STUDY THE PERFORMANCE OF SULFAMIC ACID AND CITRIC ACID IN REMOVAL THE SCALE DEPOSITED ON THE DURA REFINERY HEAT EXCHANGE PIPING SYSTEM

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ABSTRACT

This paper describes an experimental study on the performance of sulfamic acid and citric acid in scale removal of Dura refinery heat exchange piping systems.

Experiments were carried out using sulfamic acid and citric acid inhibited by hexamine as cleaning solutions at different time, temperature and concentrations. A dynamic flow system was designed for this state. A scaled copper alloy pipes from the main hot water lines (heat exchanger) was used. Hexamine was used as corrosion inhibitor.The research involved a study of effect of the time ,temperature and acid concentration of each acid on the scale removal, and a comparison of the performance of the two used acids were investigated.

دراسة ادائية حامضي السلفامك والستريك في ازالة التكلسات المترسبة على انابيب اجهزة المبادلات الحرارية في مصفى الدورة

الخلاصة

يهدف البحث الى دراسة عملية لادائية حامضي السلفامك و الستريك في ازالة التكلسات المترسبة على انابيب المبادلات الحرارية المستخدمة في مصفى الدورة .اجريت تجارب عملية استخدم فيها حامضي السلفامك والستريك المثبطة بمادة الهكسامين كمواد كيمياوية مزيلة للتكلسات عند ازمان مختلفة ودرجات حرارة مختلفةوتراكيز متعددة.

صممت منظومة جريانية لهذا الغرض استخدمت فيها قطع من انابيب مأخوذة من اجهزة المبادلات الحرارية المستخدمة في مصفى الدورة.لقد تضمن البحث دراسة تاثير زمن المعالجة ودرجة الحرارة وتركيز الحوامض المستخدمة واجراء مقارنة لادائية كل من الحامضين المستخدمين لازالة تكلسات الانابيب المستخدمة في المبادلات الحرارية في مصفى الدورة.

INTRODUCTION

Problems involved with use of water are caused by the dissolved constituents namely solids. Chemical reaction sometimes occur between some constituents dissolved in water produce insoluble compounds. These insoluble compounds deposited by the water are called scale.

Scale deposition in the heat exchanger tubes is the most undesirable yet unavoidable problem.[1]

Formation of scale on the interior surfaces of pipes,tubes,tanks,heat exchangers,and other vessels has been a source of trouble where such pipes come in contact with aqueous liquid.The formation or deposition of scale markedly reduces the heat transfer through walls of such pipes and furthermore,the capacity of the pipes and the passage of fluids therthrough is restricted by the formation of such scale.Because of the scale formation on the inner surfaces of the pipes,particularly in the heat transfer appliances,pipes are subjected to excessive heat due to the loss in the heat transfer capacity.Furthermore,greater pressures are required to over come the restricting effect of the deposited scale.These disadvantages often lead to leaks and rupture which necessitate undesirable down time and maintenance cost.Still further,the reduced cross-section of pipes caused by the deposition of scale can cause increased pressure drop.[2]

Cleaning can be done either mechanically or with the use of chemicals. Mechanical cleaning obviously takes a great deal of downtime and does not always get all the scale out.Chemical cleaning can get at scale buildup not always reachable in mechanical cleaning scale removal by acid cleaning is commonly employed in many types of plants.[3]

For removal of Calcium Carbonate and/or Magnesium hydroxide scales, Circulation of an inhibited acid solution (HCl, H_2SO, $C_6H_8O_7$(citric acid) or HSO_3NH_2) through the scaled system was found to be appropriate.

Adding an inhibitor to the acids is essentially to diminish its corrosive effect on metals. [4]

Explanation of the scale inhibitor action is that the inhibiting compounds serve to blanket the entire metal surface with a protective layer of compound used.This occurs as simple adsorption of the inhibitor ion on the metal surface.[5]

The modes of adsorption of an inhibitor are dependent on chemical structure of the molecule, chemical composition of the solution, nature of the metal surface and the electrochemical potential at the metal solution interface.[6]

Hexamine as corrosion inhibitor has been effectively used with the solutions for acid cleaning.[5]

The present investigation of the problem of scale removal is being studied mainly on tubes of heat exchanger obtained from Dura Refinery using sulfamic acid and citric acid as cleaning solutions.

A special flow system has been designed where parts of these piping were being fixed in exposed to the treating solution.

Percentage of scale removal was studied as a function of time and acid concentration.Furthermore, a comparison between sulfamic acid and citric acid performance in the scale removal process has been investigated in this study.

EXPERIMENTAL WORK :

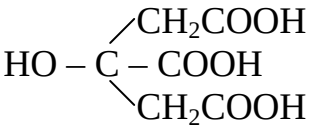
Materials

All chemical cleaning bench-scale tests, metals (copper alloy) heat exchanger tubes from Dura refinery.

The scaled tube specimens were prepared by cutting sections from the exchanger tubes. The tubing was of (20mm) outside diameter, 100mm long and (2mm) thickness having the chemical composition listed in table(1).

The large thickness (2.5-5mm) scale used has a mixed type composition as shown in table (2).

SOLUTIONS AND TEST APPARATUS:

Citric acid  with concentrations of

(3%, 6%, 9%) and sulfamic acid (HSO_3NH_2) at concentrations of (3%, 6%, 9%) were used. Hexamine with concentration of 0.1% was used as corrosion inhibitor. The dynamic system for descaling investigation was all made of Q.V.F. glass(Quick fitting). It consisted of 5 liter round bottom container with three necks, the container was connected from the bottom with tubing through which hot solution circulated. A controlled heating tapes were rapped around the insulated Q.V.F glass tubing for heating the circulating solution.

The circulation of the chemical solution was effected using Q.V.F pump (0.25kw) and total flow rate was measured by a rotameter ranged from (0-1000) liter/hr.The flowing liquid passed the scaled metal specimen, and returned to the round bottom container, as shown in figure (1).

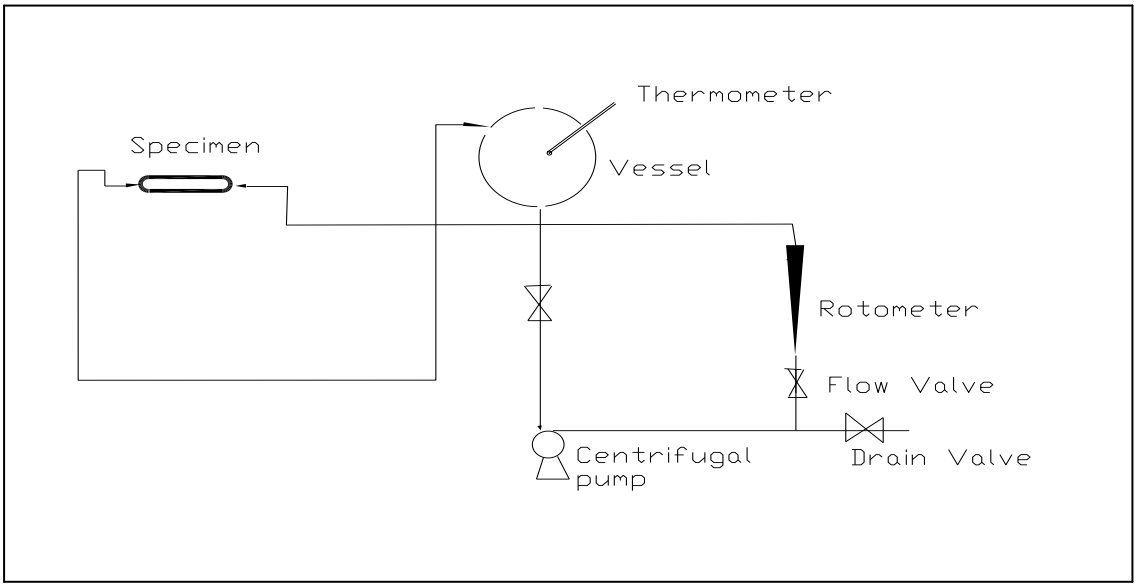
The temperature of the test solution ranged from 0-100^{o}C and it was measured by means of thermometer.

The amount of the scale deposits which has been removed at each run was calculated by weight difference of the scaled tube before and after the tests.

PROCEDURE

The scaled tube was inserted into Teflon section and the Teflon section was tightened carefully to prevent leakage of test fluid.

The flow system contained (5) liter of circulating fluid. To obtain scale removal rate data, the pre-weighed test specimens were removed and weighted after the experiment. The tests were conducted at constant flow rate of 300l/hr.



Fig(1) Schematic digram of the experimental system

RESULTS AND DISCUSSION:

The present work including the effects of temperature, time and concentration, on scale removal for a given turbulent flow rate.

-EFFECT OF TEMPERATURE

Rising temperature imparts kinetic energy to molecules causing them to move faster and collide more frequency and causing the rate of reaction in general to increase.

Such an increase in temperature on a cleaning job should speed up chemical reaction, There by decreasing the cleaning time [7].

Temperature ranged from ($25^{o}C$ – $65^{o}C$) have been used for the process of scale removed.

Figures (2), (3),and table(3) show the effect of temperature on the scale removal process for sulfamic acid and citric acid respectively it was clear that the higher the temperature the higher the percentage of scale removal when other conditions of the process (time, concentration) remained constant.This may be due to the effective penetration of above compounds at high temperature to internal structure of the scale.Also the reaction rate constant increases as the temperature increases,and has its maximum value at the highest temperature.

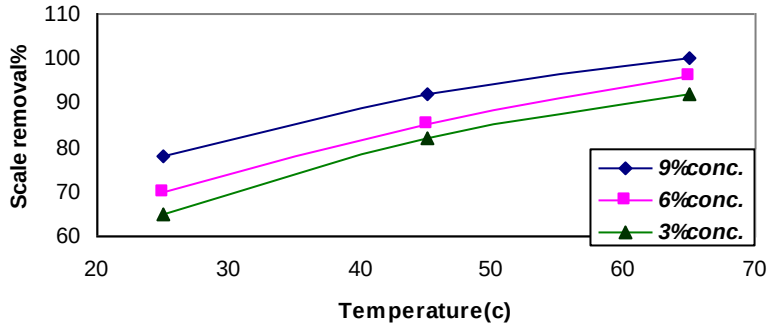
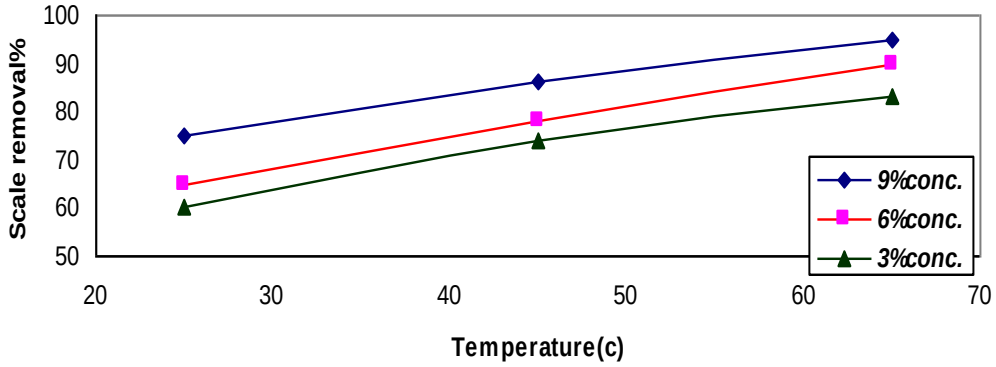


Fig.(2)-Sulfamic acid scale removal versus temperature at different concentration



concentration

- EFFECT OF TIME :

The effect of time on scale removal is observed in figures (4), (5) for citric acid and sulfamic acid respectively at different concentrations and (temperature 45^{o}C).

It can be seen that the percentage of scale removal increases with reactions time at a constant concentration and temperature.

The pattern of the curves is similar to those of Moor [8]. Above 4 hours of reaction time with all concentrations of sulfamic acid greater than 85% scale removal could be accomplished while at all concentrations of citric acid above 75% scale removal could be obtained after 4 hours at 45^{o}C temperature and different concentrations.

Increasing the time cause the scale removal to increase, that is due to increasing the action of the fluid to break the bound between the scale particles as increasing the time of passing over it.

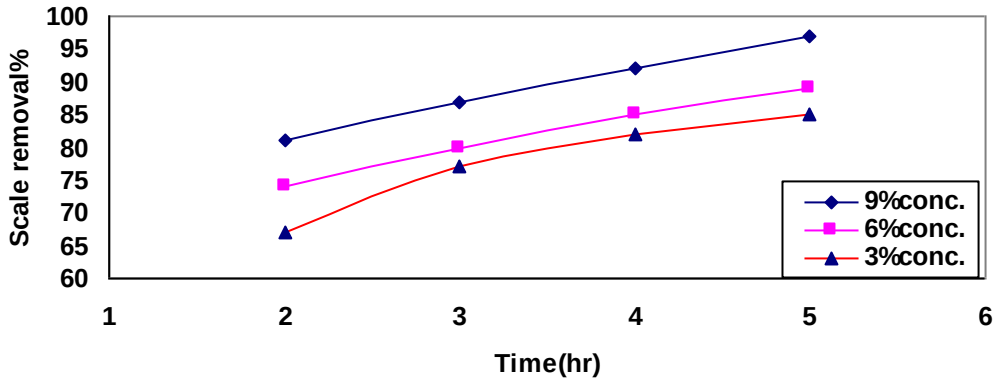


Fig.(4)-Sulfamic acid scale removal% versus time at different concentration

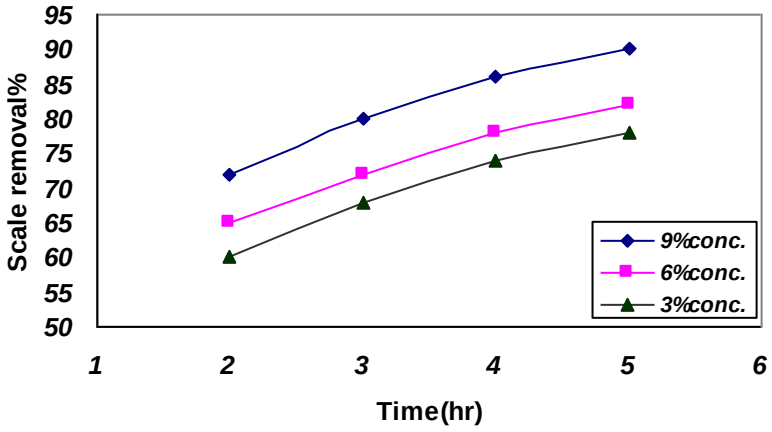


Fig.(5)-Citric acid scale removal% versus time at different concentration

-EFFECT OF CONCENTRATION :

Sulfamic acid and citric acid were tested in three concentrations of 3%, 6%, 9%. Figures (6), (7) shows the effect of increasing the concentration of each acid with scale removal percentage. It was clear that increasing the acid concentration cause to increase the scale removal percentage at any time.

It can be observed that more than 75 wt% of scale can be removal at concentration of 4 wt% of sulfamic acid and more than 70 wt% of scale can be removed with citric acid of concentration above 4 wt% at constant time and temperature.

Increasing the scale removal with increasing acid concentration due to the increase in concentration gradient between the bulk and the solid solution interface consequently, the reaction rate of the scale with the acid will be increased.[9]

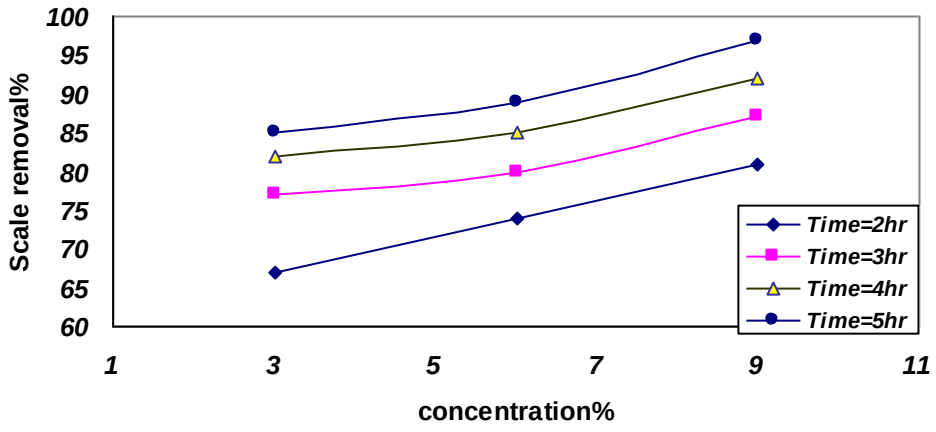


Fig.(6)-Sulfamic acid scale removal % versus concentration at different time

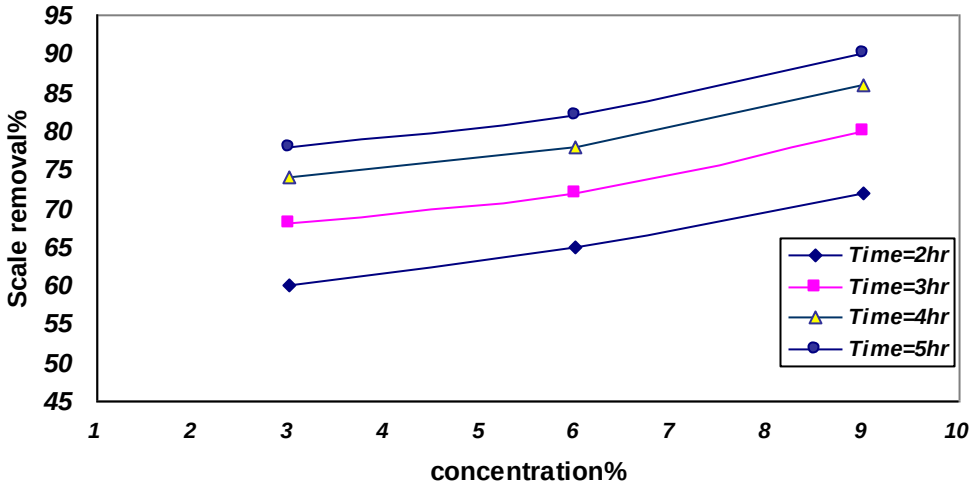


Fig.(7)-Citric acid scale removal % versus concentration at different time

-COMPARISON OF THE TWO ACIDS USED :

Figure (8) shows the performance of sulfamic acid and citric acid in the scale removal, it was clear that sulfamic acid appears to be the better scale removal than citric acid.

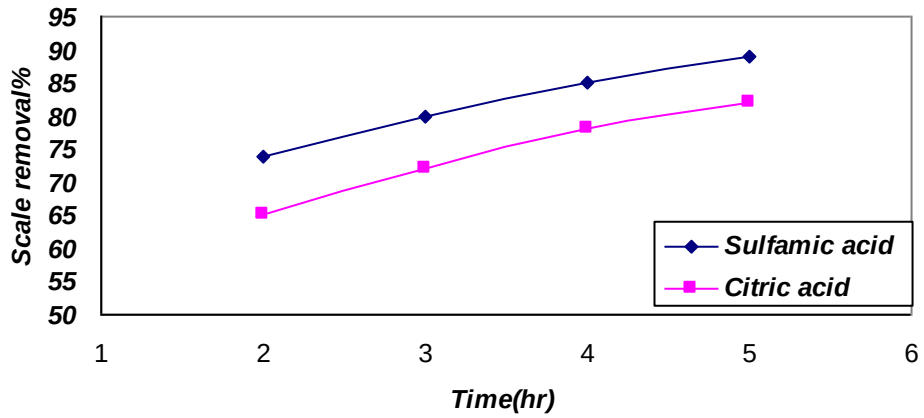


Fig.(8)-Copmparison of scale removal % of sulfamic acid and citric acid versus time at 6%concentretion

CONCLUSION

- The following conclusions could be obtained from the present study :
- Scale removal by means of inhibited sulfamic acid and citric acid increases as the temperature of the process increase and it was observed that above 80 wt% of the scale was removed when the temperature of the process was 45^{o}C at time 4 hr and different concentration.
- The amount of scale removal increases with increasing the reaction time, and above 75% of the scale removed at a time greater than 4 hours using any of the two acid solutions.
- The amount of scale removal increases with increasing the acid concentration for each of the two acids used and it was found that above 70wt% of the scale was removed with acid concentration more than 4wt% of each acid.
- Sulfamic acid was found to be the better solution than citric acid for Dura refinery heat exchanger piping scale removal.

Table (1) Chemical Composition Of The Tube Used From Dura Refinery Heat Exchangers

Comp.	Copper	Tin	Lead Max.	Iron Max.	Zinc	Arsenic
Wt%	70-73	0.9-1.2	0.07	0.06	Balance	0.02-0.1

Table (2) Complete analysis of scale Al-Dura refinery water deposit from heat exchanger tubes

Element Analysis	Wt%
Iron (Fe_2O_3)	20.6
Aluminum (Al_2O_3)	2.04
Calcium Carbonate ($CaCO_3$)	32.71
Calcium (CaO)	14.1
Magnesium (MgO)	3.25
Sulfur (SO_3)	2.2
Potassium (K_2O)	0.04
Copper (CuO)	1.12
Zinc (ZnO)	3.6
I.R (Insoluble Residue)	9.11
L.O.Z (Loss on Ignition)	11.23

Table(3) Effect of temperature on scale removal% using sulfamic and citric acids at different concentrations

Temperature (C^o)	Scale removal%		Concentration
	Sulfamic acid	Citric acid	
25	65	60	3%
	70	65	6%
	78	75	9%
45	82	74	3%
	85	78	6%
	92	86	9%
65	91	83	3%
	95	90	6%
	100	95	9%

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