Design, Fabrication and analysis ofcoiltypeshell andtubeheatexchanger

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ABSTRACT-In the field of physics, the improvement of heat transfer from helical heat exchangers is a hot theme. A helically coiled heat exchanger for fluid to fluid Transformation is not yet an experimental or theoretical study is needed. Therefore, we expect Methanol to be a cold solvent in the solution of water. Methanol with the formula CH3OH is an organic compound. It is sometimes referred to as methyl alcohol, carbonyl, alcohol for wood, wood naphtha or forest spirits. It is a light, acidic, colourless, burning, poisonous liquid that has a distinct aroma and is more subtle and sweeter than ethanol. It is the basic alcohol (ethyl alcohol). It's a polar solvent used as an anti-freeze, solvent and ethyl-alcohol denaturator at room temperature. Methanol can be used as a heat exchanger as a cooldant (in our case, a coil heat exchanger) when it is prepared as a solution for water to make use of its better thermal transfer characteristics which lead to an enhanced heat transfer of the helical heat exchanger. For this purpose, a solution was prepared with different amounts of methanol in water. We have been using in 1 litre of water four different concentrations of methanol by volume: 25%, 50%, 75%, and 100%. Like water, methanol is polar. So it induces intermolecular forces, including hydrogen bonding, as we dissolve methanol in water. Tests were carried out on pH, electrical conductivity, thermal conductivity, boiling point and other properties.

Keywords—Helicalcoilheatexchanger,pH,thermalconductivity

I. INTRODUCTION

Heatexchangers

Heat exchangers are instruments which transmit heat between two fluid without fluid mixing at different temperatures. There are two fluids that are colder at different temperatures than the other one. The heat is transferred from the warm fluid to the cool fluid; it is called a heat exchanger. H eat exchangers are commonly used in a range of applications, from home heating, air conditioning and chemical processing to large-scale power generation.

Helicallycoiledheatexchangers (Shellandtubetype)

Many engineers in various industries are familiar with process heat transfer using traditional shell and tube heat exchangers. Their application and success are well-documented. While helical coiled heat exchangers have been around for a long time, they are not as well known.While different designs are available, the most simple and widely used version is a helically coiled tube. The tube ends are joined to manifolds, which serve as fluid entry and exit points. The tube bundle is made up of several tubes piled on top of each other, and the whole bundle is housed within a casing or shell.

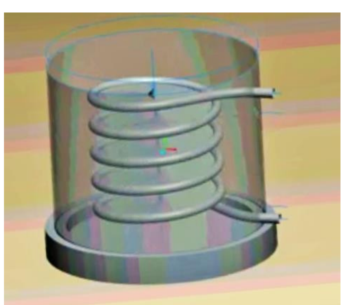

Fig1: Helicalcoiledheatexchanger

Methanolascoolantinheatexchanger

Methanol with the formula CH3OH is an organic compound. It is sometimes referred to as methyl alcohol, carbonyl, alcohol for wood, wood naphtha or forest spirits. It is a light, acidic, colourless, burning, poisonous liquid that has a distinct aroma and is more subtle and sweeter than ethanol. It is the basic alcohol (ethyl alcohol). It is a polar solvent used as an anti-freeze, solvent, oil, and ethyl alcohol denaturant at room temperature. It is not usual for machinery, but can be used as washing grease, de-icers and fuel additives for windshields.

II. LITERATUREREVIEW

In the paper submitted by RamchandraK.Patil- Industrial Equipment Co; B.W. Shende- Polychem Ltd; And Prasanta K. Ghosh- Hindustan Antibiotics Ltd., where a fluid pressure drop is limited, the pressures would decrease at about 1 m/s by determining the speed of the annular Fluid in an HCHE.

Heat transfer through fabricated coil type shell in tube heat exchanger by SurakasiRaviteja, GondesiSatya Mahesh Reddy, RaghavendraSanthosh (2018) explained in brief aboutg the heat transfer characteristics of a shell and tube heat exchanger.

The efficiency of the heat removal process used by a spin-coiled heat exchanger was examined by Jayakumar and Grover for different system parameters (1997). The thesis was extended to establish the stability of the function of this device while the barge it is on (Jayakumar, 1999; Jayakumar et al., 2002).

Berger et al. (1983) and Shah and Joshi (1984) have detailed reviews of heat transfer and flow through a curved tunnel (1987).
Naphon&Wongwises include the most recent analysis of flow and heat transfer characteristics (2006).

III. FABRICATIONOFHELICALLYCOILEDHEATEXCHANGER

Selectionofmaterialforhelicaltube

For a better heat exchange from the tube in shell and tube type or helical coil type heat exchanger, the tube material should havegood thermal conductivity. The material that we have used for the helical coil is Copper. Copper has the best thermal conductivitypropertyaftersilver.

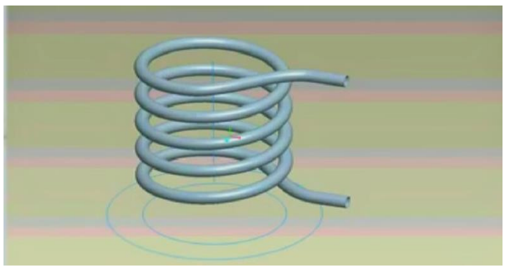

Fig. 2: DesignofHelicalCoil

Fabricationofheatexchangerpartsbyparts

Specificationsandconstructionofhelicalcoil

- Thepipehasaninner diameterof0.8cm
- Thecoildiameter is18cm
- Thedistance betweentwo adjacentturnsiscalled pitch whichisof2cm
- Thenumber ofturnsmadeto thecoilis6
- Thematerial usedfor themakingofthehelicalcoiliscopper

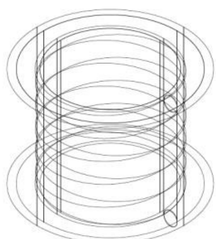

Fig3:Wireframedesignofhelicalcoil

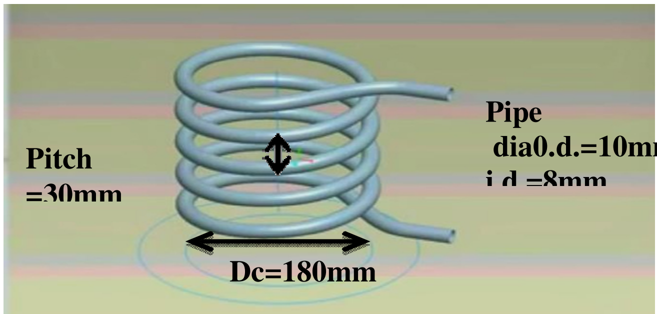

Fig.4: Dimensionsofhelicalcoil

SpecificationsandconstructionofcylindersInner cylinder

(a) Theinnercylinderisofdimensions30*16cm.
(b) Thematerial usedforthemakingoftheinnercylinderisacombinationofgalvanisedironsheetandmildsteel.
(c) Thesheetisrolledtotherequireddimensionsandtheedgesofthecylinderarebrazedtopreventleakageofwaterintotheinner cylinder.
(d) Sawdustisused asinsulating materialand ispoured intheinner cylinder.
(e) Thetop and bottomofinner cylinder are completelyclosed byusingbrazingoperation.
(f) Theinnercylinderisplacedinbetweenthehelicalcoil.

Fig.5:Innercylinderfilledwithsawdust

(a) Theoutercylinderisofdimensions30*20cm
(b) Thematerialusedfor makingoutercylinderisalsoacombinationofgalvanisedironsheetandmildsteel
(c) Thesheetisrolledtotherequireddimensionsandtheedgesofthecylinderarebrazedtopreventleakageofwater outsideofthecylinder
(d) Thecoilisheldinsidetheoutercylinderfromaheightof6cmfromtopandbottombythemeansofhookswhicharerovided inside the cylinderso that the coilstandsonthe hooks
(e) Inletand outletareprovidedto thecylinder ataheightof3cmfromthe top andother ataheightof3cmfromthebottom
(f) Theseinletandoutletareprovided to allowthepassageof hotwaterinsidethecylinder
(g) Thecoilisalsoprovided withinletand outletto allowcoldwatertoflowinsidethecoil
(h) Gatevalvesareprovidedtotheinletsandoutletsofthecylindertoregulatethe flowinsidethecoilandcylinder

Fig. 6:Outerandinnercylinder

Fig. 7: Coilinsidetheoutercylinder

Assemblyofthesetup
Alltheabove-mentionedpartswereassembledtogetherandfewof othercomponentswerealsoaddedasasupporting part,whichfacilitated the ease inconductingthe practical experiment.

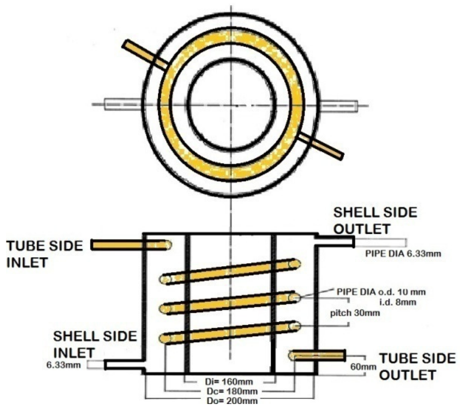

Fig.8:Sectionalviewofheatexchanger

Fig.9: TheoutlookofHCheatexchanger

Thesupplementarycomponentsareaslistedbelow.

(a) *Heater:*A heater is an organ that emits heat which allows another body to become hotter. Heaters are usually appliances that are used to produce heat in a home or domestic environment (i.e. warmth). Ovens and furnaces are two other types of heaters.

Fig10:Heater

(b) *Submersible pump:*An immersion pump is a machine with a hermetically-stitched engine closely connected to the pump body, or a subsubpump, electric submersible (ESP). The whole assembly is soaked in the injected solvent. It prevents pumping cavitation as the main advantage of this pump shape. Submersible pumps bring surface oil, while jet pumps have to draw fluids. In terms of efficiency, submersibles outperform jet pumps.

Fig.11:Submersiblepump

(c) *Laboratory Thermometer:*It is an instrument used in labs to accurately determine temperature. It may be immersed partly or completely in the fluid being weighed.

Fig.12:Laboratorythermometer

Assemblyofsetup

As seen below, all the above components were combined. The water circulating through the shell is filled with a tank with electric heater. The heater is 1000W of total strength. The temperature of the water at the inlet of the test segment at the fixed value is maintained using the control. A 18 W submersible pump and a pumping height of 6 ft pump the hot fluid from the tank. With a measurement pot, the flow rate of the hot fluid is calculated manually. Both the temperatures for the inlet and exit of the thermal fluid are determined using temperature sensors. Water is constantly coolThe tubing circulates into the temperature tank. Its flow rate, outlet temperatures and temperatures are calculated.

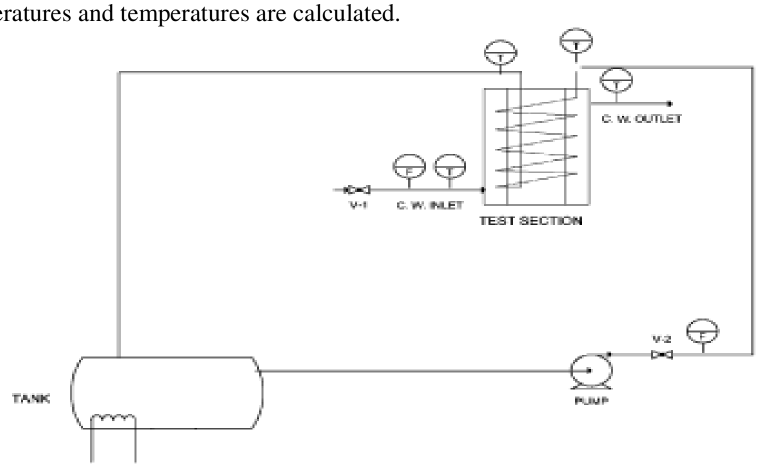

Fig.13: Linediagramofexperimentalsetup

Fig.14:Actualexperimentalsetup

IV. PREPARATIONOFSOLUTIONS

Preparationofwater-watersolution

As water is polar solvent 1000 ml of cold water and 1000 ml of hot water are injected into the helically coiled heat exchanger andthevaluesare notedandthe rate ofheatexchange iscalculated.

Preparationofmethanol-waterandethanol-watersolution

A solution of Methanol in Water: Methanol can be used as a refrigerant in the Hot Exchester when prepared with water to benefit from the better temperature transfer features that can lead to an increased heat transfer in the Helical Heat Exchanger. The Methanol is the only solvent that can be used as a heat exchanger. This is a low-cost anti-freeze solution that is used for cooling and heat pumps from the earth. This can be blocked in order to resist degradation, similar to glycols. Due to its very high temperature transfer rates, this fluid can be used up to -40°C. Their biggest drawbacks are toxicological issues as a heat transfer fluid. It is regarded as toxic rather than ethyleneGlycol and thus has been used exclusively for outdoor process applications. Methanol is often a solvent that is flame retardant and, as such, presents a potential fire hazard when stored, processed or used.

Amount of methanol added by volume in water: Various concentration of the methanol-water solution wasprepared for comparing the thermal properties. We prepared four different concentrations of 25%, 50%, 75% and 100% ofmethanolbyvolume in1litreofwater.

Methodofpreparationofthesolution:Methanol, like water, is polar. So, when we dissolve methanol in water, it produces intermolecular forces, i.e. hydrogen bonding. As a result, preparing a methanol-water solution is very simple; simply pouring the appropriate volume of methanol into water and softly stirring it prepares the solution of our interest.

V. EXPERIMENTONTHEHELICALLYCOILEDHEATEXCHANGER

Experimentalprocedure

Thepresentinvestigationaimsatimprovingtheefficiencyofahelicalheatexchangerusingamixtureofwaterandethylene glycolsolution.Italso aimsto checkthe effectsofthe concentrationofmethanolin waterasacoolantsolution.

Stepsto follow

*Step 1:*Initially, the heater is turned on and we wait till the temperature of the hot water reaches 52°C. The RELAY circuit has atemperature controller which is configured so that the maximum temperature ofthe hot fluid is 52°C. So, if the fluid inthehotreservoir reaches52°Cthenthe heater circuitiscutoff.

*Step 2:*After the required temperature is attained, the pump in the hot fluid reservoir is turned on and allowed to fill the shell andit waits till it gets filled. As soon as the hot water starts flowing from the top valve, the pump in the cold reservoir isturned on.

Step3:Therearefourthermocouples providedatinletandoutletofhotfluidandalsoatinletandoutletoffcold fluid.

*Step 4:*Now the temperatures at inlets and outlets are measured using thermocouples and their values are displayed on the digitaldisplay of RELAY circuit temperature controller. This is done with the help of connection of the thermocouple to thatcontrollersoatthe requiredpointwe get thereadingoftemperature.

*Step 5:*In this way, the experiment is conducted by adding a different concentration of methanol at different stages in water. Ateverystage,the temperature isrecorded

*Step6:*Thetemperaturedifferenceinfour differentconcentrationsofmethanolinwaterwasnotedonthetablebelow.

LET

T_{hi}=Hot fluid inlet temp.T_{ho}= Hot fluid outlet temp.T_{ci}= Cold fluid inlet temp.T_{co}=Coldfluidoutlettemp.

Table 1: Temperature Observation table

Solution		T_{hi}(℃)	T_{ho}(℃)	T_{ci}(℃)	T_{co}(℃)
Hotmedium	**Coldmedium**				
Methanol (25%sol)	Water (1000ml)	56	53	30	31
Methanol (50%sol)	Water (1000ml)	56	50	30	31
Methanol (75%sol)	Water (1000ml)	56	49	30	31
Methanol (100%sol)	Water (1000ml)	56	48	30	31

Observations:

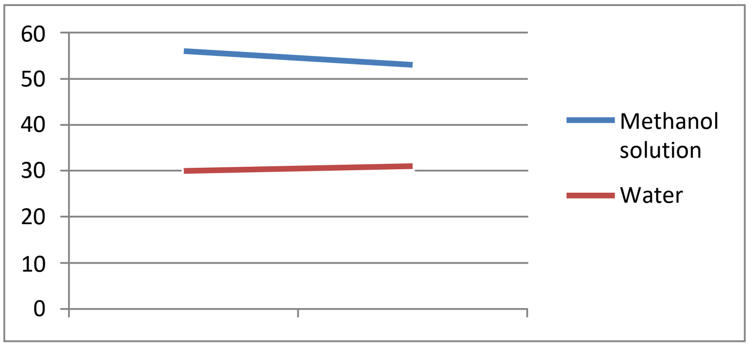

Fig.15: Temperaturechangein25%Methanolashotfluidandwaterasthecoldfluid

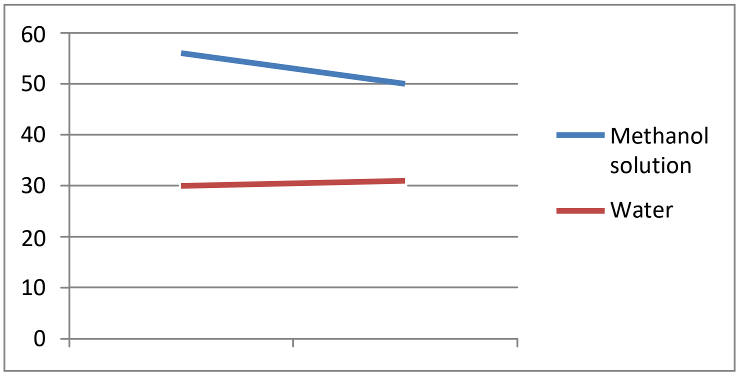

Fig.16:Temperaturechangein50%Methanolashotfluidandwaterasthecoldfluid

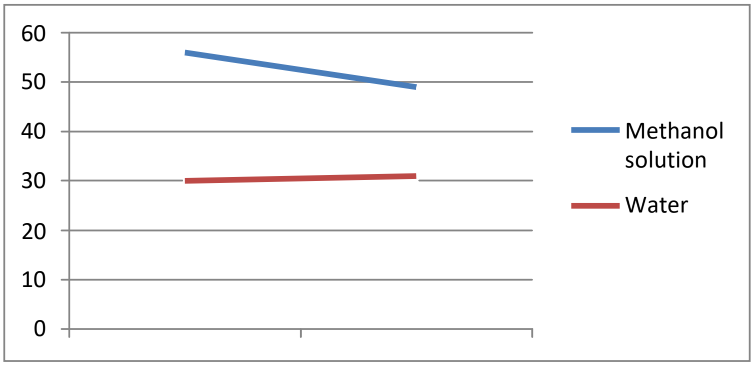

Fig.17:Temperaturechangein75%Methanolashotfluidandwaterasthecoldfluid

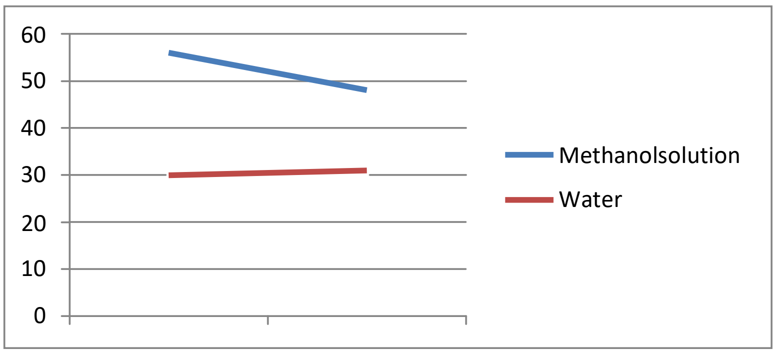

Fig.18: Temperaturechangein100%Methanolashotfluidandwaterasthecoldfluid

Table2: Experimental Calculations

	%Methanol+Water			
	25%	**50%**	**75%**	**100%**
A	1	1	1	1
B	1	1	1	1
C	0.945	0.896	0.844	0.792
D	1	1	1	1
E	0.945	0.896	0.844	0.792
F	1	1	1	1
G	56	56	56	56
H	53	50	49	48
I	30	30	30	30
J	31	31	31	31
K	2.51	2.51	2.51	2.51
L	4.18	4.18	4.18	4.18
M	23.99	22.41	21.86	21.31
N	2.244	2.402	2.462	2.526

Where,

A. Theflowrateofoil(L.P.M)
B. Theflowrateof water (L.P.M)
C. Thedensityofwater (hot)(g/cm^3)
D. Thedensityof water(cold)(g/cm^3)
E. Massofwater(hot)(g)
F. Massofwater(cold)(g)

G. Theinlettemperatureofhot water(T_{hi})(J)
H. Theoutlettemperatureofhotwater (T_{ho})(J)
I. Theinlettemperatureofcold water (T_{ci})(J)
J. Theoutlettemperatureofcoldwater (T_{co})(J)
K. Specificheatofmethanol(J/°C)
L. Specificheatofwater(J/°C)
M. LogarithmicMeanTemperatureDifference(LMTD)
N. Overallheattransfercoefficient(W/m^2-K)

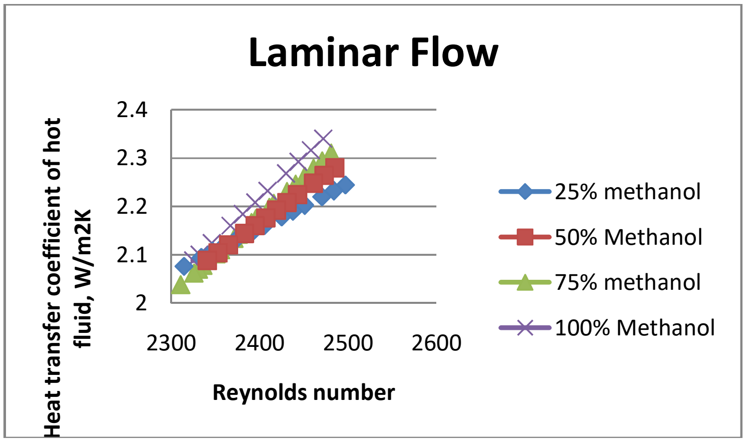

Fig19: graph between Reynolds number and HTC

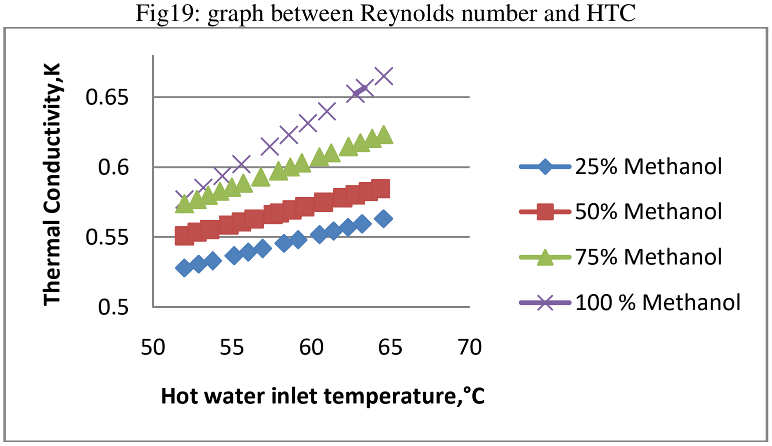

Fig20: Graph between hot water inlet temperature and Thermal conductivity

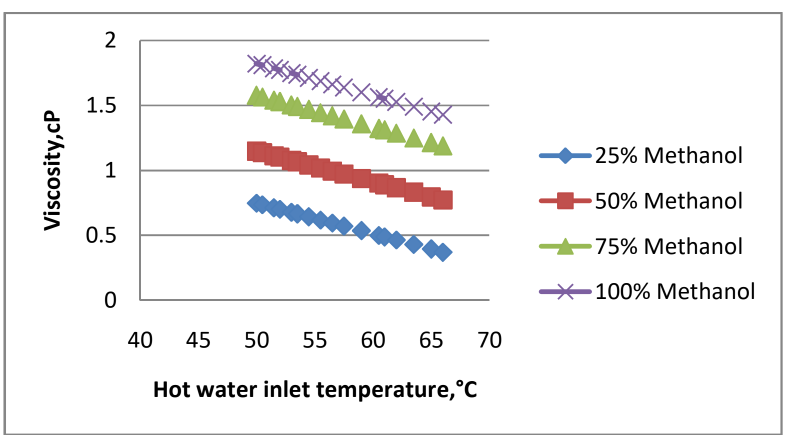

Fig21: Graph between hot water inlet temperature and Viscosity

OTHER TEST CONDUCTED ON METHANOL-WATER SOLUTION

The following tests were conducted on the used mixture of methanol and water to find out its properties:

(a) pH test

(b) electrical conductivity test

(a) pH TEST:

Fig22: pH meter

A pH metre (acidity or alkalinity) is an instrument used to calculate liquid (pH) (though special probes are sometimes used to measure the pH of semi-solid substances). A standard pH metre includes a metre attached to a sensor (a glass electrode) that measures and displays the read pH.

The pH of a methanol solution dependent on water is 6.20.

(b)*ELECTRIC CONDUCTIVITY METER*: The electrical metre (EC metre) is a tool for measuring the electrical leading of the solution. A potentiometric unit and four electrodes are used for most laboratory conductivity metres. Also concentrated and cylindrical are the electrodes. The power driving capacity The difference between the electrodes and their surface can generally be measured by Ohm law, but calibrations with proven electrolytes of conductivity can be used in practise accurately.

Fig23: electrical conductivity meter

The electrical conductivity of the solution is 0.480 μmho

VI. CONCLUSION

Obviously, it is advisable to concentrate on cooling fluids in order to adjust the design and installation of the heat exchange as we increase the methanol content in water. The performance was, as in our case, obtained by the helically coiled heat exchanger with methanol.

VII. FUTURE SCOPE OF WORK

It was evident that the capacity of the heat exchanger to transfer heat cannot be significantly improved by adapting the design but also by modifying the cooling fluid (helically coiled heat exchanger in our case). The heat transfer can also be further improved by the application of additives to this, which minimise the possibilities of corrosion by means of methanol by increasing the thermal efficiency of the helically coiled exchangers. However, since methanol is not allowed to have greater concentration in the heat exchanger as it is naturally harmful, other refrigerants such as ethylene glycol, propylene glycol etc. can also be used.

The use of nano-fluid can be a better option for enhancing the heat transfer properties. Nano-fluid can also be tested such as Al2O3 and silver-based nano-fluids.

Better heat exchange in the helically turned heat exchanger at higher temperatures can therefore be tested in future at higher temperatures.

VIII. REFERENCES

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