Microfluid Nanofluid
DOI 10.1007/s10404-013-1282-x

RESEARCH PAPER

Erosion–corrosion synergism in an alumina/sea water nanofluid

A. M. Rashidi · M. Packnezhad · M. Moshrefi-Torbati · F. C. Walsh

Received: 27 June 2013 / Accepted: 22 October 2013

Abstract Since nanofluids increase the thermal conductivity of a fluid mixture compared with the base fluid, it is important to investigate any damaging effects caused by the presence of the solid particles. Thus, this paper explores the nanofluid synergistic effects produced by the addition of 1 g dm^{-3} Al_2O_3 nanoparticles to sea water and compares the performance with the base fluid without nanoparticles. Studies are conducted on carbon steel, using a hydrodynamically smooth-rotating cylinder electrode in turbulent flow at 298 K. The pure corrosion rate and erosion rate of carbon steel in the fluids free of nanoparticles are, respectively, higher (up to 82 %) and lower (ca. 11 %) than in the nanofluids. The synergistic effect of erosion and corrosion in a nanofluid is much higher (up to 237 %) than in the base fluid. These results indicate that the presence of nanoparticles in a flowing fluid could lead to considerable rates of material loss.

Keywords Carbon steel · Erosion–corrosion · Metal loss · Nanofluid · Synergy

A. M. Rashidi (✉) · M. Packnezhad
Department of Mechanical Engineering, Faculty of Engineering, Razi University, P.O. Box 67149-67346, Kermanshah, Iran
e-mail: rashidi1347@razi.ac.ir

M. Moshrefi-Torbati
Electromechanical Research Group, Faculty of Engineering and the Environment, University of Southampton, Southampton SO17 1BJ, UK

F. C. Walsh
Electrochemical Engineering Laboratory, Engineering Sciences, University of Southampton, Southampton SO17 1BJ, UK

1 Introduction

Ultrahigh-performance cooling is one of the most vital needs of many high-tech industries, such as microelectronics and high-powered lasers. In recent years, liquid-cooling technologies such as micro-channel heat sinks for chip or package-level cooling have been used. Improvement of their performance requires the use of new coolants with thermal properties superior to the traditional heat-transfer fluids, such as water, oil and ethylene glycol (Das et al. 2008). It is well known that suspensions of solid particles in liquids have thermal properties superior to those of their host fluids (Keblinski et al. 2002). Although suspensions with millimetre or micron-sized particles do indeed display the desired increase in thermal conductivity, they suffer from stability and rheological problems such as rapid settling of particles, high dynamic viscosity, high pressure drop and large pumping power required for practical applications (Ghadimi et al. 2011; Keblinski et al. 2002). In contrast, dispersion of a very small concentration of nano-sized particles, with dimensions typically below 100 nm, in heat-transfer fluids gives rise to better long-term stability and rheological properties and can have dramatically higher thermal conductivities (Godson et al. 2010; Ozerinc et al. 2010). For example, the addition of 3–5 % vol Al_2O_3 particles has been reported to increase the resulting thermal conductivities of base fluids by up to 30 % (Xie et al. 2002). Nanofluids is the term coined by Choi (1995) to describe this new class of nanotechnology-based heat-transfer fluids that exhibit thermal properties superior to those of their host fluids or conventional particle fluid suspensions. With the continued miniaturization of technologies in many fields, nanofluids with a capability of cooling high heat fluxes exceeding 1,000 W cm^{-2} would be paramount to the advancement of all high technology (Das et al. 2008).