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Electronic anti-fouling technology to mitigate precipitation fouling in plate-and-frame heat exchangers

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Abstract—The objective of the present study was to investigate the validity of an electronic anti-fouling (EAF) technology through accelerated fouling tests. A plate-and-frame heat exchanger (with 20 stainless steel plates) was used for the tests, in which pressure drop across the heat exchanger, and the universal heat transfer coefficient were measured over a range of flow rates. In order to accelerate the rate of fouling, artificial hard water of 1000 ppm (as $CaCO_3$) was used in the present study. The test results showed that the EAF technology could significantly reduce new scale deposits even in the accelerated fouling test, which was an extremely harsh fouling environment.

1. INTRODUCTION

Scales are formed when hard water is heated (or cooled) in heat transfer equipment such as heat exchangers, condensers, evaporators, boilers, and pipe walls. 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 [1]. One of the most common forms of scales is calcium carbonate ($CaCO_3$), which occurs naturally as an ingredient of chalk, limestone, and marble. When scales deposit in a heat exchanger surface, it is traditionally called "fouling".

Once scales build up on a heat transfer surface, at least two problems associated with scales occur [2–4]. The first problem is the degradation in the performance of the heat transfer equipment. Due to the small thermal conductivity of scales, a thin coating of scales on the heat transfer surface will greatly reduce the overall heat transfer performance. The second problem is that a small change in tube diameter substantially decreases the flow rate or increases the pressure drop across the heat transfer equipment.

Various scale-inhibiting chemicals such as dispersing or chelating agents are used to prevent scales [1]. Ion exchange and reverse osmosis are also used to reduce water hardness, alkalinity, and silica level. However, these methods are expensive at the industrial level and require heavy maintenance for proper operation. Once fouling occurs in heat exchangers, scales are removed by using acid chemicals, which shorten the life of heat exchanger tubes, thus necessitating premature replacement. When acid cleaning is not desirable, scraping, hydroblasting, sand blasting, metal or nylon brushes are used—operations which incur downtime and repair costs [4].

The present study introduces a new electronic anti-fouling (EAF) technology, which has been developed for the purpose of mitigating new scales in both plate-and-frame and shell-and-tube heat exchangers. If the EAF technology can be used to reduce the maintenance efforts, one can discontinue the use of scale-inhibiting or scale-removing chemicals, thus preserving a clean environment. The primary benefit of the EAF technology, if proven, will be in maintaining the initial peak performance of a heat exchanger indefinitely.

This paper reports the test results obtained with and without a new electronic anti-fouling (EAF) technology. Since detailed descriptions of this new EAF technology were given elsewhere [5–7], we will only briefly explain the operating principle.

2. ELECTRONIC ANTI-FOULING (EAF) TECHNOLOGY

The EAF technology creates induced oscillating electric fields using time-varying magnetic fields gen-

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