

## Experimental analysis of advanced materials for Anticorrosive Heat Exchanger

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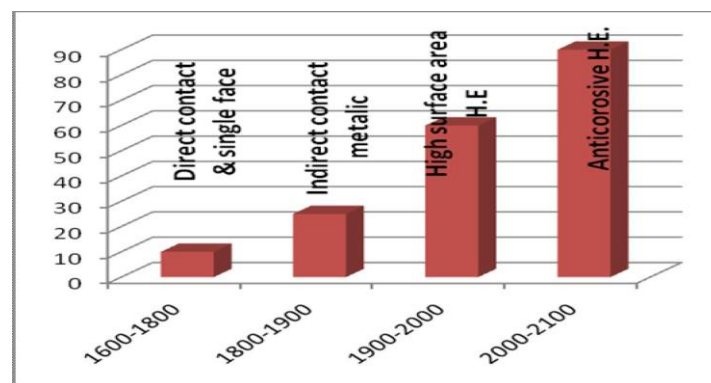
**ABSTRACT** :- Heat exchanger are inevitable part of any thermal system which involves exchange of heat between two fluids, but when we come across special purpose application such as H<sub>2</sub>SO<sub>4</sub> dilution plant acid cooling, chromium bath cooling, Chlorinator cooling etc. Then major problem is due to corrosion and its effects due to fouling and scaling.

In this research work, new polymer coated materials are developed and tested for its thermal and mechanical properties which include Polly vinyl chloride based, PTFE based plastic based materials. This research work can be extended by use of conductive plastic coating on walls of corrosive fluid handling heat exchanger.

**Keywords** - corrosion ,chromium bath cooling, fouling, scaling, Teflon coating.

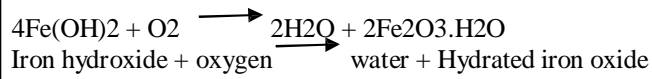
### I. INTRODUCTION

Heat exchangers are crucial part of industry to utilize the heat energy. Performance of heat exchanger defines the system efficiency & optimization of operating costs. Performance of heat exchanger depends on the operating variables and specification of Heat Exchanger. Corrosion resistant, fouling resistance, thermal conductivity, etc. are major specification which affects the performance of H.E. Over the period of time heat exchangers were developed continuously for the performance and reliability with cost effective way. Recent development in heat exchanger is in the field of anticorrosive heat exchanger for higher operating life & reliability is takes place.



**Fig.1.Development of heat exchange**

All corrosive fluid handling application required heat exchanger which can fulfill the requirement of efficient heat transfer. Corrosion is major problem associated with this application: due to this performance of the heat exchanger deteriorates from its mean line. Due to this deterioration in efficiency of H.E. reduces [1]. Again because of corrosion external contaminants get added in the product fluid which can hamper the Quality. So for all these application basic requirement is corrosion resistance heat exchanger. Corrosion can be given by,



(Rust)

## II EFFECT OF VARIOUS PARAMETERS ON RATE OF CORROSION

### 2.1 Effect of velocity of flowing fluid on Corrosion rate:-

In the heat exchangers which are handling corrosive fluids, Velocity of flowing fluid plays important role. We have conducted experiments to observe the behavior of heat exchanger for this phenomenon and we found some results which we have collected in the graph shown below shows that as the velocity increases rate of corrosion increases up to certain limit, after this attaining this limiting value it will remain constant even though velocity of flowing fluid go on increasing.[1]

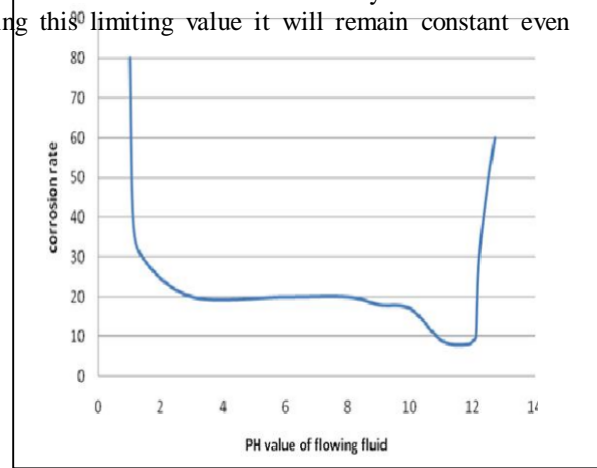
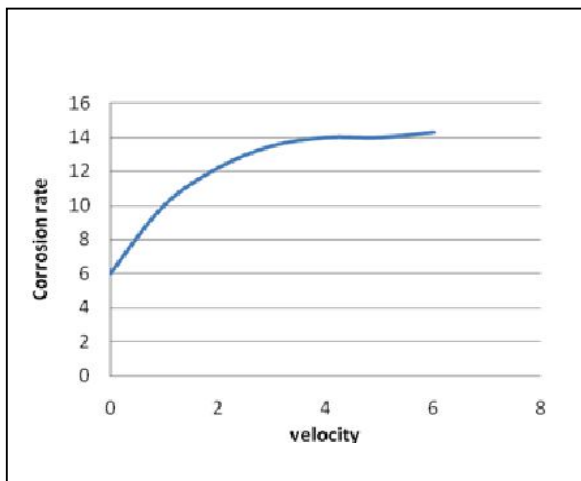


Fig.2. Effect of velocity of fluid on Corrosion      Fig.3. Effect of PH Value of fluid on corrosion

### 2.2 Effect of PH Value of flowing fluid on Corrosion of H.E.:-

We have also arranged one test to find out effect of PH value on of flowing fluid in heat exchanger .For this test various fluids like Hcl , soda water, distilled Water, NaoH, having different PH(from 0-14) were made to flow through the heat exchanger and corrosion rate have measured with iron content meter. The Graph shows that Corrosion rate is high not only in case of fluids with low PH but also in case of fluids having high PH value[3]. Thus to avoid the corrosion in special purpose heat exchanger becomes a challenging task.

### 2.3 Effect of scaling & Fouling on Thermal conductivity:-

Fouling is generally defined as the accumulation of unwanted materials on the surfaces of processing equipment. It has been recognized as a nearly universal problem in design and operation[2]. The fouling layer has a low thermal conductivity. This increases the resistance to heat transfer and reduces the effectiveness of heat exchangers.

Sr. No.	Thickness of Scaling(*microns)	Thermal Conductivity(W/mk)
1	1	100
2	10	80
3	20	60
4	30	40
5	40	35
6	50	33
7	60	32
8	70	30

Fig.3graph of fouling Vs thermal conductivity

Fig.3 shows graph of thickness of fouling in microns against thermal conductivity. From graph it clears that; as thickness of fouling increases thermal conductivity goes on decreasing. Today research is going on for the use of heat exchanger of polymer material in order to increase corrosion resistance and decreases the fouling problem [3]. Design of such heat exchanger with affordable overall heat transfer coefficient is very important part in this research work In current research work, I am trying to find suitable polymer from group of polymer material by comparing its properties. By using that material I will design and manufacture the heat exchanger for proper working temperature and pressure conditions for getting optimum overall heat transfer coefficient. At the end I will analyze the performance of the heat exchanger by taking taste on it.

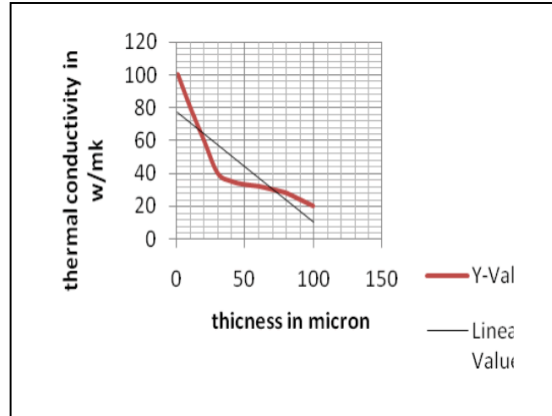
### III MATERIAL TESTING FOR ANTI-CORROSIVE HEAT EXCHANGER

#### 3.1 Development of test rig

The whole assembly is made up of 4 inch PVC pipe. The structure is 'H' shape with two unequal arms. Pipe is of 100mm diameter. Long arm has provision for handling specimen for testing. Proper leak proof joint is achieved with the help of gasket. The heater of 3000watt is attached at the base of long arm of 'H' shape structure while stirrer is attached at the top (with 200volt, 100rpm motor) for continuous stirring of the upper fluid. Two temperature sensors are attached at the both sides of long arm to record the temperature of the fluids at the two sides of the specimen. Sensors record the temperature and shows on the digital panel so that there is accurate temperature reading can be possible. Short arm is very significant in this construction .As the temperature of fluid increases at the lower side due to heater. There may be formation of bubbles which may reduces convective heat transfer so; this arm provides air and steam release provision to avoid nucleating bubbles at the heating chamber. Now whole assembly is coated with insulating foam in order to reduce the heat loss to the environment.



Fig.5 test rig for checking thermal conductivity of material



3.2 Development of test specimen:-

Conventional materials available are of less operating life, heavy in weight, and of high initial cost. At the food grade applications it is difficult to select proper material for heat exchanger. For example in milk pasteurization application, conventional materials may contaminate the food. So it is important to select the proper material. Developing material specimen for testing the thermal properties is important stage in this case.

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3.4 Specimens to be tested:-

We Have tested mild steel, PTFE (polytetrafluoroethylene),stainless steel, Graphite and Teflon coated mild steel.The actual testing process is given below.

3.5 Actual testing:-Working fluid is introduced into lower portion of long arm of the test rig.then specimen is fitted at its place for testing with the help of gasket. heater is switched 'ON'.As the time passes temperature of the fluid at lower part increases that is recorded on the digital panel by the temperature sensors.

The rise of temperature is continued till the temp of fluid becomes 57°C, as the temp reaches the specified limit the heater is switched 'OFF'. Now the upper portion of the long arm is filled with working fluid. Readings are taken which are tabulated below.

Table no.2 Observations for graphite specimen

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Sr no.	Time (min)	Temp 1(°C)	Temp 2(°C)
1	00	56	29
2	01	56	30
3	2.15	56	31
4	3.20	56	32
5	4.50	56	33
6	6.30	56	34
7	8.00	56	35
8	13.00	56	36
9	14.30	56	37

10	16.58	56	38
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**Table no.3 Observations for Teflon coated specimen**

Sr no.	Time (min)	Temp 1(°C)	Temp 2(°C)
1	00	56	25
2	02	56	27.856
3	04	56	31.02
4	06	56	32.7
5	08	56	35.3
6	10	56	37.31

3.6 Sample calculations:-

Specimen :-graphite

Quantity of working fluid:-700ml

$$Q = mC_p\Delta T$$

$$Q = \frac{0.700 \times 4.18 \times 4}{4.5 \times 60}$$

$$Q = 43 \text{ watt.}$$

$$\frac{Q}{U} = A \cdot \Delta T$$

$$= \frac{43}{0.00785 \times 30}$$

$$U = 180 \text{ w/m}^2\text{k}$$

$$K = 0.360 \text{ w/mk.}$$

This is the thermal conductivity of graphite specimen.

**IV RESULT AND DISCUSSION**

We get overall heat transfer coefficient of graphite 180w/m<sup>2</sup>k and its thermal conductivity is

0.360w/mk. This can be more when we consider Z –dimensional conductivity of the specimen [5] but, in this dimension we can't get the sufficient strength to sustain the internal pressure. Teflon coated specimen gives us thermal conductivity 2.176 w/mk which is more than thermal conductivity of graphite ,PVC ,plastic materials etc but it is less than thermal conductivity of mild steel and stainless steel specimen.

## **V CONCLUSION**

In this research work, new polymer coated materials are developed and tested for its thermal and mechanical properties which include Polly vinyl chloride based, PTFE based, plastic based materials.

After extensive work of testing we come to conclusion that; If the whole heat exchanger is made up of polymer material, it gives very poor performance due to low thermal conductivity. The thermal conductivity of graphite is better but not in the direction of thickness and it does not have the sufficient strength to handle such pressurized fluid. The materials Pollyvinyl based materials are cost effective and can solve the purpose of anticorrosive heat exchanger. We have developed the specimen with Polly vinyl based polymer coating on the mild steel plates. it gives better overall heat transfer coefficient than others. We can developed plate type heat exchanger because of its manufacturability with polymer coating.

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