A Study of Electronic Descaling Technology to Control Precipitation Fouling

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ABSTRACT

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The objective of the present study is to study the fundamental mechanism of an electronic descaling (ED) technology, an innovative technique to control precipitation fouling in a heat exchanger. The ED technology utilizes a time-varying signal to create ionic agitation, resulting in the precipitation of the scale-causing ions into insoluble crystals, such that fouling can be prevented.

The ED technology involves basically three different disciplines, which are water chemistry, electromagnetic theory, and heat exchanger knowledge. The present study proposed a theory of the ED technology and examined various parameters which influence the performance of this technology.

In order to prove the hypothesis of the ED technology, the crystal growth of $CaCO_3$ in water samples (both untreated and treated) was observed using a microscope. The untreated water sample showed a large number of small crystals within a range of 1 to 10 μm in diameter, whereas the water sample treated by the ED technology showed a small number of large crystals ranging from 10 to 20 μm in diameter. Large crystals are more likely to move with bulk flow, instead of adhering onto a heat transfer surface.

Tests were also conducted to examine the feasibility of reducing hardness of water by removing precipitated $CaCO_3$ particles by a filtration

method. The batch test results showed that when the ED treatment was used without mixing, the total reduction of alkalinity was only 3%. When the ED treatment was applied together with mechanical mixing, an 18% reduction of total alkalinity was found. Such results indicated that the ED treatment greatly promoted $CaCO_3$ precipitation from water when mixing was present.

Fouling reduces pipe opening, increases pressure drop across a heat exchanger, and decreases heat transfer coefficient. A series of tests were also conducted in a single-tube heat exchanger to confirm whether the ED technology can prevent fouling or not. Artificial hard water of 1,000 ppm as $CaCO_3$ was used throughout the tests. The pressure drop obtained with the ED treatment was approximately 51% less than that without the ED treatment, and the asymptotic heat transfer coefficient obtained with the ED treatment was approximately 12% larger than that without the ED treatment. When the ED treatment was used together with a filter, precipitation fouling was almost completely prevented even for the harsh fouling conditions tested in the present study.

Curriculum Vitae of Young I. Cho

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EDUCATION

Ph.D. -1980, Mechanical Engineering, University of Illinois, Chicago
M.S. -1977, Mechanical Engineering, University of Illinois, Chicago
B.S. -1972, Mechanical Engineering, Seoul National University, Korea

PROFESSIONAL BACKGROUND

Professor Young I. Cho joined Drexel University in the Fall of 1985 as a tenure-track assistant professor, was promoted to associate professor in 1987, and to full professor in 1992. Since he joined the school, he has developed a non-Newtonian fluid dynamics laboratory and has initiated the investigation of a new electronic anti-fouling technology to prevent and remove scales from various heat exchangers.

In 1986 and 1989, he served as one of US delegates to the US-Korea Heat Transfer Conference and Fluid Flow Conference both sponsored by NSF held in Seoul, Korea. He received two NASA Space Act Tech Brief Awards (NPO-17237) and (NPO-16593) for his work on the flow visualization of tip vortex generated by a helicopter rotor blade. He was the recipient of the 1992 Lindback Award for excellence in teaching at Drexel University. In 1993, Dr. Cho was nominated by U.S. DOE and elected as the chairman of the Advanced Fluid Committee under International Energy Agency. In 1995, he was the recipient of the Research Professor of the Year at Drexel University.

During the summer of 1986, he had a Summer Faculty Appointment at the Argonne National Laboratory, IL, to work on a Department of Energy project to develop an advanced degradation-free non-Newtonian fluid. During the summer of 1990, he worked as a Summer Faculty at Newport News Shipbuilding to investigate the automated grease lubrication problem in the design of the Navy's underwater vehicle.

Prior to joining Drexel University, he spent four years at the Jet Propulsion Laboratory, California Institute of Technology, as a Member of the Technical Staff. At JPL he was involved in a number of experimental and analytical investigations in the field of heat transfer, fluid mechanics, acoustics and energy. Included was the development of an acoustic steam flowmeter for the Department of Energy (Office of Industrial Program) and a study of aircraft cabin fire during crash landing for FAA.

Professor Cho has authored/co-authored approximately hundred fifty papers in the area of heat transfer, fluid mechanics, rheology, acoustics, combustion and energy. He is a reviewer for ASME Applied Mechanics Reviews, J. of Heat Transfer, International Journal of the Heat and Mass Transfer, AIChE Journal, J. of Biomechanics, J of Biomechanical Eng., AIAA, and Chemical Engineering Communications. He is an editor for *Handbook of Heat Transfer* (McGraw Hill, 3rd ed.) and an associate editor for the *Advances in Heat Transfer* (Academic Press).

He has been cited in Who's Who in the East, Who's Who in the American Education, Who's Who in Science and Engineering, Who's Who in the Emerging Leaders in the World, Who's Who in America, and Who's Who in the World.