The two-stroke swivel motion engine performance using the lotus engine simulation software

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Keywords: Engine, performance, analysis

ABSTRACT – This work simulates the two-stroke swivel motion engine configuration using Lotus Engine Software (LES). The LES is one of the popular engine simulation packages. The two-stroke swivel motion engine was a novel engine designed in 2003. The study works by simulating the single-cylinder engine and then compared the output with previous study that was done using GT-Power simulator. The study suggests both software show similar output trend in brake power and torque. However, LES predicts a better result for the brake specific fuel consumption or BSFC. Hence, using software is excellent in teaching the performance of the internal combustion engines.

1. INTRODUCTION

There are two types of reciprocating internal combustion engines, namely, two-stroke and four-stroke. A four-stroke engine would make 2 revolutions to cover four actions that are intake stroke of air and fuel, compression stroke of the mixture towards a spark plug, combustion that produces power stroke, and lastly the exhaust stroke where the gas is pushed out. The engine is complex with many subsystems including lubrication and cooling. A two-stroke is much simpler. The intake and compression happen in the first stroke, followed by the second stroke of power and exhaust. All that happen in one complete revolution. The main problem has always been the presence of various pollutants in the emission mostly due to incomplete combustion.

New designs of two-stroke engines are on the rise to solve this problem. To aid this, commercial engine simulation packages could predict engine performances. Two-stroke swivel motion engine was studied by Shamsudin [1] to understand the performance of the novel design. This swivel-motion engine design shown a good performance in term of power and torque output. The research was done using GT-Power, a commercial code for engine simulation. In this study, simulation packages, Lotus Engine Simulation will be used to test the swivel motion engine. The results will be compared to the result obtained by Shamsudin [1].

Chan et al. [2] reviewed engine simulation software for control system development. Their study utilize several commercial codes, Ricardo WAVE and Lotus Engine Simulation and one in-house developed package. Lotus Engine Simulation was developed by Lotus Engineering which process in two module, which is data module and solver module [3]. Meanwhile, Ricardo-WAVE [4] is an engine simulation package that is designed to analyze and simulate the dynamics of engine pressure waves, mass flows and energy loses.

Duleba [5] stated four commonly used engine simulation package are Ricardo WAVE, LES, GT-Power and AVL FIRE. The packages are quite comparable where input parameters are used to simulate engine performance in a holistic fashion.

2. SIMULATION

The cylinder shape is defined by the geometry of the combustion chamber. It is also to specify geometric surfaces and volume zones used for heat transfer and combustion sub models. The combustion chamber volume is dictated by the engine geometry that include the bore, its stroke, the connecting rod length, as well as the resulting compression ratio. It is also related to the rate of change of cylinder volume and the crank angle.

Piston motion sub-model is used to determine the position of the piston in the cylinder and volume of the combustion chamber as a function of crank angle. Note that this study is meant for two-stroke swivel motion engine, the crank angle is taken as the swivel rotation. The idea of the engine is inspired by another novel engine that is the swashplate engines. The concept is shown in Figure 1.

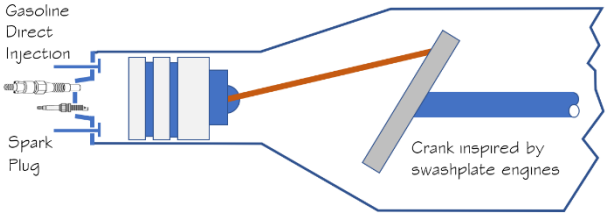

Figure 1 A simple layout of the swivel motion engine.

The combustion model used in this simulation is the default Wiebe model. It is using a single zone for heat release model. During combustion, the released heat will effect the whole combustion area. This will result that the

bulk gas temperature will be lower than the core combusted gas temperature behind the front flame. It may influence the detailed in-cylinder heat transfer but since the semi-empirical heat transfer models make cumulative assumption on heat transfer coefficient and wall temperature, the effects will be minimal. The LES model diagram is displayed in Figure 2.

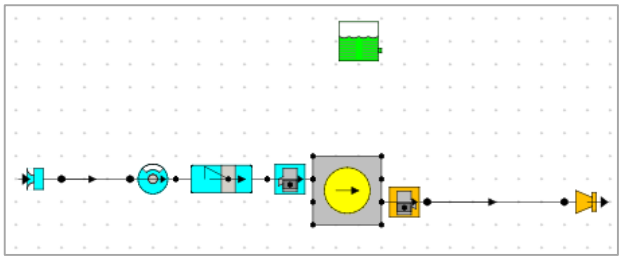

Figure 2 The system setup of the engine in LES.

Analysis of the two-stroke swivel engine has been dependent on Lotus Engine Simulation user's manual and the help menu that is available in the software. However, most of the tutorials in the user's manual are mostly on four-stroke engine. There is only one tutorial mainly discuss on a two-stroke engine.

3. RESULTS

Figure 3 shows that torque and brake mean effective pressure (BMEP) reach its maximum at 6000 rpm while the brake power reach its max at 6500 rpm with value of about 6.5 kW. The brake specific fuel consumption (BSFC) result shows the best fuel consumption is obtained at 6500 rpm.

We could see that similar to brake power, simulation from GT-Power and LES trends are almost similar with both peaked at 6000 rpm. However, the value given by the LES torque output is 29% less than that of GT-Power output.

In terms of value, on average, LES predicted lower values. However, Shamsudin [1] stated that the correct trend should be high value at lower and low value at higher RPM. GT-Power results show its BSFC peaked at 1500 rpm. Amir in [6] also explained that the torque is obtained by measuring the net loading, W with a known radius, R from the axis of rotation.

$$T = WR \tag{1}$$

Hence, the brake power is then given by

$$bp = \frac{2\pi NT}{60000} \tag{2}$$

The torque, T transmitted by driving shaft is measured directly and the brake power is calculated. N is the rpm of the two-stroke engine.

4. SUMMARY

LES have shown similar trends in torque and brake power. LES proved that it is useful to predict every parameter to get the engine performance results.

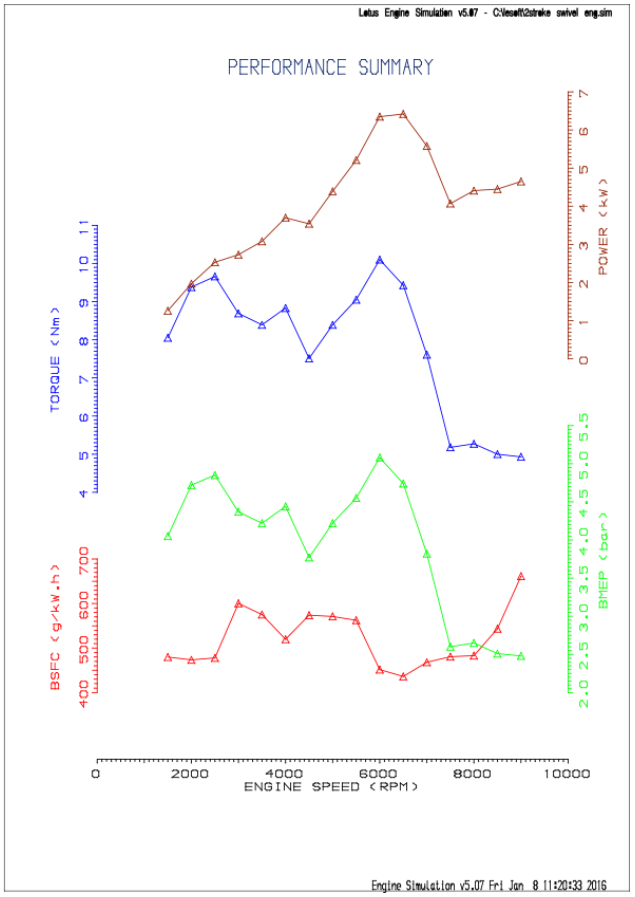

Figure 3 Performance plots of the single-cylinder two-stroke swivel-motion engine using LES.

5. ACKNOWLEDGEMENT

The authors are grateful for the support given by FKM, UTeM and the *Majlis Amanah Rakyat* (MARA). This work was based on the work by Mr. Alifh Omar bin Amir of *Institut Kemahiran MARA* in Bintulu, Sarawak who passed away peacefully on 29 December 2016.

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