DESIGN AND ANALYSIS OF PLATE HEAT EXCHANGERS

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ABSTRACT
The plates design and cooling fluids through a plate heat exchanger affects the Heat transfer rate. A Normal plate with enhanced surfaces increases heat transfer rate. A Nano fluids absorbs more heat than the Water when cooling Lubrication oil. In this Paper, Analysis is done to compare the heat transfer rates between the different plates: 1) Flat plate and 2) Flat plate with enhanced surfaces. Thermal analysis is done on the different plate heat exchangers for different fluids by taking hot lubrication oil and cooling water, titanium oxide and aluminum oxide. 3D models is done in CATIA and analysis is done in ANSYS.

Keywords: Lubrication oil, Water, Aluminum-oxide and Titanium-oxide water Nano fluids.

INTRODUCTION
The Heat transfer occurs between hot lubrication oil and cold water through corrugated plates. The each plate is fitted with gasket for sealing and to direct the fluid. The fluid properties, flow rate, temperature and pressure determines the number of plates to be installed. The fluid turbulence and for against differential pressure between the plates is achieved by corrugations. The fluid undergoes single pass within the exchanger. The hot and cold fluids flows alternatively plates in the counter-current direction. At present for industrial applications there are various types of plates technology are useful. Plate heat exchangers is having high heat transfer coefficient and is achieved by inducing turbulence between the plate's channels and also reduces fouling effect.

DESIGN AND ANALYSIS OF PLATE HEAT EXCHANGER

Design of plates by using CATIA
Design calculations of a plate heat exchanger include flow distribution and pressure drop and heat transfer rate. The total rate of heat transfer between the hot and cold fluids passing through a plate heat exchanger may be expressed as: Q = UA∆Tm where U is the Overall heat transfer coefficient W/m², A is the total plate area m², and ∆Tm is the Log mean temperature difference. U is dependent upon the heat transfer coefficients in the hot and cold streams.

Dimensions:
Length: 1460 mm
Width: 650 mm
Height: 1885 mm

Technical Details:
Fluid direction: Countercurrent
Number of plates: 187
Effective plates: 185
Hot side Fluid: Lube oil ISO VG46 and Cold side: Water
Flow rate: 41.27 l/s
Inlet/Outlet temperature: 71.9 /60 °C
Pressure drop: 0.884 bar
Volume of liquid in cooler: 144 litres
Number of passes: 1

Materials
Frame plate, pressure plate: Aluminum plates
Plate gasket: Nitrile Rubber

Calculations:
Table shows Theoretical Results of Heat Plate Exchanger with Four Models:

<table>
<thead>
<tr>
<th>Case</th>
<th>Surface Area (A) m²</th>
<th>Overall Heat Transfer Coefficient (U) W/m²</th>
<th>Log mean Temperature Difference (ΔT_m) K</th>
<th>Heat Transfer Rate (Q) W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>0.862</td>
<td>304</td>
<td>7.9166</td>
<td>2074.529</td>
</tr>
<tr>
<td>Model 2</td>
<td>0.865</td>
<td>304</td>
<td>7.9166</td>
<td>2081.740</td>
</tr>
<tr>
<td>Model 3</td>
<td>0.846</td>
<td>304</td>
<td>7.9166</td>
<td>2036.022</td>
</tr>
<tr>
<td>Model 4</td>
<td>0.848</td>
<td>304</td>
<td>7.9166</td>
<td>2040.836</td>
</tr>
</tbody>
</table>

ANALYSIS OF PLATE HEAT EXCHANGER

Analysis is done for all the models with Hot fluid as lubrication oil and cold fluid as water, Aluminum oxide Nano fluid and titanium oxide Nano fluid. These are Ansys results of Model 2 with
lubrication oil and water. And compared the heat transfer rate, mass flow rate, velocity, pressure and temperature.

RESULTS AND DISCUSSIONS

In this analysis, the heat transfer rate is found by using the different cooling fluids and plate models.
### Table: 1 (Water/Lube oil)

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Dynamic pressure (pa)</th>
<th>Total temperature (k)</th>
<th>Velocity magnitude (m/s)</th>
<th>Mass flow rate (kg/s)</th>
<th>Total heat transfer (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min</td>
<td>max</td>
<td>min</td>
<td>max</td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>2.29*10^0</td>
<td>1.04*10^-6</td>
<td>283</td>
<td>362</td>
<td>0.228</td>
</tr>
<tr>
<td>Model 2</td>
<td>3.26*10^-4</td>
<td>8.97*10^-5</td>
<td>264</td>
<td>350</td>
<td>8.61*10^-4</td>
</tr>
<tr>
<td>Model 3</td>
<td>3.05*10^-2</td>
<td>2.26*10^-6</td>
<td>286</td>
<td>384</td>
<td>7.82*10^-3</td>
</tr>
<tr>
<td>Model 4</td>
<td>2.95*10^-3</td>
<td>8.65*10^-5</td>
<td>484</td>
<td>383</td>
<td>2.59*10^-3</td>
</tr>
</tbody>
</table>

### Table: 2 (Titanium oxide/lube oil)

<table>
<thead>
<tr>
<th>Case 2</th>
<th>Dynamic pressure (pa)</th>
<th>Total temperature (k)</th>
<th>Velocity magnitude (m/s)</th>
<th>Mass flow rate (kg/s)</th>
<th>Total heat transfer (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min</td>
<td>max</td>
<td>min</td>
<td>max</td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>1.93*10^-1</td>
<td>9.99*10^-5</td>
<td>281</td>
<td>349</td>
<td>0.209</td>
</tr>
<tr>
<td>Model 2</td>
<td>1.26*10^-1</td>
<td>1.44*10^-6</td>
<td>297</td>
<td>341</td>
<td>1.69*10^-2</td>
</tr>
<tr>
<td>Model 3</td>
<td>5.17*10^-2</td>
<td>2.88*10^-6</td>
<td>241</td>
<td>369</td>
<td>8.96*10^-3</td>
</tr>
<tr>
<td>Model 4</td>
<td>9.61*10^-3</td>
<td>8.63*10^-1</td>
<td>100</td>
<td>371</td>
<td>4.67*10^-3</td>
</tr>
</tbody>
</table>

### Table: 3 (Aluminum oxide/lube oil)

<table>
<thead>
<tr>
<th>Case 3</th>
<th>Dynamic pressure (pa)</th>
<th>Total temperature (k)</th>
<th>Velocity magnitude (m/s)</th>
<th>Mass flow rate (kg/s)</th>
<th>Total heat transfer (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min</td>
<td>max</td>
<td>min</td>
<td>max</td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>2.40</td>
<td>1.01*10^6</td>
<td>282</td>
<td>349</td>
<td>6.06*10^-2</td>
</tr>
<tr>
<td>Model 2</td>
<td>0.195</td>
<td>1.48*10^6</td>
<td>296</td>
<td>344</td>
<td>2.11*10^-2</td>
</tr>
<tr>
<td>Model 3</td>
<td>6*10^-2</td>
<td>3.04*10^6</td>
<td>223</td>
<td>359</td>
<td>1.17*10^-2</td>
</tr>
<tr>
<td>Model 4</td>
<td>1.6*10^-2</td>
<td>1.28*10^6</td>
<td>300</td>
<td>364</td>
<td>6.10*10^-3</td>
</tr>
</tbody>
</table>

Graphs representing for lubrication oil and water for Model 2

![Variation of pressure](image1.png)

![Variation of velocity](image2.png)

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Variation of temperature

By observing ANSYS analysis results, the heat transfer rate is more for modified plate Channels and more temperature drop occurs with cooling fluid Titanium oxide. From the results the analysis of heat transfer between lube oil and water for Model 2 is 1977.74 W and for the analysis of heat transfer between lube oil and water for Model 1 is 1949.52 W and Hence more heat transfer is obtained from modified plate structure and is 28.22 W. Mass flow rate is reduced from 0.3270092 kg/s to 0.13871574 kg/s. Mass flow rate is reduced in all the modified models when compared with the basic model of the heat plate heat exchanger. From the table 1, the minimum temperature is 264 K and maximum temperature is 350 K in Model 2 and which is having high heat transfer rate when compared with other models. The heat transfer rate when the plates corrugations arranged in-line or parallel to direction of fluid as Model 2 is more when plate corrugations is arranged in staggered to the fluid direction. The Velocity is maintained constant for Model 1, 2 and 4 and is 4.5 m /sec and velocity increases in the Model 3 and Maximum velocity is 6.73 m/sec. The Maximum pressure is achieved for Model 2 when Nanofluids is used as cooling medium. Plate heat exchanger when compared with flat plates, plates with corrugations increases heat transfer rate by inducing turbulence in the plates by increasing velocity at channels.

The theoretically calculated heat transfer between lube oil and water for Model 2 is 2081.74 W and from the analysis of heat transfer between lube oil and water for Model 2 is 1977.74 W. When compared these two the heat transfer obtained is same.

CONCLUSION

In this work a plate heat exchanger used to cool the lube oil used in turbines is studied, few modified designs of plate heat exchangers are developed and studied so that we can improve the life of the turbine components by providing cool lubrication. In this analysis is done using ANSYS work bench to compare the heat transfer rates between the models of heat plate heat exchanger.

The following are concluded made from the Analysis.

1. Highest heat transfer rate is recorded in modified model 1 in which projections are arranges in the direction of flow in a rectangular patron.
2. Heat transfer rate in remaining two modified models are also higher than the basics model but not as high as Model 2.
3. Mass flow rate is reduced in all the modified models when compared with the basic model of the heat plate heat exchanger.
4. Maximum velocity is recorded in modified model 2 because of the zig-zag arrangement of the projections.
5. Using Nano fluid as coolants in the place of water can help in reducing the maximum temperature in lube oil by an average of 6 °C.
6. Performance variations are similar when compare between cooling fluids in all models of heat plate heat exchangers.

REFERENCES