Application and Simulation of Atkinson Cycle Engine for the Range Extender

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Abstract: The range extender can effectively improve the driving mileage of the electric vehicle, which is equipped with an engine and a generator. The characteristics of the Atkinson engine are evaluated in this paper. Additionally, Cruise software is used to simulate the performance of the range extender which is composed of an Atkinson cycle engine and a generator. The study has illustrated that the Atkinson cycle engine if used in the range extender can greatly reduce fuel consumption.

1 INTRODUCTION

The range extender is composed of a generator and an engine. It is arranged in a straight line with the battery pack and the transmission system. The traction device of the range extended electric vehicle is made up of three parts: the engine device, the generator device and the motor device. When the vehicle is running, the engine drives the generator to produce electricity, then the controller transfers the generated electricity to the battery or traction motor, and finally drives the vehicle through the transmission system (Zhu Longfei, 2012).

Though the electric vehicle is evolved from the traditional vehicle, the operation mode of the range extended electric vehicle is different from the traditional vehicle. It operates mainly in all-electric mode, with the extended range mode only serving as a supplement. The driving mileage is effectively improved by this mechanism. As the core of the range extended electric vehicle, the range extender works only when the power battery is insufficient. In this way, it always works in the high efficiency zone when activated. The system configuration of the current range extender is similar, but the power source of the generator varies. It is essential to choose an engine which is stable, efficient and environment-friendly.

2 CHARACTERISTIC ANALYSIS OF THE ATKINSON CYCLE ENGINE

Atkinson cycle is the working cycle of the internal combustion engine with high compression ratio and long expansion strokes. It is designed with only one flywheel to drive the crank connecting rod mechanism to achieve 4 strokes (Mehedad Ehsani, 2010).

The implementation of Atkinson cycle technology can greatly improve the fuel economy of the engine. The oil consumption of the gasoline Atkinson cycle engine can reach as low as 200g/kWh, as shown in figure 1. The thermal efficiency of the conventional engine is approximately 30% (250g/kWh) while the thermal efficiency of the Atkinson cycle engine is as high as 36% (200g/kWh), saving about 25% of the oil. The saving credit attributed to compression ratio increase from 10 to 13 is about 15%, while the remaining saving credit attributed to reduction of oil pumping loss is about 10%. If it is used as a utility model engine, the objective of ultra low fuel consumption and low emission can be realized effectively.

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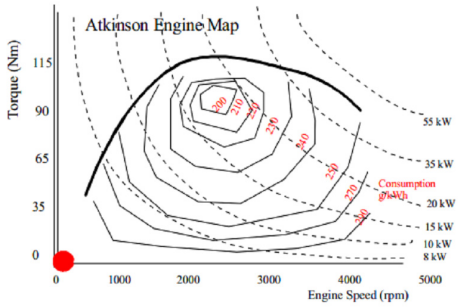

Figure1: Map of the typical Atkinson cycle engine

3 APPLICATION AND SIMULATION OF THE ATKINSON CYCLE ENGINE FOR THE RANGE EXTENDER

In this paper, a small Atkinson gasoline engine and a generator are used as the range extender. The engine performance data is obtained from the bench test. The engine model and the generator model are established in the Cruise, which ensures the high precision of the simulation.

3.1 Engine Model

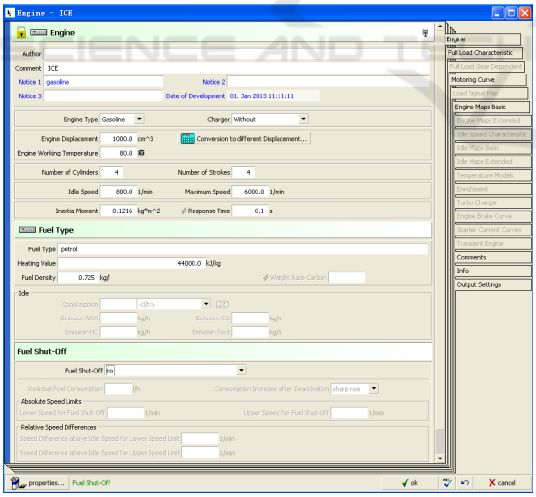

Figure 2: Input interface of basic parameters of the engine module

The parameters that need to be set under the engine module mainly are: engine type, displacement, normal working temperature, cylinder number, idle speed, maximum speed, moment of inertia and fuel parameters (type, calorific value, density) (Dong Xinyang,2012). The input interface of basic parameters of the engine module is shown in figure 2. The engine characteristics are specified by following parameters: engine external characteristic data, engine universal characteristic data, anti-drag characteristics, fuel consumption and emission performance, as shown in figure 3 through figure 5.

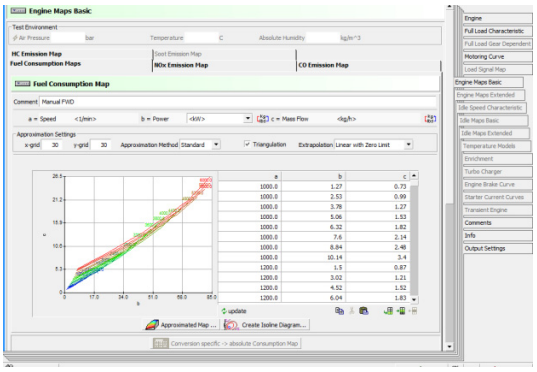

Figure 3: Efficiency diagram of the engine

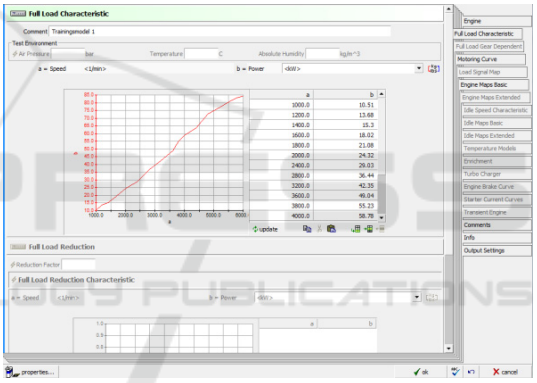

Figure 4: External characteristics of the engine

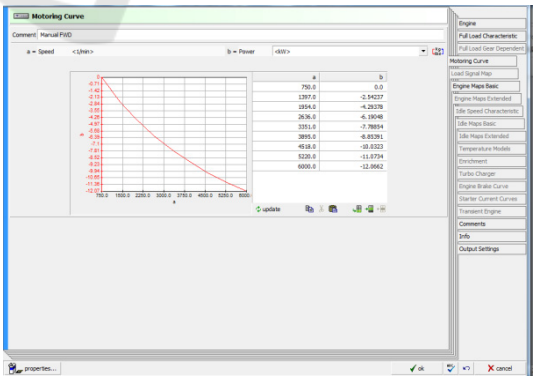

Figure 5: Anti-drag characteristics of the engine

After torque calibration by bench test and emission test, the map of the internal combustion engine of the range extender is generated, in addition to three-dimensional table containing engine load,

speed and fuel consumption rate, as shown in figure 6. The function model of the engine is formulated by putting it into the corresponding module of the Cruise.

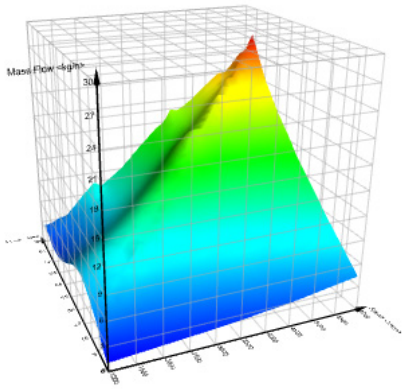

Figure 6: Map of the engine

3.2 Generator Model

The built-in motor module in the Cruise is used as the generator (Zhao Jinlong, 2014), and the input interface of the generator parameters is shown in figure 7 through figure 10 below.

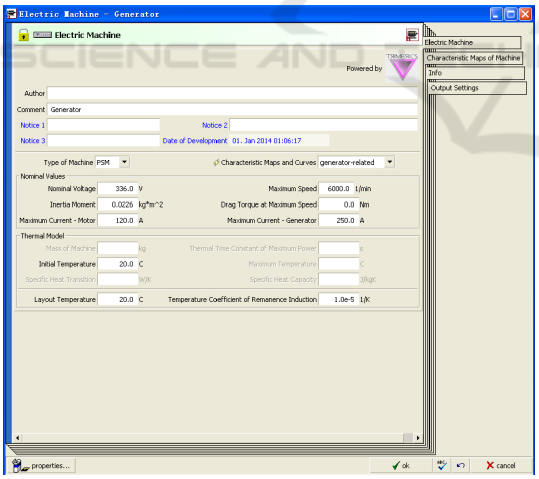

Figure 7: Input interface of the generator parameters

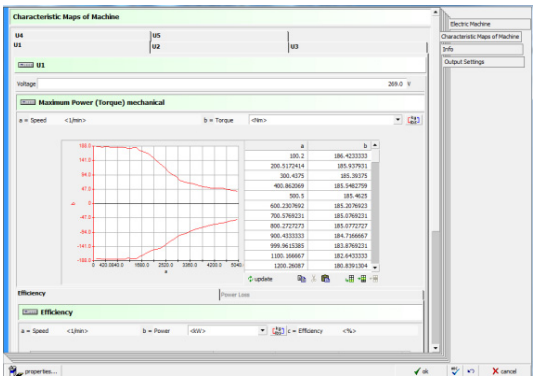

Figure 8: External characteristics of the motor

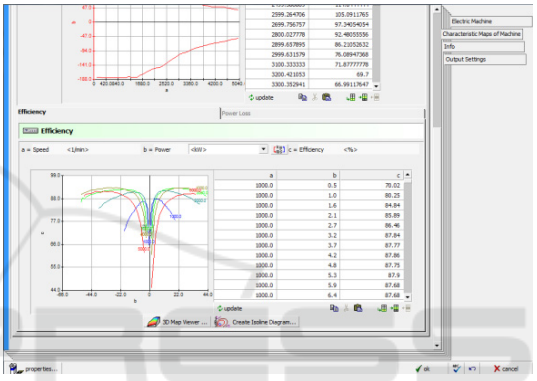

Figure 9: Universal characteristics of the motor

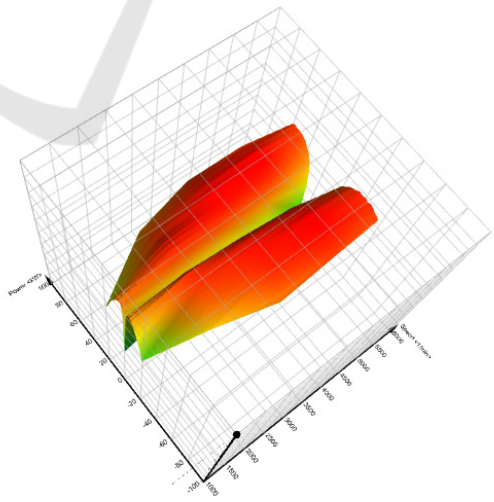

Figure 10: Efficiency map of the generator

4 SIMULATION ANALYSIS

After the simulation test, the fuel consumption curve of the Atkinson engine is obtained as shown in figure 11. It can be seen that the minimum fuel consumption can reach 230g/kWh.

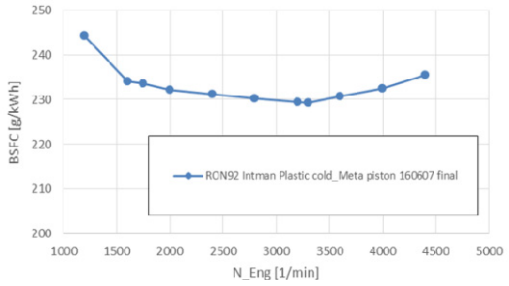

Figure11: Fuel consumption curve of the engine

The external characteristic curve is generated as shown in figure 12 by taking data from the best efficiency working points of the engine (the low fuel consumption point) and setting up the engine working conditions.

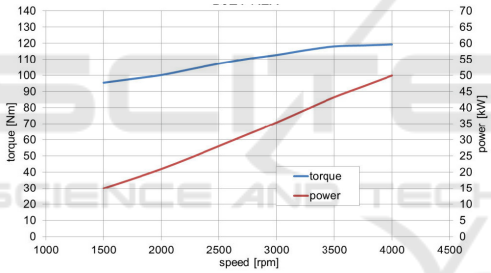

Figure 12: External characteristic curve of the engine

The comprehensive fuel consumption per hundred kilometres (L) (GB/T 19753-2005) is less than 1.9, which is obtained by operating the range extender according to the Atkinson cycle optimal curve.

5 CONCLUSIONS

The study shows that applying the Atkinson engine to the range extender can reduce the fuel consumption, so that the comprehensive fuel consumption per 100 km can reach 1.9 or less by running the engine at the optimal efficiency points.

REFERENCES

Zhu Longfei. Parameters design and performance optimization of the power system of the range extended electric vehicle [D], Hefei, Hefei University of Technology, 2012.

Dong Xinyang. A study of control strategy design and optimization for the powertrain of the range extended electric vehicle [D], Hefei, Hefei University of Technology, 2012.

Zhao Jinlong. Parameter matching and control strategy research of powertrain system for Range-extended electric vehicle [D],ChongQing University, 2014.

Mehedad Ehsani, Yimin Gao, Ali Emadi. Modern electric vehicles, hybrid electric vehicles and fuel cell vehicles -- basic principles, theories and designs (second edition of the original book) Translated by Ni Guangzheng, Ni Peihong and Xiong Suming[M].Beijing, Machine Press, 2010.

Wang Da, Wang Bo. Research on Driving Force Optimal Distribution and Fuzzy Decision Control System for a Dual-motor Electric Vehicle [A]. Chinese Control Conference[C]. Hangzhou: Institute of Electrical and Electronics Engineers, 2015.

Zhang Xiaoling. Simulation and analysis for the power system of the extended range electric vehicle[J], Journal of Chinese Agricultural Mechanization, 2017, 37(6).

Wang Peng. A Study on powertrain matching and optimizing for R ange -extended electric vehicle[J], Computer Simulation, 2016,33(8).