PERGAMON

International Journal of Heat and Mass Transfer 41 (1998) 2961–2966

International Journal of HEAT and MASS TRANSFER

Use of electronic anti-fouling technology with filtration to prevent fouling in a heat exchanger

Y. I. Cho,* Chunfu Fan, Byung-Gap Choi

Department of Mechanical Engineering and Mechanics, Drexel University, Philadelphia, PA 19104, U.S.A.

Received 7 August 1997; in final form 12 December 1997

Abstract

An innovative technology to control fouling in heat exchangers was developed, based on a combined use of electronic anti-fouling (EAF) technology and filtration. To validate the concept, the present study conducted a series of accelerated fouling tests with an artificial hard water of a hardness of 1000 mg l^{-1}. The pressure drop across a heat transfer test tube and the overall heat transfer coefficient were measured as a function of time. The pressure drop obtained with the combined use of the EAF treatment and filter showed almost no change from the initial value. Furthermore, the overall heat transfer coefficient obtained with the combined use of the EAF treatment and filter decreased by 6% from the initial value, whereas the U value dropped by 29% without any treatment.

Nomenclature

A interior surface area of heating tube
A cross-sectional area vector
B magnetic field strength vector
C_p heat capacity
E induced electric field intensity vector
$\dot{m}$ mass flow rate
q'' heat flux
R_f fouling factor
s line vector along the circumferential direction
T temperature
t time
U overall heat transfer coefficient.

Subscripts
b bulk
clean clean tube
fouled fouled tube
in inlet
out outlet
o initial state
s surface
w tube wall.

1. Introduction

The scale problem originates in the use of hard water. When hard water is heated (or cooled) inside heat transfer equipment, the solubility of dissolved mineral ions often decreases [1]. When conditions such as temperature, pressure, and pH change in a flow system such that the solubility of a mineral ion decreases, the mineral ions precipitate to form crystals. This phenomenon usually happens on the heat transfer surface, because the water temperature suddenly changes as water makes contact with the heat transfer surface. When scales deposit on a heat exchanger surface, it is traditionally called 'fouling'.

The scale deposition mechanism is often explained by a process that includes the dissolution of minerals, supersaturation, nucleation, precipitation, crystal growth, and, finally, scale deposition [2]. Many variables control the fouling in a heat exchanger, including water characteristics (i.e., pH, hardness, alkalinity, suspended solids, fluid temperature variation), heat exchanger surface temperature, pressure, flow velocity, flow separation and recirculation, etc.

The type of scale differs from industry to industry, depending on the mineral content of available water. Scales often observed in industry include calcium carbonate, calcium sulfate, barium sulfate, silica, iron scales, and others. The solubility characteristics of these scale-

* Corresponding author. Tel.: 001 215 895 2425; fax: 001 215 895 1478; e-mail: ycho@coe.drexel.edu.

0017-9310/98 $19.00
PII: S0017-9310(98)00011-8