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Effect of input energy on the emission of a motorcycle engine with an electrically heated catalyst in cold-start conditions

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Abstract

Experimental investigation on the cold-start condition of an electrically heated catalyst of a four-stroke motorcycle engine was carried out at idle operation. The effects of input energy from heaters and unburnt gas oxidation on the exhaust temperature and the exhaust emission were investigated.

Apart from heating temperature and the CO setting level, the other studied parameters included the heating position and input energy. The heating temperatures included 100, 140 and 180 °C and the CO levels were set as 1.0%, 1.3%, 1.8% and 2.3%. Six different heating positions were adopted.

The experimental results showed that at high CO setting levels, less heating energy was required from the heaters to induce self-initiated reaction of the catalyst. It was also observed that a high total input energy led to a high CO conversion efficiency. Heating at the inlet of the catalyst has also the same effect. When a high heating temperature was coupled with a high CO setting level, self-initiated reaction of the catalyst was easily achieved.
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Keywords: Total input energy; Heating energy; Catalyst; Cold start

1. Introduction

Motorcycles have been the most popular short distance transports in Taiwan for over two decades, with the national production volume ranking fourth in the world. Emission from

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Nomenclature

c_p	specific heat at constant pressure
E_{heat}	heat produced by heaters
E_{CO}	heat dissipated from the oxidation of the CO gas
h_{CO}	enthalpy of reaction of the CO gas
$\dot{m}$	total mass flow rate through the exhaust pipe
$\Delta\bar{m}_{CO}$	mass reduction of the CO gas before and after passing through the catalyst
P	heating power
$\dot{Q}_{heat_gas}$	heat rate transferred to the exhaust gas
t	time

motorcycle is well known to be a serious cause of environmental pollution. For the past few years, the main research focus in Taiwan has been on the study of emission reduction strategies [1–5]. However, the introduction of the new regulation in 2004 on the cold-start emission of motorcycles by the Taiwan Environmental Protection Administration (EPA) will see a radical change in research directions. The main focus will be on the improvement to the emissions during cold start of the motorcycle engine as poor exhaust emissions are caused by the inadequate mixing of the fuel and air and incomplete combustion during engine warming-up period.

Nationally published literature on the research on the cold-start conditions of an engine is still sparse. Horng et al. [6–8] investigated the emission characteristics of four-stroke motorcycle engines with electrically heated catalyst during cold start. It was revealed that pre-heating the catalyst during cold start with a high CO level can improve the time to achieve the reaction temperature of the catalyst. The emission, as a result, can also be significantly improved. In the international scene, Boam et al. [9] studied the source of the hydrocarbon (HC) emissions during cold start and warm-up periods on automotive engines. Ludykar et al. [10] ran a three-way catalyst car at three different temperatures (22, −7 and −20 °C) to study the emission characteristics under cold start. Umehara et al. [11] used the retardation of the ignition angle to increase the exhaust gas temperature for re-activating the reaction of the unburnt fuel in the exhaust pipe, which reduced the emission pollution of an engine after cold start. Joumard et al. [12] studied the influence of driving cycles on the emissions from petrol or diesel engines. They found that emissions were not stabilized and were still cold even after the vehicle had traveled 3.5 km. Lafyatis et al. [13] proposed a method for rapid increasing of engine temperature after cold start. The strategy was to raise the CO level in the exhaust by adding the CO to the exhaust stream. The oxidation reaction of CO enabled the catalyst to reach the operating temperature rapidly. Kirchner and Eigenberger et al. [14] developed a mathematical model to study the cold start characteristics of an automotive catalytic converter. The relevant geometrical parameters and the approximate heating strategy were presented.

In the study, a 150-cm^3 four-stroke motorcycle engine operated at idle conditions with an electrically heated catalyst was investigated. The effects of heating temperature, the CO setting level, input energy and heating position, on the reaction characteristics of catalyst in the cold-start conditions were carried in the experiments.

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