IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 2, Issue 5, May 2014, 285-292

DESIGN, DEVELOPMENT AND PERFORMANCE ANALYSIS OF ANTICORROSIVE HEAT EXCHANGER

S. Y. SAWANT[1], SAGAR E. MORE[2] & H. M. DANGE[3]

[1]Assistant Professor, Rajaram Institute of Technology, Sakharale, Islampur, Maharashtra, India

[2]Director, Uthopia Membranes, Satara, Maharashtra, India

[3]Professor, PVPIT, Budhgaon, Sangali, Maharashtra, India

ABSTRACT

When we come across special purpose application such as H2SO4 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. We have develop plate type heat exchanger with this developed material Polly vinyl based polymer coating on the mild steel plates. This heat exchanger is tested for different industrial corrosive application like Acid cooling application, saline or brackish water cooling, chlorinated water cooling, chromium plating bath cooling, etc.

KEYWORDS: Anticorrosive, Plate Type, Polymer Coated

INTRODUCTION

Heat exchangers are typically used in the various applications to utilize the heat energy. All these application required heat exchanger which can fulfill the requirement of efficient heat transfer. Corrosion is major problem associated with this application [1]. Due which, performance of the heat exchanger detorates from its mean line. Due to this detoriation inefficiency of H.E. reduces. 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.

Our aim is to provide the Engineering solution to corrosion problem with polymer coated heat exchangers which can give better thermal properties with very cost effective way. Our source of motivation for coming towards this engineering solution is polymer coated pans successfully commercialized heat exchanger.

FACTORS TO BE CONSIDERED WHILE DESIGNING THE SYSTEM

Limitations of Conventional Method

- Mild steel has low cost but oxidation rate is moderate one. It can’t handle highly corrosive materials.
- Stainless steel can handle highly corrosive fluids but has high installation and replacement cost.
- Scaling and fouling may block the normal flow of fluid [2].
- Fouling may leads to decrease in thermal conductivity of fluid.

Due to above limitations there is need of alternative heat sink which overcome all these deficiencies [2].

Effect of Scaling & Fouling on Thermal Conductivity

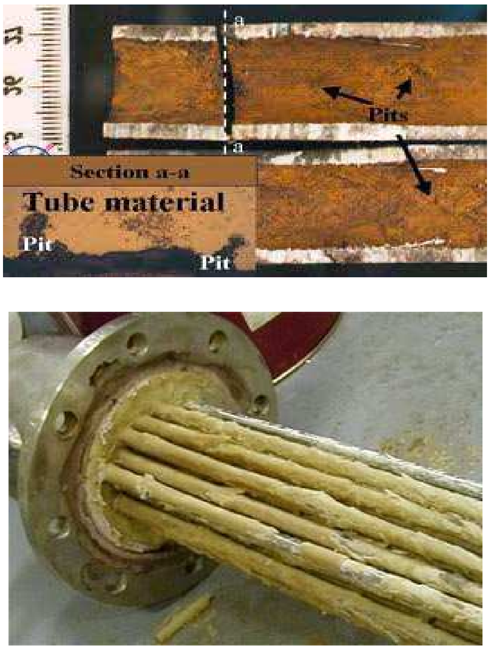

Figure 1: Scaling & Fouling in Heat Exchanger

Following figure shows graph of thickness if fouling in microns against thermal conductivity from graph it clears that; as thickness of fouling increases thermal conductivity goes on decreasing.

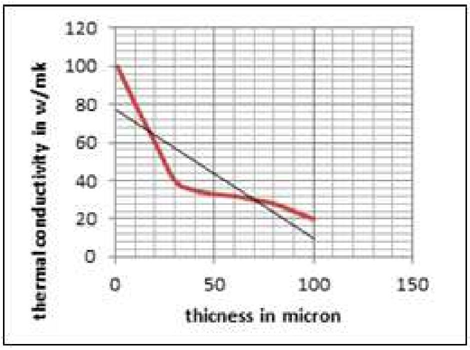

Figure 2: Graph of Thermal Conductivity vs Thickness

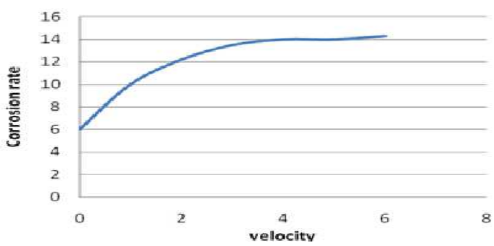

Figure 3: Effect of Velocity of Flowing Fluid on Corrosion of H. E

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].

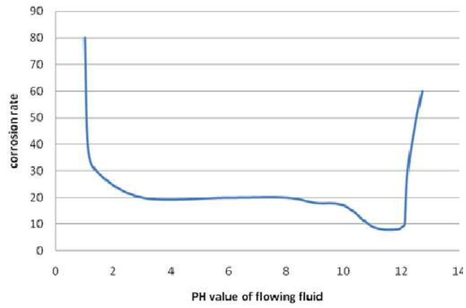

Figure 4: Effect of PH Value of Flowing Fluid on Corrosion of H.E. [3]

Thus to avoid the corrosion in special purpose heat exchanger becomes a challenging task. 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. 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.

Material Testing for Anti-Corrosive Heat Exchanger

Development of Test Rig

Figure 5: Test Rig for Checking Thermal Conductivity of Material

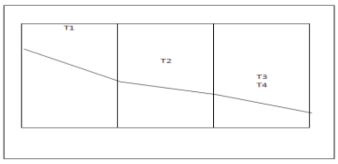

Figure 6: Observations for Teflon Coated Specimen

Temp 1: Temp of hot fluid

Temp 2: Temp of cold fluid U=180w/m^2k, K = 0.360w/mk.

Table 1: Observations for Graphite Specimen

Sr No.	Time (Min)	Temp 1(°C)	Temp 2(°C)
1	00	56	29
2	01	56	30
3	2.15	56	31

Table 1: Contd.,

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

This is the thermal conductivity of graphite specimen.

Specimen: Teflon coated mild steel

Table 2

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

$R=\frac{b}{K\times A}$

$K=\frac{0.9\times10^{-3}}{0.4135\times10^{-3}}$

K= 2.176 w/mk

This is the thermal conductivity of Teflon coated specimen under test.

DISCUSSIONS

Thus we come to conclusion that; If the whole heat exchanger is made up of polymer material, it gives very poor 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 Polly vinyl based materials are cost effective and can solve the purpose of anticorrosive heat exchanger [4].

Design of Heat Exchanger

Case Consideration

CrVi plating bath filtration plant cooling requirement

Composition of Cr Vi Plating Bath

Chromic acid = 230 gm/ltr.

Sulphuric acid = 2 to3%.

= 20 to 30 gm/ltr

Britner = 10 ppb

Additives = 150ppb

Plating Conditions for Cr Vi

Working fluid temperature = 60 to 80 ˚C.

Iron impurity = 7 to 15 ppm

Other metal = up to 10 ppm

Suspended particals = 20 to 40 ppm

Plating Bath Purification Requirement

Temperature = 40˚C.

Reasons to Reduce the Temperature

- To reduce activation of bath.
- To reduce the corrosive nature.
- To avoid frequent filter damage.

Conventional Approach

- Use bath continuously for one to two month built impurity level and then cool bath or stop plating for two days and then filter out impurities.

Limitation of Conventional Approach

- Due to batch filtration process impurity in bath where continuously building which affect the plating quality.
- In that case break point filtrations will not occur.
- Bath may completely damage due to high impurity building.
- Non reliable open loop system.
- It becomes difficult to control plating parameter due to impurity building.

Alternative Provided to Conventional Approach

- Use online filtration system with online heat exchanger.

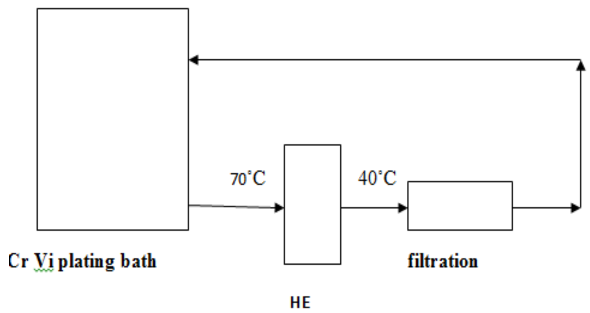

Figure 7: Design of Heat Exchanger

Due to corrosive nature heat exchangers are of titanium or graphite so due to unavailability and high cost these options are not used commercially so we have tried to give cost effective and reliable solution.

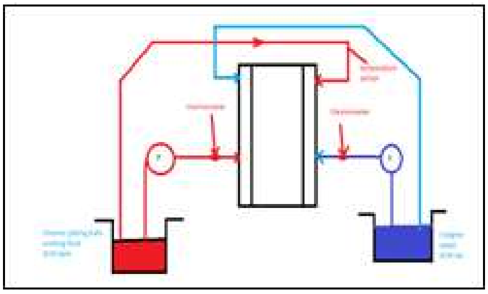

Figure 8: Design of Heat Exchanger

Testing set up 1 Tital- Chromium plating bath Pri-cooling for filtration Bath composition Cromic acid 250 gm/Liter, H2SO4 5 gm/Liter, Impurities 2 gm/Liter, Highly corrosive solution

Table 3: Observations for Testing Set Up

Sr No.	Time in Min.	Work. Fluid Tank Temp.	Work. Fluid Single Pass	Cooling Fluid Tank Temp	Work. Fluid Tank Volume	Work Fluid Flow	Cooling Fluid Flow	DT Work. Fluid
1	0	70	67	5	25	50	120	3
2	30	67	64.5	5	25	50	120	2.5
3	60	64	60	5	25	50	120	4
4	90	61	58	5	25	50	120	3
5	120	57	54	5	25	50	120	3
6	150	52	49	5	25	50	120	3
7	180	48.5	45	5	25	50	120	3.5

Therefore,

U=0.99 w/m^{2}k

U= 1.01 w/m^{2}k

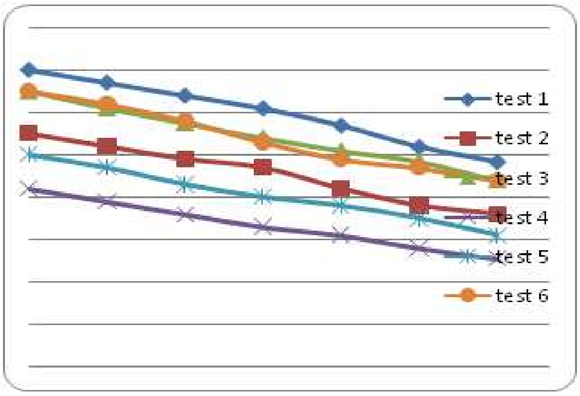

Figure 9: Graph of Difference in Temp for All Fluids

RESULTS AND DISCUSSIONS

In heat exchanger contaminants level in working fluid is measured with iron sensing instrument for sensitive applications in chlorinated water normal heat exchanger surfaces corrode and particles of ferrous oxide gets added in the working fluid. In our test we found no any iron contain is observed in the working fluid. So, it proves that corrosion will not takes place at highly corrosive environment also. Again this result encourage to use this polymer coated anticorrosive heat exchangers in food. For endurance of system we have taken accelerated test of plate specimen of heat exchanger and results are observed visually and dimensionally. No any damage and wear or tear is observed on coated surface for this test we have used 98% surface acid and test specimen is placed for 48 hours in tub. After 48 hour test specimen is observed. Endurance of heat exchanger is taken from highly disastrous environment.

CONCLUSIONS

Tests on anticorrosive heat exchanger using acidic fluids shows average 4^0C. Reduction in temperature with 1.02w/m^2k. This anticorrosive heat exchanger gives 0.98 effectiveness value which means there is no change in heat transfer coefficient due to corrosion or fouling. As there is no iron content in the outlet fluid that shows there is no any corrosion or fouling takes place while handling aggressive fluids. This technology gives proper research based solution for critical application with better overall heat transfer coefficient. We have taken a step from the present available technology by coating M.S. by another anticorrosive material. It gives the seem line between present and advanced technology. In industries like pharmaceuticals where there is requirement of sterilization and any contamination is not allowed with environment, at that place there is no option for anticorrosive heat exchanger.

REFERENCES

1. Key issues related to modelling of internal corrosion of oil and gas pipelines – A review Srdjan Nešić Corrosion Science Volume 49, Issue 12, December 2007, Pages 4308–4338.
2. Lin Chen, Zhen Li*, Zeng-Yuan Guo:- 'Experimental investigation of plastic finned- tube heat exchangers, with emphasis on material thermal conductivity' published in Experimental Thermal and Fluid Science 33 (2009) 922–928.
3. Jung-Yang San*, Gean-Sheng Lin, Kai-Li Pai:-"Performance of a serpentine heat exchanger: Part I – Effectiveness and heat transfer characteristics", published in Applied Thermal Engineering 29 (2009) 3081–3087.
4. L. Zaheed, R.J.J. Jachuck:- "Review of polymer compact heat exchangers, with special emphasis on a polymer film unit", published in Applied Thermal Engineering 24 (2004) 2323–2358.