Thesis Title	Corrosion Protection on External Surface of a Thermosyphon Economizer by an Enamel Coating
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Abstract

The purpose of this paper is to study the effects of using enamel as a protection from corrosion on thermosyphon economizers. The thermosyphons used in the experiment were made of mild steel tubing with an outside diameter of 26.7 mm and a wall thickness of 2.87 mm, and copper tubing with an outside diameter of 28.5 mm a wall thickness of 1.27 mm, and all thermosyphons used in this experiment were 900 mm in length. The length of the evaporator section was 695 mm ,the adiabatic section was 10 mm and the condenser section was 195 mm. These tubes were grouped into four sets. Each set consisted of an uncoated and coated steel thermosyphon and an uncoated and coated copper thermosyphon, which were coated with three different coating thicknesses of enamel on the evaporator section. The coated sample pieces made of the same material with a 25.4 mm diameter, were prepared separately and were attached to both sides of each thermosyphon, the faced side (for direct impact

from exhaust gases) and the lee side, in order to test the effect of corrosion from the flow of exhaust gases. The test was done using exhaust gas burned at a temperature of 225°C, generated from a mixture of heavy A grade fuel and 20% diesel by volume. The experiment was conducted 16 hours a day for a total of a 1,000 hours. Data was recorded from the heat transfer, the different temperatures of the economizer, the thermosyphon's corrosion, the fouling and the sample' s weights at 250, 500, 750 and 1,000 hours. The corrosion was analyzed by photographs taken by a 25 X optical microscope. The inorganic and organic compounds in the fouling were analyzed by an X-ray defractometer and an Infra-red spectroscope. The fouling thickness was obtained from measuring the surface of the thermosyphon and the average rate of fouling obtained from the increased weight of the samples. The thermal resistance of the economizer taken at regular intervals was used directly to analyze the fouling thermal resistance. The economic viability of the thermosyphon was then considered. It was found that neither the positioning of either facing nor the thickness of the enamel coating affected the corrosion, the fouling thickness, or the average rate of fouling. On completion of the experiment, the corrosion of the coated mild steel thermosyphon and the coated copper thermosyphon was found to be less than the uncoated thermosyphons of 0.15 mm and 0.136 mm respectively. The inorganic compound found in the fouling on the thermosyphon's surface was $CaSO_4$. However, there was no organic compound found in this investigation. Thus the fouling on the thermosyphon's surface did not depend on the material used in the tubes production, the coating or the operational time. Concerning the corrosion, it was found that the correlation between corrosion and time of the uncoated mild steel thermosyphon and the coated mild steel thermosyphon is $Cr = 0.008t^{0.4578}$ and $Cr = 0.0073t^{0.2431}$ respectively, the correlation between corrosion and time of the uncoated copper thermosyphon and the coated copper thermosyphon is $Cr = 0.0231t^{0.2938}$ and $Cr = 0.03474t^{0.202}$ respectively. In the case of the average rate of fouling, it was found that the correlation between the average rate of fouling and time of the mild steel thermosyphon and copper thermosyphon is $RW_{fouling} = 18.784t^{-0.9778}$ and $RW_{fouling} = 126.97t^{-1.2373}$ respectively. In the case of the fouling thickness, it was found that the correlation between the fouling thickness and time of the mild steel thermosyphon and copper thermosyphon is $R_{fouling} = 28.6275(1-e^{-0.0018t})$ and $R_{fouling} = 31.3438(1-e^{-0.009t})$ respectively. The equation of the fouling resistance and time is $Z_{fouling} = 0.0925(1-e^{-0.0031t})$. It can be concluded that the most cost effective tubing used in a thermosyphon at temperatures between 150 - 250°C was made of mild steel or copper with a thickness of 190 microns.