Wear Measurement of Valve Assemblies by using the Machine vision

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Abstract: Engine performance depends upon wear of valves and seat inserts. To improve quality and life of valve assemblies, wear mechanism and 3D surface topography should be analyzed according to operating conditions. After developing an engine simulator that generates valve speed up to 90Hz and high temperature up to 900°C as well as controls test load, wear tests have been conducted for two different operating conditions. In order to observe the wear characteristics of the valve assemblies, a cost-effective measurement system based on the shape from focus (SFF) has been fabricated in this paper. 3D surface topography of the valve assemblies has been analyzed to understand the wear behavior according to the operating conditions.

Keywords: Machine vision, Shape from focus, Valve and seat wear, Wear measurement, 3D topography

1. Introduction

Performance of vehicle engines is evaluated from several criteria such as power output, durability and fuel economy. Manufacturers invest a lot of money and time to improve fuel economy and engine power, as well as to reduce emission. Major component of the engine that affects above problems is the valve assembly composed of a valve and a seat insert.

Wear of the valve assembly is observed in various ways according to the operating conditions of engines. Condition monitoring of wear mechanism of the valve assembly is important to produce high quality engines. However, as the valve assembly is small and has a groove, wear measurement of the valve assembly is very difficult. In order to measure wears of the valve assembly, measurement systems such as SEM and confocal microscopes have been used(3-5). However, these measurement systems are expensive and impossible to apply in the rugged factory.

In this paper, a machine vision technique using a SFF method(6,7) is applied to measure surface wear on a precision servo-stage. A novel illumination unit fabricated with LEDs and halogen lamps is devised to obtain clear images and reduce noises due to reflection. Wear experiments of the valve assembly are conducted on the engine simulator according to engine operating conditions. Visual and parametric characterizations have been studied to analyze wear behavior of the valve assembly(5).

2. Wear Test Apparatus and Valve Assembly

The valve assembly wear simulator used for the wear experiments has been fabricated, which is similar to an internal combustion engine(8). The engine simulator consists of three modules: a hydraulic power unit, a control unit and a mechanical unit. The hydraulic unit simulates combustion pressure of engines to regulate the wear simulator pressure and transmit force to the valve head. The control unit composed of a computer, signal generator, data acquisition system, etc. It controls experimental conditions such as the force imposed to the valve head, seat insert temperature, distance between the valve and the seat insert, and so on.

Actual valve assemblies are used for experiments. Valves are made of STR35. HVS1-2 is used for seat inserts. Hardness of the valve is 419 (HV500g) and of the seat insert is 397.7 (HV500g). Fig. 1 shows the valve and seat insert geometries.

![Fig. 1 Geometries of the valve and seat insert.](image)

Wear experiments are conducted for two engine speeds, 10Hz and 25Hz. Temperature conditions are