Development of 3-cylinder composite engine: Analysis on strength and fuel efficiency

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ABSTRACT – Engine is the important part of automotive industry. From time to time, all automotive manufacturer tries to develop the very powerful engine due to high demand of performance of the engine. Basically, vehicle performance from speed analysis is depend on the weight of vehicle. Reduction on weight can give the best fuel efficiency. Averages car engine without the transmission system weights is about 158 kilograms. To give an example of typical weights, a small car engine and transmission weights around 151 kilograms, and a large car engine with transmission weights around 272 kilograms. Development of composite engine can reduce the weight about 30 - 40%. the type of composite material use in this research in fiber-reinforced polymer.

1. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties. Composites are formed by combining materials together to form an overall structure with properties that differ from the sum of the individual component. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons, which are stronger, lighter, or less expensive when compared to the traditional materials. There are two main categories of constituent materials which is a matrix and reinforcement. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcement's material imparts their special mechanical and physical properties to enhance the matrix properties. Currently, there are so many type of composite materials such as mortars, concrete, reinforced plastics (fiber-reinforced polymer), metal composites and ceramic composites.

The use of composite material has been grown up because of their improvement properties over conventional material. Composite have high specific modulus and also the strength similar with the steel material. Otherwise, the composite is lighter and because of that, they can improve of fuel efficiency. The core of the engine is the cylinder, with the piston moving up and down inside the cylinder. The engine described in my research has three cylinder. That is typical of most lawn mowers, but most cars have more than three cylinder such a four, six and eight cylinders. In a multi-cylinder engine, the cylinders usually are arranged in one of three ways which is inline, V or flat [1].

The application of modern systems for pollution protection increases the mass of the vehicles which require the use of new (lighter) materials for the manufacturing of the engine and its constituent elements. The engine weight reduction leads to a decrease of fuel consumption, and therefore the environmental pollution. For production of engine blocks, cylinder liners, connecting rods, crankshafts and camshafts, the conventional material are commonly use such an aluminum, magnesium, titanium and their alloys. Engine parts, such as the cylinder casing, could shed up to 20% of its weight if it were made of fiber-reinforced plastic rather than aluminium, without additional costs.

A car's powertrain system, which includes the engine, accounts for a large proportion of the vehicle's weight. Until now, car makers have relied on aluminium to reduce the weight of engine components such as the cylinder block. However, in the future, car manufacturers will be able to achieve further weight savings by designing cylinder blocks in which certain parts are made of fiber-reinforced plastics. The materials used have to be able to withstand extreme temperatures, high pressure and vibrations without suffering damage. Depending on the application need, how the new composite material is to be fabricated and used to solve the performances issues is the main focus of this research.

2. METHODOLOGY

There are so many focus on research about composite material in automotive component. The objective of all researcher done for composite analysis is to reduce the weight then increase the performance. In automotive industry, composite material already uses in the external part, such a bumper, dashboard and accessories part. However, for engine part, conventional material like cast iron and aluminium was use due to the high temperature and strength. With new technology, the usage of composite material in engine part can be apply with some research from automotive manufacturers.

The paper written by Lee [2] describes the development of a hybrid valve lifter composed of

composite and steel for use in a valve train in an automotive internal combustion engine. Valve lifter is a mechanical part that transmits the motion of the camshaft to the rest of valve train. Conventional valve lifter is produce from steel and aluminium and the weight is about 0.048kg. The weight of prototype hybrid valve lifters is 0.017kg. The composite hybrid valve lifter is separate into two pieces, which is steel cap and composite skirt. The important thing to consider and control is the method to join the steel cap and composite skirt. There are too many process of joining between two materials. The researcher uses the interference fit by radial interference as a method to assemble both two material parts. The tests showed that hybrid valve lifter were sufficiently durable to withstand the test loads.

The paper written by Tiruvenkadam et al. [3] was presented about the development a material to replace the current conventional cast iron cylinder liner (CL) with an improved performance and reduced emission biodiesel engine. They divided the experiment into two section. The first section is discussed about the Al nano hybrid composite sample preparation and selection based on frictional characteristics analysis. The second section is discussed about the development of a lightweight NL using suitable sample. They also tested the sample under real time experiment to find the accurate data. During the experimental process, they completed it by follow the relevan step include matrix and reinforcement' s preparation, fabrication of nano hybrid composite, photomicrograph examination, evaluation of tensile strength, pin on reciprocating plate test and plan experiments. At the end of this research, the percentage reinforcement and sliding distance do not affect the friction coefficient of the fabricated composite sample. Otherwise, the tensile strength and coefficient of friction are the most important properties for NL to reduce energy losses.

The paper written by Arsha et al. [4] was presented investigation aims at design, fabrication and evaluation of functionally graded automotive piston using in-situ primary silicon reinforced A390 aluminium composite by centrifugal casting technique with a view of obtaining improved thermo mechanical properties at specific locations. The dies are designed and fabricated so as to obtain the primary silicon rich region towards the head portion of the piston. FGM pistons with A390 and A390-0.5%Mg are produced. They are characterised along the vertical cross section of the piston from piston head towards the skirt by microstructural, chemical, mechanical, thermal and tribological characterisations methods. The results are also compared with that of gravity cast piston. Microstructure and chemical composition analysis of FGM piston shows graded distribution of primary silicon from the head portion of the piston towards skirt and a eutectic composition in the skirt region. That yields an increase in hardness towards the head region. The wear testing revealed that the gradation also resulted in a remarkable enhancement of the wear properties of the piston head.

The paper written by Hayashi [5] was discussed about the application of metal matrix composite (MMC) in engine cylinder blocks and also brake disks. The researcher designed the cylinder block with cylinder bore reinforcement by alumina and carbon fibers. Basically, there have to way to produce MMC by using new intermediate-pressure die-casting (NDC) method and another one is high-speed, high-pressure die-casting (HPDC) method. Then, the researcher **uses** the conventional HPDC for MMC cylinder block production due to the accelerated application problem. The HPDC product show a value several points higher than its predecessor. Then, the MMC cylinder block allow the combination of high performance with weight reduction compared to the conventional cylinder block. Conventional brake disks id designed from cast iron material. The researcher developed the aluminium MMC disk brake to achieve a reduction in weight. He **uses** an infiltrating method to produce MMC disk brake. From the test result, the MMC disk brake have advantages. Even, with weight reduction, the MMC disks brake have a good cooling performance. It also **has** high stability against deceleration and temperature. Then, the MMC disk brake can improved resistance to brake judder. It also easy to design, which is can prevent brake noise.

The paper written by Ashori [6] was discussed about wood plastic composite (WPC) which is a very promising and sustainable green material to achieve durability without using toxic chemicals. WPC refers to any composites that contain plant fiber and thermosets or thermoplastics. In comparison to other fibrous materials, plant fibers are in general suitable to reinforce plastics due to relative high strength and stiffness, low cost, low density, low CO_2 emission, biodegradability and annually renewable. Plant fibers as fillers and reinforcements for polymers are currently the fastest-growing type of polymer additives. From a technical perspective, these bio-based composites will enhance mechanical strength and acoustic performance, reduce material weight and fuel consumption, lower production cost, improve passenger safety and shatterproof performance under extreme temperature changes, and improve biodegradability for the auto interior parts. Automotive components including plant fibers are currently being used by many vehicle manufactures. The researcher found the problem due the poor compatibility exhibited between the fibers and the polymeric matrices. However, the researcher solves the problem by chemical coupling and compatibilizing agents. This researcher of WPC that only use for external component of automotive part such front and rear door linens, boot linens, seat back, sunroof sliders and headliners. There is no discussed about the potential of WPC into engine part [7].

The potential automotive parts suitability from various composite materials are engine block, pisto, crankshaft, camshaft.

3. SUMMARY

In this project of develop the 3-cylinder composite engine that can reduce the weight about 30 – 40%. The MMC engine block already designed according to the T. Hayashi. But in this research, the researcher tries to develop engine block by using fiber-reinforced polymer that can give lighter engine block. Otherwise, the piston,

connection rod, crankshaft and camshaft also will develop using the fiber-reinforced polymer. The materials used have to be able to withstand extreme temperatures, high pressure and vibrations without suffering damage. This is done properly with strength analysis.

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