A Study on Cavitation Erosion Behavior of Different Metals in Biomass Fuel/Diesel Blend

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ABSTRACT

The cavitation erosion behavior of different metals, such as pure copper (Cu), steel GCr15 (ASTM A295) and stainless steel 1Cr18Ni9Ti (ASTM A276 321), in the emulsified biomass fuel/diesel (10wt% biomass fuel in blend with diesel fuel) was investigated by using a magnetostrictive-induced cavitation vibratory apparatus. The morphology of surface was observed by optical microscope and scanning electron microscope, and the cavitation erosion rates of three metals were evaluated by mass loss method. The surface compositions after cavitation erosion were analyzed by energy-dispersive X-ray spectroscopy. The experimental results showed that the surface morphologies and elements of Cu and GCr15 were changed greatly before and after cavitation erosion in the emulsified biomass fuel/diesel blend, as contrast to 1Cr18Ni9Ti. The degree order of cavitation erosion among three metals was Cu, GCr15 and 1Cr18Ni9Ti, because that the anti-corrosion effect of 1Cr18Ni9Ti played a great role in the mass loss by cavitation erosion.

Keywords: Cavitation Erosion, Emulsified Biomass Fuel/Diesel, Erosion Pit, Mass Loss, Metal

1. INTRODUCTION

Cavitation erosion is a common phenomenon in modern high-speed flow systems, such as turbo-machinery, pump, water turbine, marine propeller, and the diesel engine (Abouel-Kasem & Ahmed, 2008). Cavitation occurs when pressure drops below the saturated vapor pressure of the liquid, consequently resulting in the formation of gas filled or vapor filled bubbles. When bubbles encounter a high-pressure zone, a large pulse of stress is generated and this is often accompanied with a high velocity jet of liquid that impinges the solid surface (Kwok, 2008).

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According to literatures, there are several types of devices and techniques that have been used for collecting data about cavitation erosion in laboratory tests. The vibratory test rigs are the most commonly used for cavitation erosion tests, as reported by Hammit (1980). However, most cavitation erosion experiments were conducted in the distilled water, distilled water with sand and 3.5% NaCl solution (Ahmed, et al., 1994; Fang, et al., 1999, Luo, et al., 2003). There is no any report about the cavitation erosion behavior of metals in the emulsified biomass fuel/diesel blend, which is related the atomization or spraying effect of injection nozzle and pump use life of compression ignition engine.

The biomass-fuel obtained by the fast pyrolysis of straw is an acidic fuel with pH value of 3.4-3.5. It contains a large amount of organic acids, phenol and water. Its application in varied industrial fields may cause corrosion to different metals. In our previous study, the corrosion performances of four kinds of metal (iron, lead, steel and copper) in the biomass-fuel obtained by the fast pyrolysis of straw were studied under different temperatures and different test periods using a simulation corrosion evaluation apparatus of internal-combustion engine fuel. The experimental results showed that iron and lead were corroded seriously by biomass-fuel, while the corrosion of AISI 1045 steel and copper was much smaller. Layers of oxide and/or hydroxide were formed on these metal surfaces according to surface analysis (Hu, et al., 2011). Cavitation erosion of GCr15 was observed in the emulsified biomass fuel/diesel blend. Moreover, its cavitation erosion aggravated along with the increasing of biomass-oil in the emulsified biomass fuel/diesel (Wang, 2012).

2. EXPERIMENTAL PROCEDURES

Figure 1 shows that schematics of the ultrasonic vibration cavitation erosion apparatus. The vibration horn performs an axial vibration with the frequency of 20kHz and the amplitude of 60μm. Cavitation tests were carried out in emulsified biomass fuel/diesel with different components. Since the test liquid temperature markedly affects the degree of erosion and impact pressure (Ahmed, 1997), the temperature was kept within 25±2°C by circulating cooling water around the beaker.

Figure 1. Schematics of the cavitation experimental apparatus (1. water inlet, 2. cooling water, 3. container wall, 4. transducer, 5. vibratory horn and sample, 6. breaker, 7. water outlet, 8. ultrasonic generator)
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