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A Study of Heat Transfer Using Corrugated Al_2o_3microparticles

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Abstract:- In the present work studies are carried on a three channel one-one pass corrugated plate type heat exchanger in parallel flow arrangement. Hot fluid was made to flow in the central channel at different inlet temperature ranging from 40°C to 60°C to get cooled by the cold fluid in the upper and the lower channels.Al_2O_3microparticle were added in the hot fluid in different proportions to enhance the system performance. It is observed that addition of Al_2O_3 micro particle in the hot fluid may improve the effectiveness of the heat exchanger by 50%.
Keywords: Corrugated Plate Heat Exchanger, Effectiveness, Exergy Loss

Nomenclature
A = Cross sectional area, (m^2).
C_p = Specific heat at constant pressure, ($J\ kg^{-1}\ K^{-1}$).
C = Heat capacity rate, ($W\ K^{-1}$).
E = Exergy loss, (W).
L = length, (m) m Mass flow rate, ($kg\ s^{-1}$) Q Heat transfer rate, (W).
T = Temperature, (K).

Suffixes
C= Cold.
E= Environment, ambient.
h = Hot.
i = Inlet.
m = Mean min (Minimum), max (Maximum).
o = Outlet.

I. INTRODUCTION

Heat exchangers are one of the most commonly used process equipment in the industry and research. The work of a heat exchanger is to exchange energy from the body at higher temperature to the body at lower temperature. This transferred of energy may occur to a single fluid (as in the case of boiler where heat is transfer to water) or between two fluids that are at different temperature (as in the case of an automobile radiator where heat is transfer from hot water to air). In some case, there are more than two stream of fluid exchanging heat in a heat exchanger. It is of several designs heat in a variety of size varying from 'miniature' to 'huge' (with heat transfer area of the order of 5000 to 10,000sq.meter) have been developed over the year. In the 1930s corrugated type heat exchangers were introduced to meet the hygienic demand of the dairy industry. Now days' plate heat exchangers are mostly used in many fields like automobile industry, power industry, and dairy, food processing, chemical and petrochemical industries. In heat exchangers, there is usually no external heat and work interactions, typical applications involves heating or cooling of any fluid stream of concern and evaporation or condensation of single or multi component fluid streams. The objective can be to recover or reject heat, or sterilize, pasteurize, fractionate, distill, concentrate, crystallize, or control process fluid. In a some heat exchangers, the fluid exchanging heat may be through direct or indirect contact. In many heat exchangers, transfer of heat between fluids takes place through a separating wall or into and out of a wall in a transient manner. Usually the fluids in heat exchanger are separated by a heat transfer surface and ideally they do not mix or leak. Some examples of heat exchangers are shell-and tube exchangers, automobile radiators, condensers, evaporators, air pre-heaters, and cooling towers. There could be internal thermal energy sources in the exchangers, such as in electric heaters and nuclear fuel elements. Combustion and chemical reaction may take place within the exchanger, such as in boilers, fired heaters, and fluidized-bed exchangers. Mechanical devices may be used in some exchangers such as in scraped surface exchangers, agitated vessels, and stirred tank reactors. Heat exchangers are devices used to transfer heat between two or more fluid streams at different temperatures. Heat exchangers find widespread use in power generation, chemical processing, electronics cooling, air-conditioning, refrigeration, and automotive applications. A corrugated plate type heat exchanger, as compared to a similar sized tube and shell heat exchanger, is capable of transferring much more heat. This is due to the large area that plates provide over tubes. Corrugated plate heat exchangers are used for transferring heat for any combination of gas, liquid and two-phase streams. Fins or appendages added to the primary heat transfer surface (tubular or plate) with the aim of increasing the heat transfer area. The two most common types of extended surface heat exchangers are plate-fin heat exchangers and tube-fin heat exchangers. Consist of a stack of parallel thin plates that lie between heavy end plates. Each fluid stream passes alternately between adjoining plates in the stack, exchanging heat through the plates. The plates are corrugated for strength and to enhance heat transfer by directing the flow and increasing turbulence. These exchangers have high heat-transfer coefficients and area, the pressure drop is also typically low, and they often provide very high effectiveness. A corrugated plate type heat exchanger consists of plates instead of tubes to separate the hot and cold fluids. It would be misleading to consider only capital cost aspect of the design of a heat exchanger, since high maintenance cost increase the total cost during the service life of the heat exchanger. Therefore, exergy analysis and energy saving are very important parameters in the heat exchanger design.

II. ABOUT MICRO PARTICLE OF ALUMINIUM OXIDE (AL_2O_3)

	Table 1
Chemical formula	Al_2O_3
Molar mass	101.96 g·mol^{-1}
Appearance	white solid
Odor	odorless
Density	3.95–4.1 g/cm^3
Melting point	2,072 °C (3,762 °F; 2,345 K)

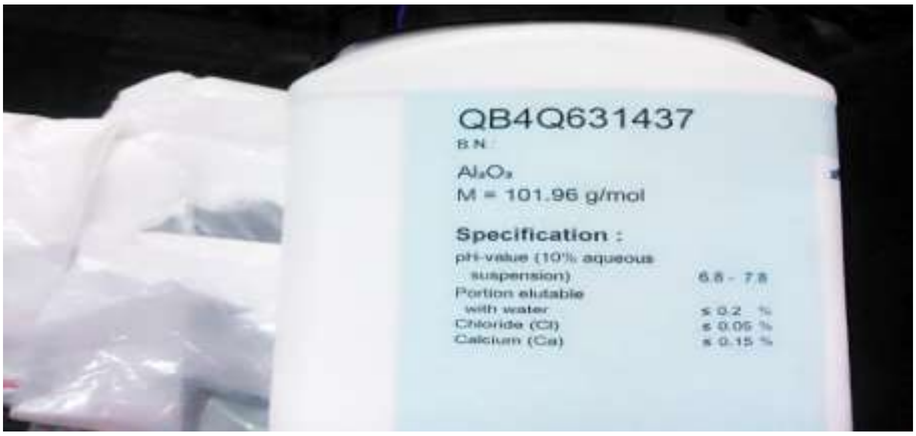

Figure 1 Aluminium oxide micro particle.

III. EXPERIMENTAL SETUP AND PROCEDURE

The experimental setup established, to investigate the heat transfer characteristics in the corrugated channel for different flow conditions are shown in the figure 2.The test section of the corrugated plate heat exchanger has three ducts. In cases of parallel arrangements have been made. Hot fluid was made to flow through the central channel and cold fluid through the two outer channels. Experimental apparatus include fluid (cold & hot) loop and a measurement system. The hot water loop comprises a water tank containing a heater, a pump and a temperature controller. The flow rate is measured by measuring time for collection of fixed volume. The heat exchanger is thermally insulated so that the wall temperature of the corrugated channel can be maintained at a nearly constant temperature. Digital thermometers are used to measure the temperature of the fluids at the inlet and outlet of the heat exchanger.

1. Length of the test section, 100 cm.
2. Width of the test section, 10 cm.
3. High of the test section,5 cm.
4. Corrugation angle 30^0.
5. Material of the plate is GI of 22 gauges.

Figure 2 Corrugated types heat exchanger

IV. METHODOLOGY

The experimental data was used to calculate the heat transfer rate,
$Q= m_hC_h (T_{hi} - T_{ho})$

Each channel has equal flow area and wetted perimeter given by,
A_o=H.W, and p=2(W+H)

Specific Heat capacity
$C_h = m_hc_{ph}$

Cc = mccpc
Logarithmic mean temperature difference.
LMTD= $[(T_{ho} – T_{ci}) – (T_{hi} - T_{co})]] / \ln[(T_{ho} – T_{ci})/(T_{hi} - T_{co})]$

Effectiveness of heat exchanger,
$\varepsilon =[C_c(T_{co} – T_{ci})]/[C_{min}\ln(T_{hi} – T_{ci})]$

The exergy changes for the two fluids are obtained as given below,

For hot fluid (i.e. water),
$E_h = T_e[C_h\ln(T_{ho}/T_{hi})]$

And for cold fluid
$E_c = T_e [C_c \ln (T_{co} /T_{ci})$

Exergy loss for steady state open system can be found as a sum of individual fluid exergy,
$E = E_h+E_c$

V. RESULTS AND DISCUSSION

5.1. Effectiveness of heat exchanger

Heat exchanger is calculated for different value of t_{h1}(hot fluid inlet temperature). For the same t_{c1} when $t_{h1}$is increase, different of t_{h1}&t_{c1} increase for a slight change on hot and cold fluid temperature at outlet. Hence, as expected effectiveness decreases. Mixing of microparticle in the hot fluid increase the heat transfer capability of the fluid. It is clear from figure 3 that increases of weight percentage of microparticle dy of Heat Transfer In A Corrugated Plate Heat Exchanger Using Al_2o_3 Microparticles in the hot fluid increase the effectiveness of heat exchanger. Amaximum of 50% increase of effectiveness is observed by mixing Al_2O_3 microparticle at 45^o C of inlet hot temperature than pure hot water

Figure 2 Corrugated types heat exchanger

Figure 3 Plot of effectiveness of heat exchanger with micro particle of AL_2O_3

5.2. Exergy of heat exchanger

Fig.4 shows exergy loss increase with increasing inlet hot water temperature for the same cold fluid inlet temperature. Exergy loss is reduced by mixing Al_2O_3 microparticle in the hot fluid. The maximum of 78% exergy loss is reduced by mixing 0.004 wt% AL_2O_3microparticle in the hot water.

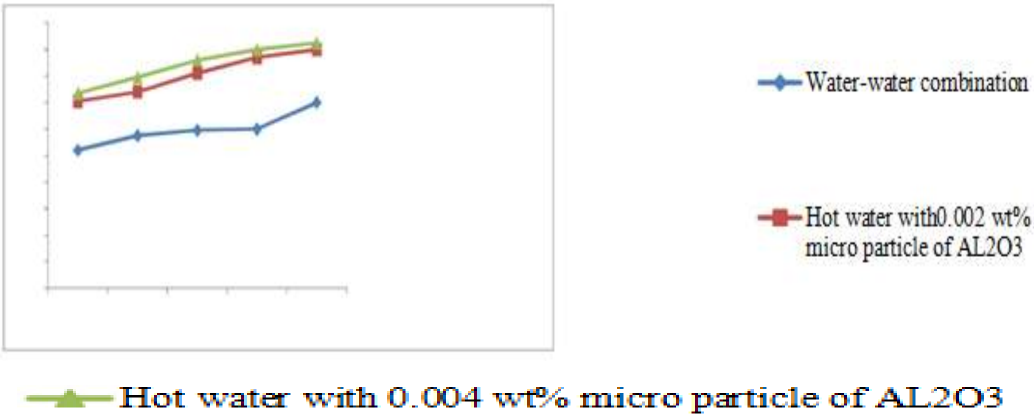

Figure 4 Plot of exergy of heat exchanger with micro particle of AL_2O_3.

5.3. Maximum heat transfer

Fig.5 shows the variation of maximum heat transfer in thecorrugated plate heat exchanger in parallel flow arrangements. It is observed that maximum heat transfer rate increases with increase of weight percentage of the microparticle in the hot fluid. It is also observed that with rise in inlet hot water temperature, the maximum heat transfer rate increases.

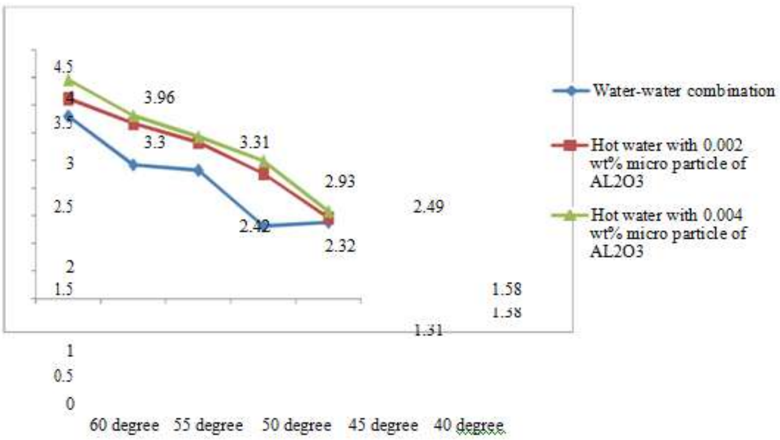

Figure 5 Plot of maximum heat transfer of heat exchanger with micro particle of AL_2O_3

5.4. E/Q_{max} of heat exchanger

Fig.6 shows the variation of non-dimensionalexergy loss (E/Q_{max}) of corrugated plate heat exchanger in parallel flow arrangement. With rise of inlet hot fluid temperature, non-dimensional exergy loss increases. Addition of microparticle in the hot fluid also reduces the non-dimensional exergy loss. With increase of weight percentage of microparticle in the hot fluid, E/Qmax goes on decreasing.

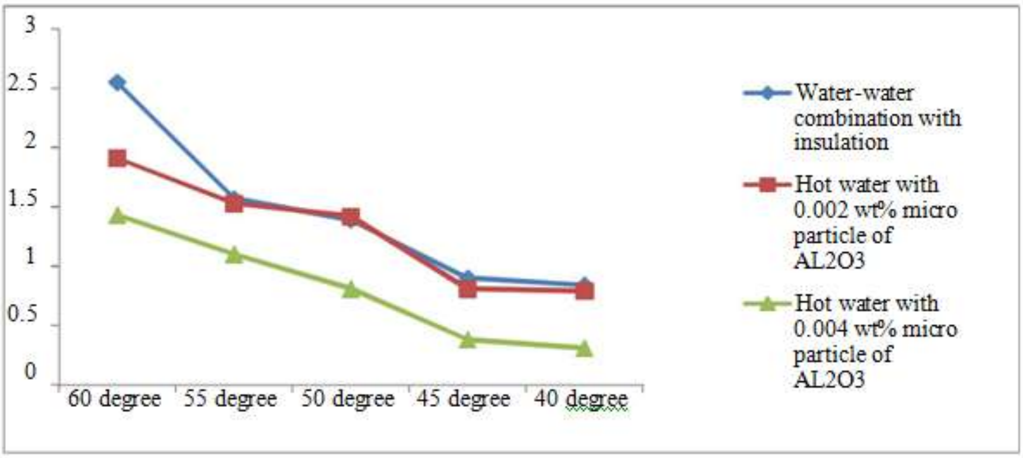

Figure 6 Plot of E/Q_{max} of heat exchanger with micro particle of AL_2O_3

VI. CONCLUSION

A three channel one-one pass corrugated plate heat exchanger is studied in parallel flow arrangement. Hot fluid was made to flow in the central channel at different inlet temperature ranging from 40^oC to 60^oC to get cooled by the cold fluid in the upper and the lower channels. Al_2O_3microparticle were added in the hot fluid in different proportions to enhance the system performance. It is observed that addition of Al_2O_3 micro particle in the hot fluid may improve the effectiveness of the heat exchanger by 50%.

- A maximum of 50% increase of effectiveness is observed by mixing Al2O3 microparticle at 45o C of inlet hot temperature than pure hot water
- Exergy loss is reduced by mixing Al2O3 microparticle in the hot fluid. The maximum of 78% exergy loss is reduced by mixing 0.004 wt% AL2O3 microparticles in the hot water.Study of Heat Transfer In A Corrugated Plate Heat Exchanger Using Al_2o_3 Microparticles.
- It is observed that maximum heat transfer rate increases with increase of weight percentage of the microparticle in the hot fluid. It is also observed that with rise in inlet hot water temperature, the maximum heat transfer rate increases.
- Addition of microparticle in the hot fluid also reduces the non-dimensional exergy loss. With increase of weight percentage of microparticle in the hot fluid, E/Qmax goes on decreasing.

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