

**UNIVERSITI TEKNOLOGI MARA**

**EFFECTS OF ISO-BUTANOL  
ADDITIVES IN ETHANOL-  
GASOLINE BLEND (E10) ON  
ENGINE PERFORMANCE AND  
EXHAUST EMISSIONS OF A MULTI-  
CYLINDER SPARK-IGNITION  
ENGINE**

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## ABSTRACT

Modern life requirements have been related to the increased of energy consumption, in which major part of the consumption is focusing on the automotive industries. Limited sources of fossil fuel and increasing concerns on environmental issues due to the high emissions of unburned hydrocarbon (HC), carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>) have attracted the attention of researchers and scientists to investigate alternative fuel, especially alcohol. One of the familiar names in the alcohol group is ethanol; a two carbon chains alcohol with a high oxygen content and latent heat of vaporization. Vast research studies in recent years have been triggered to examine the feasibility of ethanol as a blended fuel with pure gasoline at a different blend ratios and varieties of engines' operating conditions to find the optimum results in spark-ignition (SI) engines. It was found from literatures that there is still improvement need to be performed due to the low calorific value of ethanol. Thus, this study aims to examine the properties of iso-butanol additives at three volume percentages; 5%, 10% and 15% in E10 blended fuel denoted as E10B5, E10B10, and E10B15, respectively. An experimental characterization for the properties of calorific value, kinematic viscosity and density for the fuel samples was carried out according to the specified standard methods of ASTM D240, ASTM D445 and ASTM D4052, respectively. The results of kinematic viscosity and density showed an increasing pattern for the iso-butanol additives in E10 fuel blend compared with those of E10 fuel blend and pure gasoline fuel, while showing a decreasing pattern for the results of heating value. In terms of engine testing operation, the investigation was conducted using a four-cylinder, four-stroke, naturally aspirated, SI engine at half and full open throttle position with a wide range of engine speed from 1000 to 5000 rpm. The results of engine brake power exhibit an improvement for the iso-butanol additives in E10 fuel blends with the maximum results were obtained by 15% addition of iso-butanol when compared with those of E10 fuel blend and pure gasoline fuel. Moreover, brake thermal efficiency (BTE) of those iso-butanol additives in E10 fuel blend shown a significant improvement with reduction of brake specific fuel consumption (BSFC) were recorded. In describing the emission characteristics for the tested fuel samples, the emission of carbon monoxide (CO) and hydrocarbon (HC) were all reduced; except for carbon dioxide (CO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>), with the addition of iso-butanol additive compared to those of E10 fuel blend and pure gasoline fuel. The increment of NO<sub>x</sub> emission can be attributed with the results of exhaust gas temperature (EGT), in which the fuel samples of iso-butanol additives in E10 fuel blends recorded a higher result than those of E10 fuel blend and pure gasoline fuel. Hence, it can be concluded that the iso-butanol additives are a feasible option to be added into a lower ratio of ethanol-gasoline fuel blend in the operation of spark-ignition engines.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 OVERVIEW

Modernization has closely interwoven with the increasing demands of energy supply which has been largely consumed for transportation, industrial facilities and manufacturing [1]. Moreover, reserves of fossil fuel, natural gas and coal were estimated to run out in the next 50, 63 and 218 years, respectively [2, 3]. Limited supply from conventional fuel has grown the interest of applying non-conventional fuel from various renewable energy sources such as alcohol fuel, vegetable, fish and waste cooking oil to maintain the energy security issues [4-7]. In addition, the combustion of conventional fuel has brought adverse effects on environment and health care [8, 9]. The main concern for the environmental issues are the emitted greenhouse gases such as carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>) and unburnt hydrocarbon (UHC) [10]. Figure 1.1 shows the total share of largest CO<sub>2</sub> emissions from top 10 countries [11]. Annually about 25 billion tons of CO<sub>2</sub> produced worldwide by anthropogenic activities [12] which it can bring serious impact on climate changes and global warming [13, 14]. In relation to this situation, it has been reported that increase in average temperature of 2°C will cause in millions of peoples' death [15].

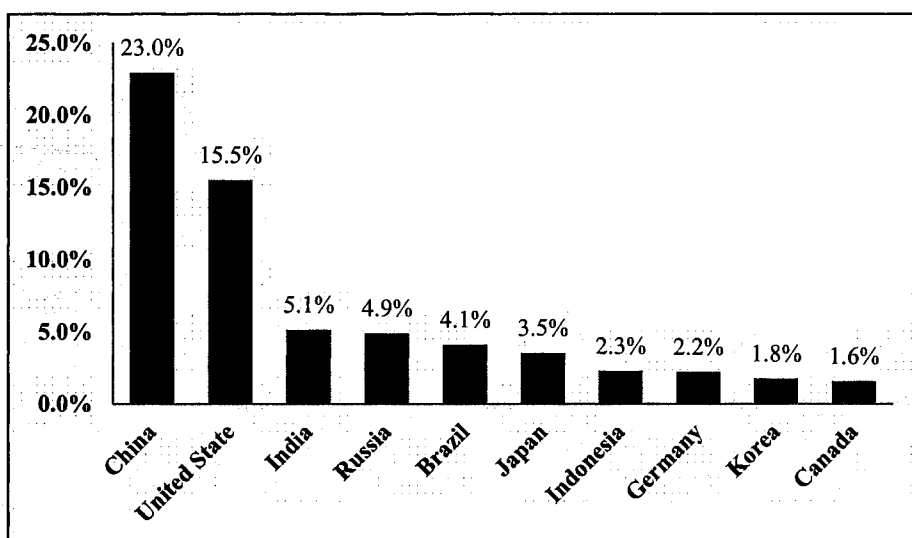


Figure 1.1: Top 10 countries with the largest CO<sub>2</sub> emissions in the world [11]