Optimum combustion chamber geometry for a compression ignition engine retrofitted to run using compressed natural gas (CNG)

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Abstract. The use of natural gas as an alternative fuels are motivated from the impact in deteriorating quality of air and the energy shortage from petroleum products. Through retrofitting, CI engine runs on CNG, will be able to reduce the negative impact mainly on the use of petroleum products. However, this required the modification of the combustion chamber geometry by reducing the compression ratio to value that suits combustion of CNG. In this present studies, four different shapes and geometries of combustion chamber were designed and simulate using CFD package powered by Ansys workbench, where k-ε turbulence model was used to predict the flow in the combustion chamber. The results of turbulence kinetic energy, velocity vectors and streamline are presented. The enhancement of air-fuel mixing inside the engine cylinder can be observed, where the design with re-entrance and lower center projection provide better results compared to other combustion geometries designs.

Introduction

Diesel engines are widely used in industrial applications and as vehicular power sources [1]. In the mechanized and fast-moving forward world of today, the consumption of petroleum products has become an important yardstick of a country’s prosperity. This ever increasing consumption has led the world to face the ever-increasing twin challenge of energy shortage and environmental deterioration [2-4]. These are the main reasons for exploring alternative fueling, which are abundantly available and less polluted in nature. Natural gas (NG) or commonly known as compressed natural gas (CNG), has been one of the highly considered alternative fuel that is gaining increasing acceptance in the transportation sector due to its advantages and benefits. The benefits of using CNG include lower fuel cost, lower maintenance cost and produces cleaner combustion by products. The operational cost is one third of vehicle running on petrol [5]. Therefore, CNG has been identified as a leading contender for transportation application [6-7] especially for vehicle fleet operators: logistic and haulage companies.

In Malaysia, most of the logistics and haulage companies are using diesel fuel and compression ignition (C.I.) engines to propel their small-duty until up to prime mover vehicles. Therefore, for those companies to gain additional economic will benefits, retrofitting their fleets with mono-gas CNG system will be the best option to take. Through retrofitting, the CI engines run using CNG, will still provide beneficial option of still operating their existing CI. engines fleet. However, modification of the combustion chamber geometry is required to reduce compression ratio to value that suits combustion of CNG [6].

The combustion chamber usually characterized by a re-entrance bowl (toroidal shape), depth of piston and piston bowl throat diameter [8-10]. Most of the literatures concerning re-entrance chambers and injection characteristics have been conducted for the C.I. engines. There are few studies on the effect of combustion chamber geometry in medium and small engine running using CNG. The aim of the present investigation is to illustrate an innovative methodology based on numerical method to optimize combustion chamber geometry for retrofitting a dedicated mono-gas