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Scale Formation of Calcium Sulfate Minerals in Cupper Pipes

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***Abstract*—The scaling inside incompressible fluid flow pipes is a serious problem in industries (paper, rubber, paint, cement, oil, drink/food and pharmacy) because it can reduce performance reduction on fluid transfer systems. Peformance decreases including reduction of the pipe diametre that leads to reduce the efficiency of these equipments and increase high energy required for the machine to operate. Thus operational and maintenance cost will increase. In a long run, it has possibility to break the pipe. The aim of this paper is to predict corrective maintenance for the pipe line system and Induction time Scale Formation. The experiment was done by constructing a simulator for continuous water flow systems by mixing CaCl2 and Na2SO4 solutions at 1500, 3000, 4500 and 6000 ppm of Ca2+ at room temperature 30o C, and at different flow rates; 30, 40 and 50 ml/min which shown in a monitor scaling with the investigated parameters. Crystalization began at especially active point-nucleation sites -such as scratches and pits, often after a considerable induction period, and the scale of CaSO4 is strong adherent at entire surfaces. The result massa scales showed 33,8 mg. in average, and the formation scale happened at IT of 13 minutes, caused by effect flow rates and concentration solution. Minerals formation were detected within decreased fluid velocity and increased concentration. It was found that the minerals deposit increased 30% with decreased fluid velocity, and 45% with increase solution concentration. In addition the solid products were characterized in terms of their mineralogical composition, using X-ray diffraction (XRD) rietveld analysis, and their morphological features by Scanning electron microscopy (SEM).**

Keywords— $CaSO_4$ scale, induction time, morphology, XRD Rietveld analysis

I. INTRODUCTION

Scaling is one of the main serious engineering problems in process industries as the scales may hinder the flow of solution in industrial pipes or tubes. Accurate estimation of scale formation is thus very important.

The calcium sulfate scale formation was influenced by several aspects such as flow rate, the precipitation of calcium sulfate phases leads to the deposition of minerals in pipes, filters and heat excangers, forming mineral scales [e.g. Mi and Elimelech, 2010]. Another researcher studied Barium sulphate scale deposition on stainless steel using a rotary cylinder electrode aparatus. The result shows that the deposition rate increases with the increasing Reynolds number during agitation of the solusion of both polished and pre-scaled samples. Abdul Quddus studied the effect of hydrodynamics on the deposition of CaSO4 scale on stainless steel using rotary cylinder electrode aparatus. The deposition rate increases linearly with the increase of the Reynolds number for both polished and pre-scaled samples [Tung Hoang (2007), Quddus et al,(2002)]. [Freyer, D.and Voigt, W., (2003) Guan,B., Yang, L. and Wu, Z., 2010].

II. EXPERIMENT SET-UP

The experiment set-up used in the present work is shown in fig. 2.1a. and 2.1b. This setup is consisted of opened circlation unit pipes. The circulation unit pipes consisted of the two perilstatik pumps, two vesselts, two spindles, unit pipes and display.

(a)

(b)

Figure 1. (a) Prototype Simulator scale and (b) material Na_2SO_4, $CaCl_2$

Reagent-grade $CaCl_2$ and Na_2SO_4 salts were used to produce CaSO4 by coprecipitation. Concentration of each salts was kept at 34.68 gr/5l. And Na_2SO_4 38.37 gr/5l. Equal two vesselts volume of the two solutions were mixed. The vesselt is also connected to two periltastic pumps during the whole period of experiment. The solution passes unit pipes as ejected by periltatik pumps. In the test section display there are some information suc as tempretature and flow rate. The

temperature were measured by using devices thermocouples and the data acquisition system was read through display. As previously mentioned, thermocouples type K were used in the present work for temperature measurements in order to be easily interfaced with the data acquisition unit. The detail is shown in Fig. 2.

III. Result and Discussion

A. Induction Time

The Calcium Sulphate/ $CaSO_4$ scale was formed at Induction while sum scale formation were first detected at different time; 7, 15, 13, 21 and 17, 24 minutes, shown in figure 3.

B. Deposit Formed

Reagent-grade $CaCl_2$ and Na_2SO_4 salts were used to produce $CaSO_4$ by mixing them in the tube at room temperature/ 30°C, the solutions concentration were 1500, 3000, 4500 and 6000 ppm with the flow rates; 30, 40, 50 ml/min and the scaling duration time was 8 h. The results are shown in table 1.

TABLE I. Solubility a Function of Tempeature

Concentration (ppm)	Velocity (ml/min)	Deposit Weight (mg)
1500	30	17.4
	40	9.7
	50	8.1
3000	30	43.7
	40	32.4
	50	19.9
4500	30	53.7
	40	38.8
	50	31.7
6000	30	63.6
	40	46.7
	50	30.9

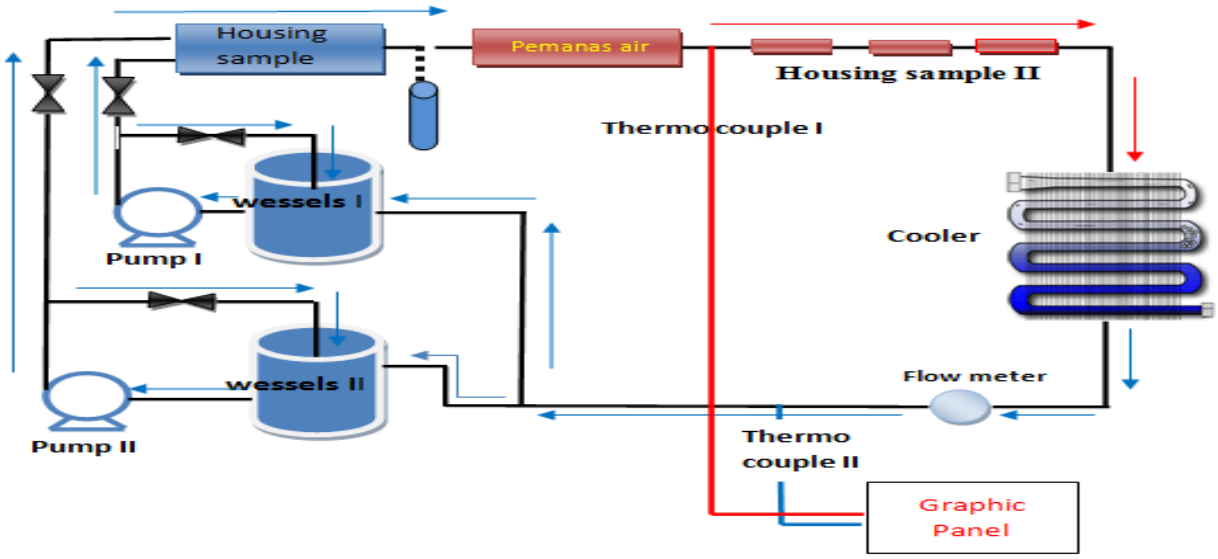


Figure 2. Equipment simulator scale formation unit

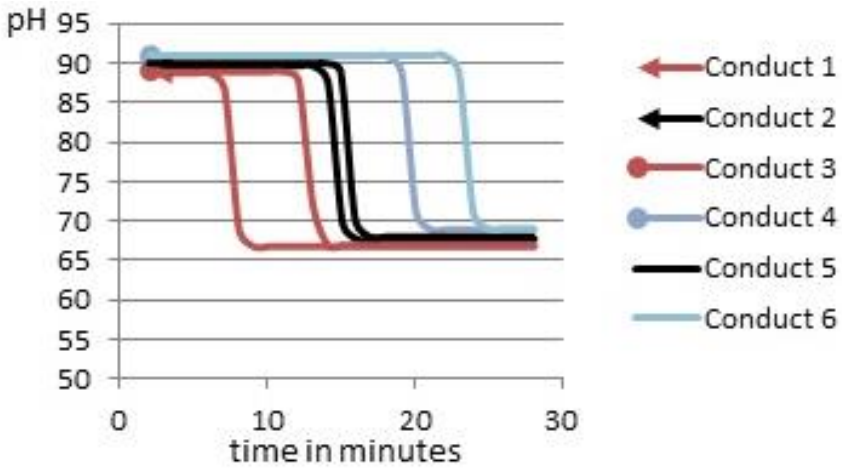
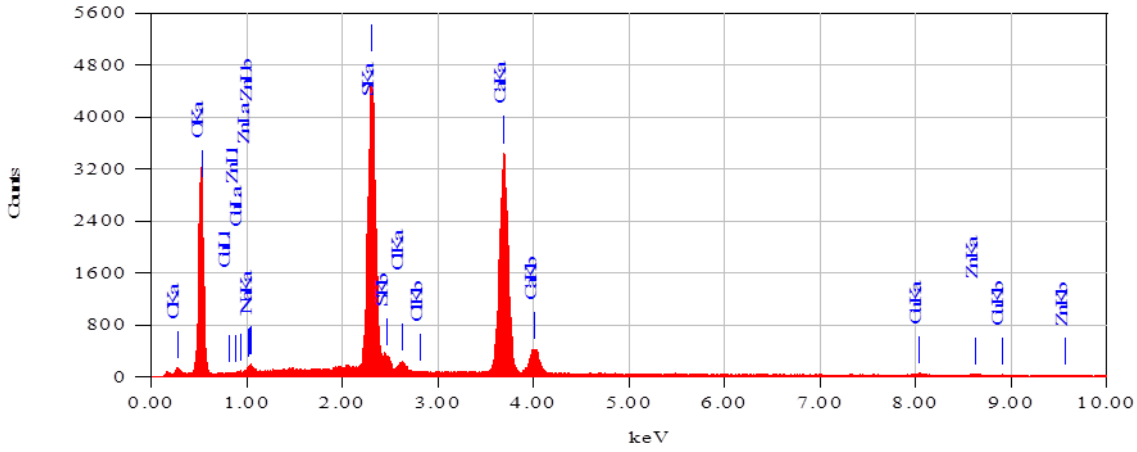
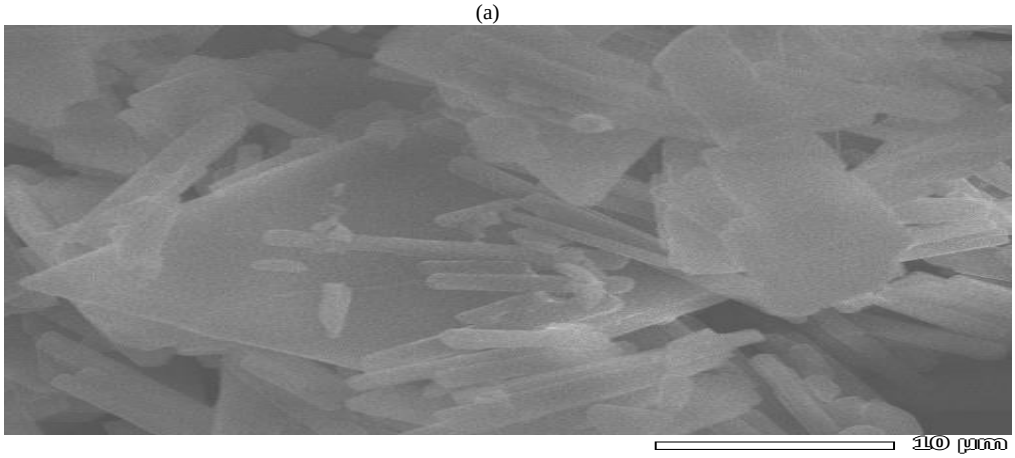


Figure 3. Induction time graph



(a)



(b)

Figure 4. (a) Composition chemisty graph and (b) Morphology of Calcium sulfate

IV. CHARACTERIZATION

A. *Scanning Electron Microscope (SEM) Images of the Deposition Layers of Morphologies*

The deposits in Fig. 4 (b) are orthorhombic, needle-shaped crystals and plate-like and EDX anlysis was used to examine Chemical composition as shown in Fig. 4 (a).

B. *The SEM examination*

SEM examnation of the CaSO4 scale exhibited a wide variety of crystal structures consisting of prismatic rod and needles like grouwth or the images of the scales reveal crystalline plate-like and. The needles are orthorhombic, which are typical forms of gypsum crystals.

V. CONCLUSION

The weight of scale calcium sulfate was 33.8 mg in average and the Induction Times was 13 minutes. The morfology $CaSO_4$ has revealed various crystal structures consisting of prismatic rods, needles and plate-like. The EDX resulted 51.84 sulpur oxside, 32.84 Calcium oxside.

REFERENCES

[1] Bahadori A. Prediction of scale Formation in Calcium Carbonate Aqueous Phase for Water Treatment and Distribution System, Water Quel. Res. J. Can. Volume 45 (2010) 379-389

[2] M. Gourdon. The Effects of Flow Velocity on Crystallization Fouling in Falling Film Black Liquor Evaporators. Proceeding of International Conference on Heat Exchanger Fouling and Cleaning (2011)

[3] Basim O. Hasan, Graham J. Nathan, Peter J. Ashman, Richard A. Craig, Richard M. Kelso, The Effects of temperature and Hydrodynamics on The Crystallization Fouling Under Cross Flow conditions, Journal. Elsevier aplied Thermal Engineering. Volume 36 (2012) 210-218

[4] Alice Antony, Jor How low, stephen gray, Amy E, Childress, Pierre Le-Clech, Greg Lesli, Scale Formation and Control in High pressure Membrane Water Treatment systems, Journal of Membrane Science 383 (2011) 1 -16

[5] Muryanto S, Bayuseno AP, Ma'mun H, Usamah M, Jotho, Calcium Carbonate Scale Formation in Pipes: Effect of Flow rates, temperature and malic acid as additive on The mass and Morphology of The Scale, Elsevier, procedia chemistry 9 (2014) 69-79

[6] Petrucci, Harwood, Herring, General Chemistry Principles and Modern Applications, ninth edition by Erlangga, translation. 2011

[7] Zhen Wu, Jane H D, Lorraine F, Effect of water chemistry on Calcium Carbonate deposition on metal and polymer surfaces, Journal of Colloid and interfacescience 343 (2010) 17-187

[8] Zhang. Yang, Nucleation and Growth Kinetics in Synthesizing nanometer calcite. Journal of Crystal Growth 245 (2002) 309-320

[9] Glade H, Kromer K, Stark A, Loisel K, Odiot K, Niet S, Essig M, Effects of tube material on Scale formation and control in mutiple-effect distillers. International World Congress of Desalination and Water reuse (2013)

[10] Muryanto S, Bayuseno AP, Sediono W, Mangestiyono w, Sutrisno,Development of a Versatile laboratory project for Scale formation and control, Education for Chemical Engineers 7 (2012) 78-84

[11] Feridoun, A. Paul Watkinson, Investigation of Initial Fouling Rates of Calcium Sulfate Solutions Under Non-Boilng Conditions, Engineering Conferences International (2003)

[12] Helalizadeh, Mixed Salt Crystallization fouling, Chemical Engineering and Processing 39 (2000) 29-43

[13] Myerson AS, Handbook of Industrial Crystallization. Boston etc. 1993

[14] Taher Rabizadeh, Caroline L. Peacock, Liane G. Benning, Carboxylic accids: Effective inhibitors for calcium sulfate precipitation 78 (2014) 1465-1472

[15] Tung A.Hoang, H. Ming Ang, Andrew L.Rohl, Effects of temperature on the scaling of Calcium sulphate in pipes, 179 (2007) 31-37.

[16] Abdul Quddus, Effect of hydrodinamics on the deposition of CaSO4 scale on stainless steel 14 (2002) 57 - 63