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A Simulation on Series Hybrid Vehicle Energy Management Based on Cruise/Simulink

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ABSTRACT

A United Simulation platform is set up by Cruise and mat lab/Simulink, a rule based on energy control strategy is introduced, and a simulation is conducted on the series hybrid vehicle. The results of the chosen driving cycle show that the simulation platform and control strategy can reduce fuel consumption obviously, and can optimize the performance of the series hybrid vehicle.

INTRODUCTION

Hybrid vehicle [1-2] generally refers to two kinds of driving system which can drive the vehicle running at the same time or separately. According to the current hybrid drive connection mode, it can be divided into three types of hybrid vehicles. The series hybrid electric vehicle is composed of three main power train: the engine, the generator and the motor. The engine directly drives the generator to charge the battery and supply power for the motor, the motor drives the wheels. The battery's function is to regulate the balance between the output of the engine and the demand of the motor. This type of car has the advantages that the working state of the engine is not influenced by the environment and the speed of the vehicle and the type is suitable for the urban working conditions of frequent starting, acceleration and low speed operation of the vehicle. Engine works in the vicinity of the best operating point, where can improve fuel economy, and improve emissions performance. The

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parallel hybrid electric vehicles are assembled of the engine and generator. The two powers can be output overlapped, and can also be output separately. The parallel hybrid electric vehicle energy efficiency is higher than that of series hybrid electric vehicle, and the fuel consumption is lower, but the engine and the wheels is connected mechanically, so in the road of frequently changing engine is very difficult to work for a long time in the best operating point, but will in the working range of low efficiency and high fuel.

Series-parallel hybrid vehicle is a combination of series and parallel structure. Though with respective advantages of series hybrid vehicle and parallel hybrid vehicle, due to the power train brings two sets of drive system together, vehicle structure than the traditional automobile is much more complicated, control system is more complex, enterprise's R & D cost and technical requirements are very high.

In summary, the series hybrid electric vehicle engine does not consider the road condition, and can work in high efficiency zone for a long time so series structure of hybrid electric vehicle have lower fuel consumption than ordinary cars in low speed, which is suitable for application of frequent starting and stopping on city buses. Making series hybrid electric vehicle as the research model, referencing current control strategy [3-6],a new energy management strategy is proposed. Through the model of analysis we can see that the energy management strategy is better than the original model fuel consumption and pollutant emissions.

MODEL CONSTRUCTING

Vehicle Driving Model Building

Cruise is a powerful vehicle simulation software，which can be used to analyze the power of the car, fuel economy and emissions performance. The modular modeling method allows users to easily build a vehicle model with different structures. Control algorithms and strategies can be easily and intuitively analyzed and studied by Simulation. Through generating a dynamic link library ‘dll’, both of them can make co-simulation study of hybrid vehicles and realize the model building, operation and analysis.

Models used modules include the driver module, vehicle module, battery, main reducer, CVT, engine, brakes, tires, etc. Click on the icon Cruise to enter the user interface, select the menu bar New icon, enter the model creation interface, select the modules we need, drag them to the modeling area, fill in the data according to the experimental vehicle. Physical connection and signal connection of the model are established according to the automobile configuration scheme and the component connection relation.

Simulink Model Building

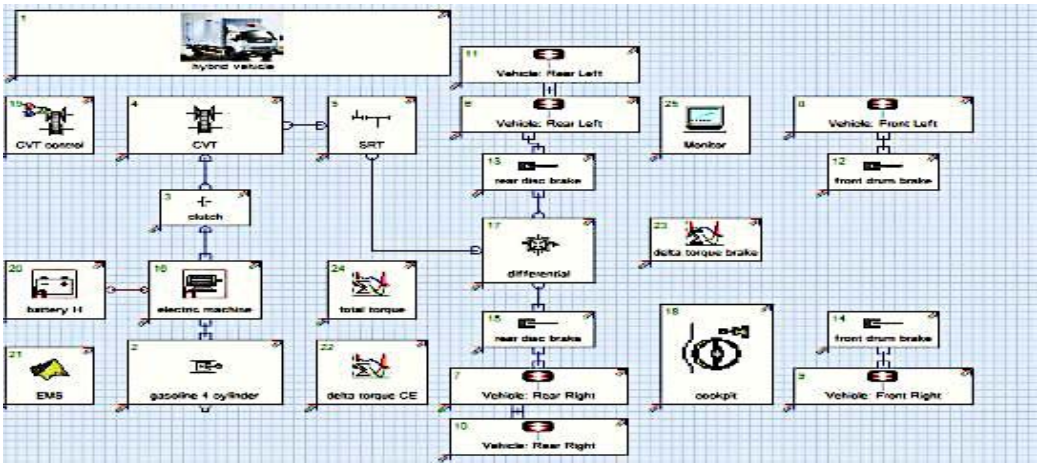

Figure 1. Structure module of series hybrid vehicle.

The Cruise model has been built, the next step is to consider the Simulink energy strategy model. Under the prerequisite of automobile dynamic property and other basic performance requirements, aiming at the running condition of auto mobile, the control strategy can realize the reasonable distribution of the engine and the motor output power, so that the efficiency of the vehicle reached the highest, and achieve lower fuel consumption and lower emissions control targets.

On-off control strategy make the engine work in the optimal operating point of series hybrid electric vehicle owing to engine and automobile running conditions are not directly linked, according to battery SOC value of the scope of work to control the start and the stop of the engine. It is described as follows: When the battery SOC is lower than the minimum required, the engine starts and works at the best operating point to charge the battery; When the battery SOC to reach the maximum value, the engine off, the car runs only rely on the battery; The engine always works at the optimum speed and torque level. The specific model is shown in Figure 2.

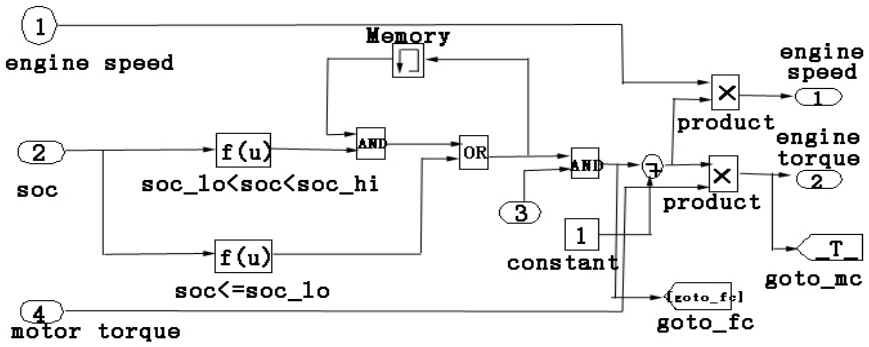

Figure 2. On-off control strategy.

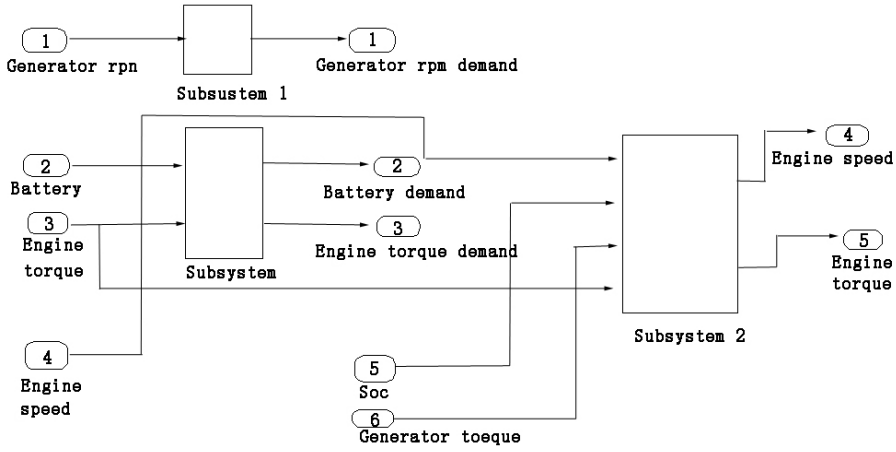

Figure 3. On-off and power follower control strategy.

Though engine does not consider the condition of working environment, the battery has to meet the instantaneous motor power requirements of the driver, which makes current fluctuation of the battery, this makes the battery loss is larger and tandem type automobile increases the energy conversion of the link, which offset one part advantage of the control strategy.

In view of this situation, an on-off and Power follower control strategy is developed and has been optimized: when the SOC is lower than the set minimum value or load power is greater than a predetermined maximum value, the engine start; when the SOC is higher than the upper limit value or the load power is lower than the set minimum value the engine is shut down. Compared with the simple on-off control strategy, the latter is equivalent to set a buffer zone can control engine frequent starting and stopping, and can buffer the battery current fluctuations, reduce the power loss and cell loss. At the same time, the fuel economy and pollutant emissions get further optimized. The specific model is shown in Figure 3.

SIMULATION AND RESULT ANALYSIS

For better analysis the control policy's influence in the model cars, the scheme 1 does not contain any control strategy, the second scheme 2 contains the on-off control strategy, schemes 3 contains on-off and power follower strategy, three schemes were simulated respectively, running in the UDC urban driving cycle (Figure4), get the condition of three groups of vehicle fuel consumption real-time data as shown in Table II, which also shows: scheme2 and the scheme 3 both optimize the vehicle fuel economy, scheme 2 optimization efficiency improve 12.05%, scheme 3 optimization efficiency can reach 21.21%; In terms of pollutant emissions, the scheme 2 pollutant index can reduce 1.47%, the scheme 3 pollutants index drop low 22.25%.

TABLE I. SIMULATION RESULT STATISTIC.

Analysis project		Analysis result		
		scheme 1	scheme 2	scheme 3
economy	Fuel consumption (1/100Km)	11.36	9.99	8.95
emissions of pollutants	NOX(g)	3.56	2.98	1.80
	CO(g)	16.33	16.66	13.90
	HC(g)	0.51	0.46	0.16

CONCLUSION

The simulation shows that Cruise software can facilitate the establishment of a car model, and meet the performance requirements, reduce the workload of the experiment. The nature of the energy management system of series hybrid electric vehicle based on Cruise/Simulink is the work mode selection and power allocation algorithm for two kinds of energy supply. The on-off and power follower control strategy can effectively reduce the fuel level and pollutant emission, which provides a new way to solve the fuel consumption and pollutant emission of city bus.

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