pipe material, shell material, baffle types, baffle angles, etc. Formulating the research in this way, we show that pipe diameter, pitch length and mass flow rate are the most effective parameters of thermal efficiency. changer.



Solid Work Model of Shell and Tube Type Heat Exchanger



3D Model of Shell and Tube Type Heat Exchanger

Experiment

Selection of Process Variable Levels From study of literature of past researcher, heat exchanger manufacturing association technical specification catalogue, the varying levels of process parameter (like tube diameter, pitch length, mass flow rate) are selected as three parameter are varying in three level. The variation levels value for each parameters are given in Table 1.

Variation level	Tube Diameter m m (A)	Pitch Length m m (B)	Mass Flow Rate kg/s (C)
1	8.525	23	1.3
2	9.525	25	1.6
3	10.525	27	1.9

Table 1: Process Variable Range

Selection of Orthogonal Array . The selection of orthogonal array for experiment was done by use Minitab-16 statistical software. By putting parameter variation levels as per Table 1 in Minitab-16 statistical software the Minitab suggest that mix level L9 (1*2, 3*3) fractional factorial orthogonal array is most compatible for our experiment. The experiment table suggested by Minitab- 16 for L9 orthogonal array is shown in Table 2

Table 2: Standard Experiment Design

Ex No.	Tube Diameter m m	Pitch Length m m	Mass Flow Rate kg/s
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2

The final experiment are designed by proving selected parameters values as per Table 3, suggested by heat exchanger manufacturing association in Minitab- 16 statistical software is shown in Table 2. The experiment suggested by this table is specifying the parameter level value of that particular experiment for find out the response value.

Table 3: Experiment Design with Expected Range

Ex No.	Tube Diameter m m	Pitch Length m m	Mass Flow Rate kg/s
1	8.52	23	1.3
2	8.52	25	1.6
3	8.52	27	1.9

CFD ANALYSIS OF TAGUCHI SELECTED ARRAY

CASE 1 Pitch length = 23 mm, tube diameter= 8.525 mm, mass flow rate: 1.3 kg/s

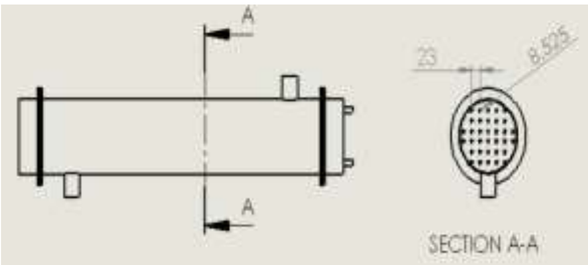


Figure 1: Model of Heat Exchanger for Case-1

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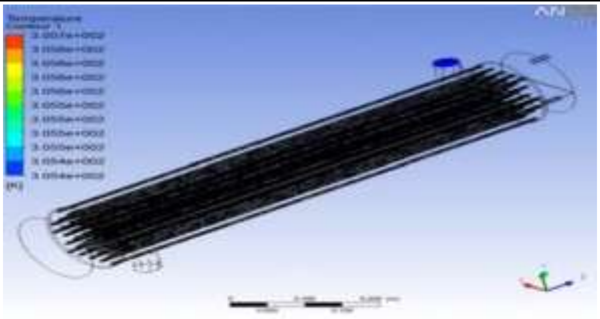

Figure 2: Outlet Temperature of Water for Case-1 Outlet Temperature = 305.66 K

CASE 2 Pitch length: 25 mm, tube diameter: 8.525 mm, mass flow rate: 1.6 kg/s

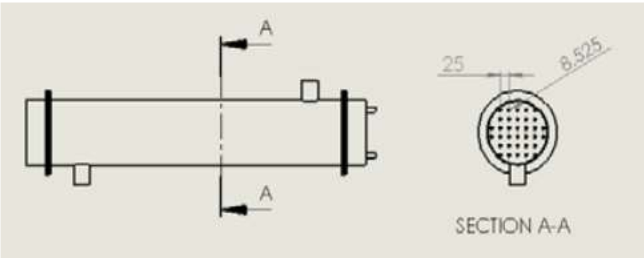

Figure 3: Model of Heat Exchanger for Case-2

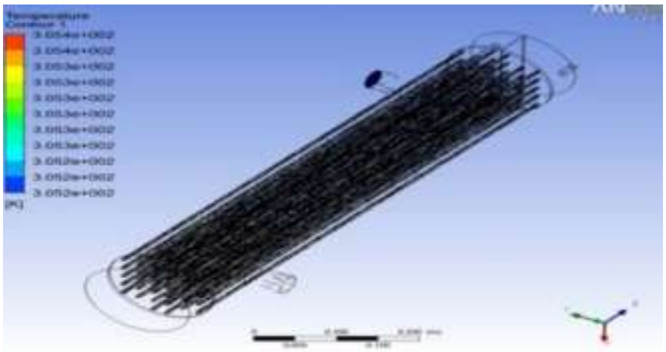

Figure 4: Outlet Temperature of Water for Case-2 Outlet Temperature = 305.37 k

CASE 3 Pitch length: 27 mm, tube diameter: 8.525 mm; mass flow rate: 1.9 kg/s

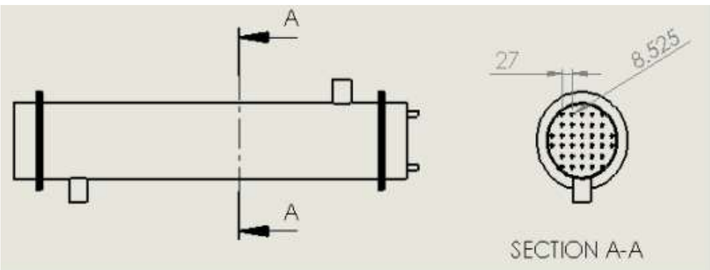

Figure 5: Model of Heat Exchanger for Case-3

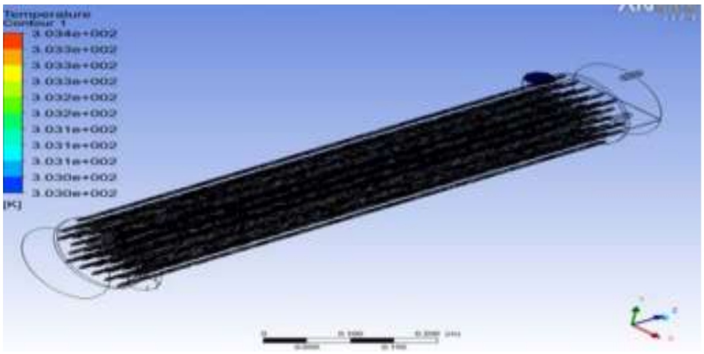

Figure 6: Outlet Temperature of Water for Case-3 Outlet temperature = 303.38 k

Results

Main Effects Plot of Outlet Temperature Main effects plot for S/N ratio of outlet temperature verses pipe diameter, pitch length, and mass flow rate generated from outlet temperature S/N ratio value according to Table 4 in Minitab-16 statistical software is useful for finding the optimal parameter value for the supply response variable. A graph generated using Minitab16 statistical software for outlet temperature is shown in Figure 7.

Ex No.	Pitch of the Tube	Mass Flow Rate	Outer Temperature (K)
8.52	23	1.3	305.66
8.52	25	1.6	305.37
8.52	27	1.9	303.38

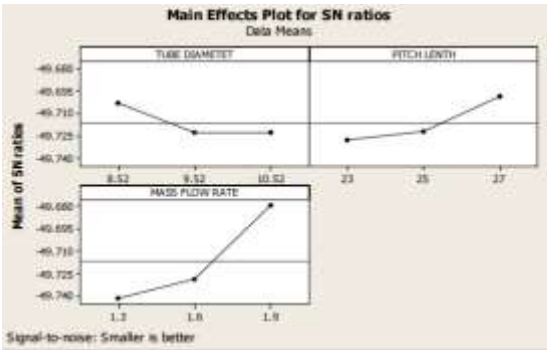

Table 4: Result of Nine Cases **Figure 7: Main Effects Plot for SN Ratio**

From the Figure 22 it is conclude that the optimum combination of each process parameter for lower outlet temperature is meeting at tube diameter (8.52 mm), pitch length (27 mm) and mass flow rate (1.9 kg/s). The S/N of the outlet temperature for each level of the each parameter can be computed in Minitab 16 and it is summarized for finding out rank of each effective parameter for response.

The analyzed value of mean of outlet temperature by use of Minitab 16 statistical software is shown in Table 5.

Level	Tube Diameter	Pitch Length	Mass Flow Rate
1	-49.68	-49.71	-49.73
2	-49.72	-49.74	-49.73
3	-49.74	-49.70	-49.68
Delta	0.06	0.04	0.05
Rank	1	3	2

From Table 5 it is show that the value of delta for each parameter tube diameter, pitch length and mass flow rate are 0.06, 0.04 and 0.05, respectively for outlet temperature. From the delta value of each parameter it is conclude that for outlet temperature the most effective parameter is tube diameter followed by mass flow rate and pitch length.

Conclusion

In present work for improving the efficiency of shell and tube heat exchanger, the optimization of heat exchanger parameters tube diameter, mass flow rate and pitch length done successfully using Taguchi approach and CFD analysis. From the study of analysis result it is concluded that The optimum parameter conditions for increase the efficiency of shell and tube heat exchanger is meeting at outlet temperature 303.38 K are tube diameter 8.52 mm, pitch length 27 mm and mass flow rate 1.9 kg/s. The tube diameter is the most significant parameter which is followed by mass flow rate and pitch length for minimum outlet temperature.

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