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The Influence of Corrosion Inhibitor (Hexamine) Concentration on Heat Exchanger Copper Alloy Tubes Corrosion Rate

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Abstract:

The influence of concentration of corrosion inhibitor was studied under static and dynamic conditions on the heat exchanger copper alloy tubes metal corrosion rate, as this influence is important factor to choose the way to protect tubes metal during the acid cleaning to remove deposited scale inside them.

It was found that increasing temperature decreases inhibitor efficiency, while increasing acid concentration needs higher inhibitor concentration but not higher than specific concentration where that will not decrease corrosion rate of copper alloy metal.

Keywords: Corrosion; Corrosion Inhibitor

Introduction:

Corrosion may occurred during the acid cleaning of the heat exchanger tubes , the good cleaning agent must be inhibited to protect the tubes metal , but at the same time the inhibitor must not prevent dissolution of the scale(1) .

The corrosion increases with increasing the concentration or temperature , but could decreased by using inhibitors , longer contact time may be required for some deposits if better inhibited acid used(2) .

The purpose of this work is to study the influence of inhibitor (Hexamine) (Hexa methyl tetra amine) concentration used in acid cleaning process(3). Various conditions tested of acid concentration, temperature and time on the copper alloy cooling system heat exchanger tubes in Daura refinery.

All the bench- scale tests were carried out using field cleaned from deposited scale admiralty metal B (copper alloy C 44300) cooling tower heat exchanger(4). The tubing was of (19mm) outside diameter and (2mm) in thickness having the following chemical composition (table 1).

Table (1) Analysis of Tubes Metal.

Comp: Copper	Tin	Lead	Iron	Zinc	Arsenic
Wt.% : 70-73	0.9-1.2	0.07	0.06	balance	0.02-0.01

Influence of Inhibitor Concentration on Tubes Metal Corrosion Rate Under Static Conditions:

As starting point we studied the effect of concentration of inhibitor for the clean galvanized tubes for two contact time levels (1,4) hours between acid solution and tubes metal with constant temperature of 70 ^{o}C and 6wt.% citric acid concentration vs. different concentrations of (Hexamine) inhibitor were used (0.0 ,0.1 , 0.15 , 0.2 , 0.25 , 0.3) wt.% at static condition .Where pieces of tubes 10 cm long were cut, inserted

between two pieces of teflon parts ,tied to insure isolating the external walls from acid solution and corrosion takes place only at inside and placed in 500 ml beakers containing 6 wt.% citric acid solution the results were as shown in table (2) .

The results showed that at zero concentration of (Hexamine) inhibitor the weight loss (i.e. corrosion rate) was quite high while it was low and almost constant when inhibitor used at higher concentrations especially above 0.15 wt.% as shown in figure (1).

Table(2): Corrosion Rate of the Copper Alloy with Variable Inhibitor (Hexamine) Concentration & Contact Time in 6wt.% Citric Acid at 70°C Under Static Conditions .

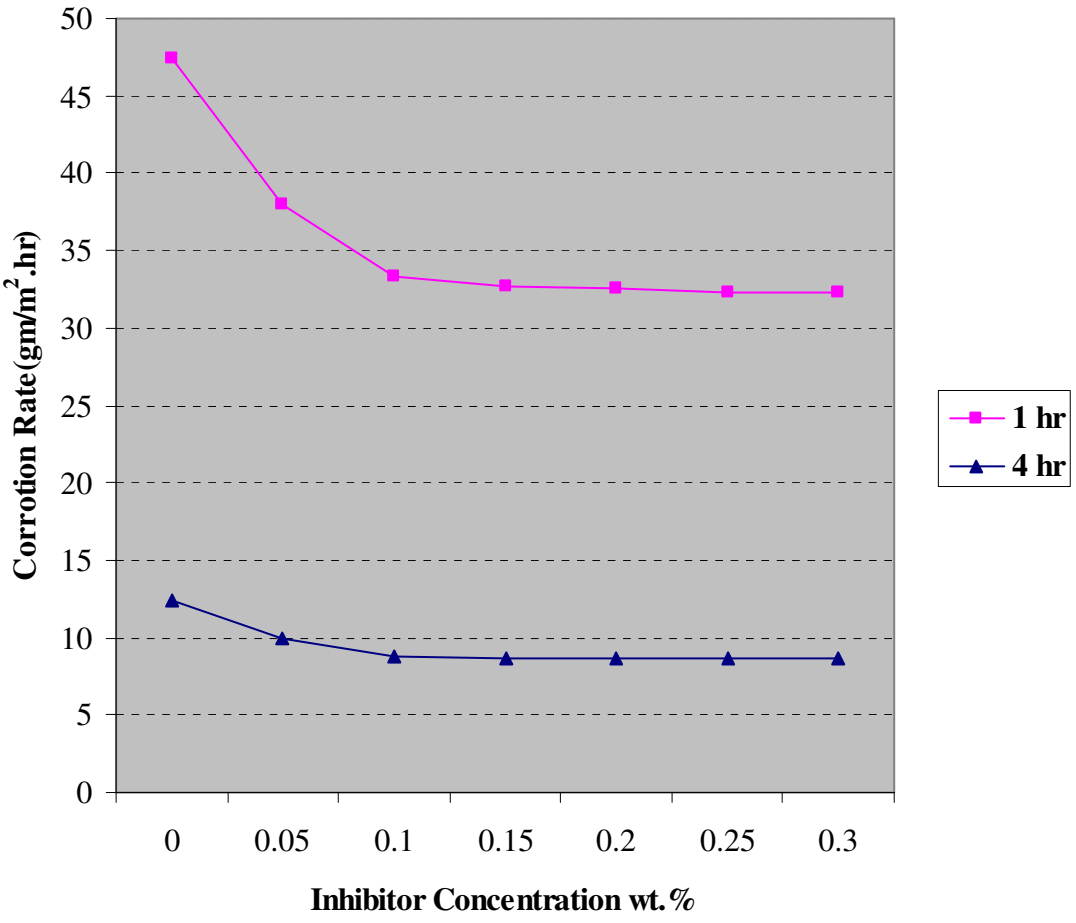
Run no.	Inhibitor Conc. Wt.%	Contact Time hr	Wt. of Sample gm	Corrosion Rate gm/m².hr	Specimen Specific.		
					Length cm	In Diam. mm	Out Diam. mm
1	0.0	0.0 1.0 4.0	81.6335 81.1145 81.0914	0.00 47.4377 12.3785	10.05	15	19
2	0.05	0.0 1.0 4.0	81.1370 80.7270 80.7049	0.00 38.0013 10.0121	10.00	15	19
3	0.1	0.0 1.0 4.0	80.2120 79.0517 79.8337	0.00 33.3976 8.7665	9.90	15	19

4	0.15	0.0 1.0 4.0	81.1342 80.7818 80.7581	0.00 32.6572 8.7143	10.00	15	19
5	0.2	0.0 1.0 4.0	81.1441 80.7935 80.7695	0.00 32.4985 8.6821	10.00	15	19
6	0.25	0.0 1.0 4.0	81.1503 80.8012 80.7773	0.00 32.3507 8.6418	10.00	15	19
7	0.3	0.0 1.0 4.0	79.4230 79.0784 79.0522	0.00 32.2617 8.5929	9.80	15	19

Influence of Inhibitor Concentration on Tubes Metal Corrosion Rate under Dynamic Conditions:

A dynamic system was assembled for corrosion rate investigation ,all made of Q.V.F. glass parts ,it consist of round bottom container with four necks, connected with glass coil heat exchanger .The circulation of acid solution was effected using Q.V.F. pump (0.25Kwatt) fig.(2).

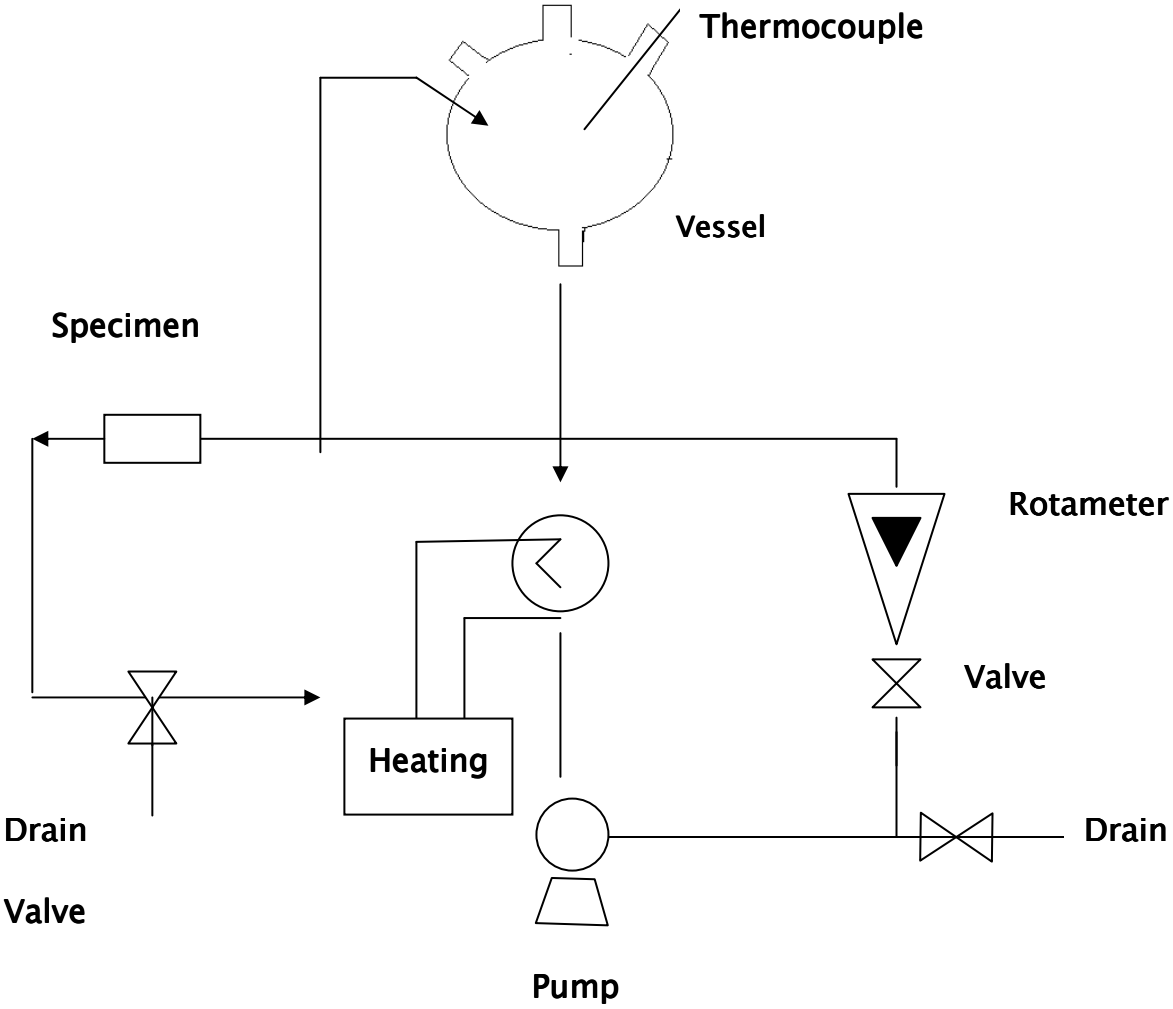
Figure (1): Corrosion Rate vs. Inhibitor (Hexamine) Concentration at Conditions of 6wt. % Citric Acid Concentration and 70 °C Temperature (Under Static Conditions).



The tested also was inserted between two teflon pieces ,the flow system contained 15 liter of circulating acid solution , all tests carried out to determine the corrosion rate by measuring the weight difference of specimen at the start and end of each test. So for every sample after each test the tube was washed with distilled water ,oven dried at 60 °C for 24 hr and weighed .

Figure (2): Schematic Diagram of Experimental Apparatus

(Under Dynamic Conditions).



The effect of the concentration of inhibitor was studied under dynamic condition for different concentrations of (Hexamine) inhibitor (0.0 , 0.05 , 0.1 , 0.35 , 0.75), with two level of acid concentration (2 , 5) wt.% and temperature (40 , 72) ^{o}C at constant time of 2 hr.

Four sets of experiments were chosen with each set containing five different runs as shown in table (3) .

In the first set at low temperature of 40°C and low concentration of acid 2wt. % the weight of dissolved copper alloy was found to be small and the weight loss due to corrosion decreased with the increase in concentration of inhibitor.

In the second set at low temperature of 40°C and high concentration of 5.0wt. % the weight of dissolved copper alloy was found small and the weight loss decreased with the increase in concentration of inhibitor .

In the third set at high temperature of 72 °C and low concentration of acid 2.0wt. % , the weight of dissolved copper alloy was found to be higher than the first and second sets and was decreased with increasing in inhibitor concentration .

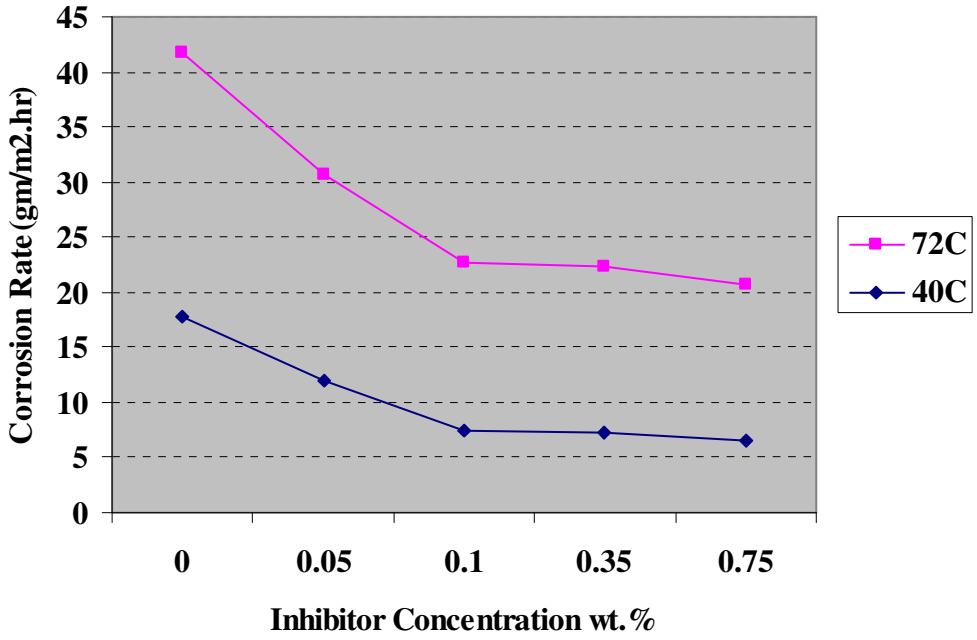
In the fourth set at high temperature of 72°C and high acid concentration 5.0wt. %, the weight of dissolved metal was found to be higher than the other sets and decreased with increase in inhibitor concentration.

Table (3): Corrosion Rate of Copper Alloy with Variable Inhibitor (Hexamine) Concentration at Constant Contact Time of 2 Hours Under Dynamic Conditions.

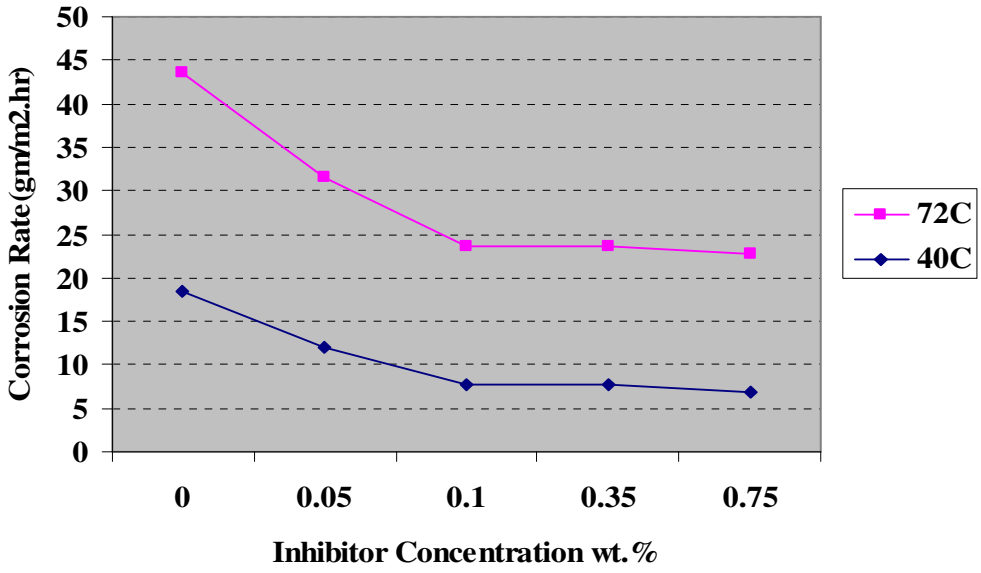
Run No.	Sample Weight gm	Corrosion Rate gm/m².hr	Inhibitor Conc. Wt.%	Temp. °C	Acid Conc. Wt.%	Length cm
1	80.3274	17.8296	0.0	40	2.0	9.92
2	80.4126	11.9937	0.05	40	2.0	10.0
3	77.7539	7.4117	0.1	40	2.0	9.60

4	80.3271	7.2146	0.35	40	2.0	10.0
5	80.0030	6.4525	0.75	40	2.0	10.0
6	80.2091	18.4142	0.0	40	5.0	9.90
7	80.4719	12.0638	0.05	40	5.0	10.0
8	80.2142	7.7003	0.1	40	5.0	9.80
9	80.1768	7.6849	0.35	40	5.0	9.90
10	80.8330	6.9665	0.75	40	5.0	10.0
11	79.9441	23.9243	0.0	72	2.0	9.92
12	80.1435	18.5836	0.05	72	2.0	10.0
13	79.3971	15.1896	0.1	72	2.0	9.90
14	79.9648	15.0317	0.35	72	2.0	9.90
15	80.7609	14.1900	0.75	72	2.0	10.0
16	77.0565	25.2196	0.0	72	5.0	9.50
17	80.0734	19.5423	0.05	72	5.0	9.90
18	81.2054	15.8604	0.1	72	5.0	10.0
19	79.8192	15.8316	0.35	72	5.0	10.0
20	79.7797	15.8192	0.75	72	5.0	10.0

Figure(3): Corrosion Rate vs. Inhibitor (Hexamine) Concentration at Conditions of 2 wt.% Citric Acid Concentration and 2 Hour Time (Under Dynamic Conditions).



Figure(4): Corrosion Rate vs. Inhibitor (Hexamine) Concentration at Conditions of 5 wt.% Citric Acid Concentration and 2 Hour Time (Under Dynamic Conditions).



Conclusions:

1. At static conditions by comparing the different inhibitor concentration, it was found that the minimum effective concentration was 0.1 wt.% Hexamine ,therefore this concentration was used throughout the rest experiments, since more than this concentration was not considerably better for protection of tubes and in order to have minimum cost .

2. At dynamic conditions from the results it was shown, that the higher temperature causes a decrease in inhibitor efficiency and also the increasing in inhibitor concentration above 0.1wt. % has small influence on decreasing the amount of dissolved copper alloy in citric acid solution

3.from whole tests results static and dynamic it was found 0.1wt.%Hexamine was the best concentration for protection and for corrosion inhibiting of the copper alloy tubes metal with acceptable cost , as above this concentration didn't improve the protection considerably ,these results agree with that of Eldrige (5).

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