Research and Application of BSG Motor Control Technology with a Start-stop System

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Abstract. by developing a start-stop system of a BSG motor, this paper systematically presents the vehicle control principle, strategy and verification and assessment indicators of the start-stop system, and applies it successfully in a motor. Exhaust emissions and fuel-consumption tests of a vehicle were performed in the rotating hub, and the results show a 5% reduction in fuel consumption for the motor, and a 12% decline in fuel consumption when the experiments were carried out in urban areas. The control technology and vehicle examination and evaluation indicators have important guiding significance to the subsequent research of the start-stop system.

Introduction

A BSG start-stop system belongs to a micro-hybrid technology. In other words, at the engine's idle speed, if the external environment and the vehicle status satisfy the start-stop system requirement, the engine automatically turns off when the driver releases the clutch pedal, and the engine automatically starts when the driver depresses the clutch pedal or the brake pedal[1,2]. The technology makes small changes to conventional vehicles and can significantly reduce fuel consumption, so it has become an important technology for vehicle energy conservation and emission reduction.

The vehicle control unit receives the sensor signal and the signal coming from the CAN bus, and judges whether the BSG system is working and determines whether to start or stop the engine according to the internal control strategy[3], and controls engine starting and flameout.

The vehicle control unit can control the starting and shutdown relay, thereby controlling the original vehicle ECU as well as controlling engine starting and flameout. When the vehicle control unit's shutdown relay controls the high level output, the shutdown relay switches off, the ECU power cord is disconnected, and the engine stalls. The starting gear of the original vehicle ECU ignition switch is connected to the signal line[4,5,6]. When the vehicle control unit starts, the relay control terminal has low level output, and the starting relay is closed. The starting gear of the ECU ignition switch is joined, and ECU controls the engine starting. Therefore, the vehicle control unit controls engine starting and flameout by using the relay simulation key.

Vehicle Control Strategy

The vehicle control strategy consists of three parts: the vehicle and driver safety, driving operation habits, and the environment and road adaptability. According to the abovementioned strategiese, the vehicle formulates a start-stop system control strategy, the automatic engine stopping control strategy and the automatic engine starting control strategy.

Factors taken into account for developing the vehicle control strategy

Factors regarding the vehicle and driver safety: whether the seat belt is fastened, whether the engine hood is closed, whether the BSG system is faulty, engine coolant temperature, brake system pressure after the engine is switched off, automatic vehicle sliding speed after the engine is switched off, the state of charge of a battery, and catalyst temperature, etc.

Factors regarding driving operation habits: whether the seat belt is fastened, whether the transmission is in neutral, whether the clutch is disconnected, and whether the transmission is in reverse gear and so on.

Factors regarding the environment and road adaptability: the ambient temperature, the air conditioner application signal and automatic engine flameout when the vehicle speed is smaller than a specific value, etc.

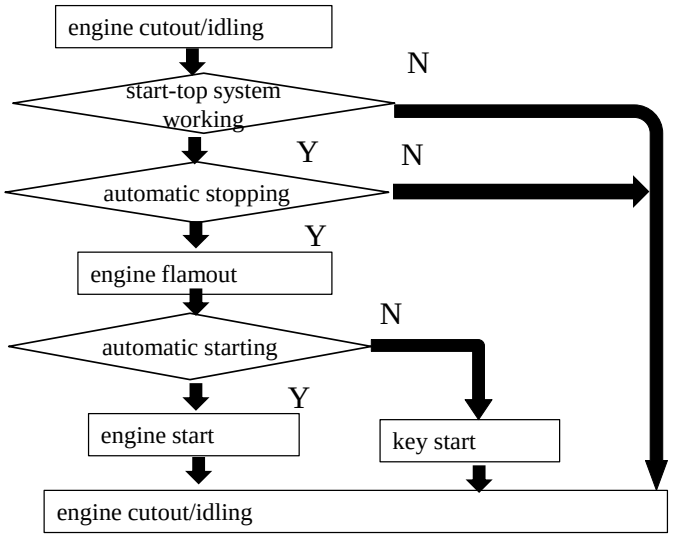

Fig. 1 The principle diagram of the vehicle control strategy

The Main Content of the Vehicle Control Strategy

The Start-stop System Closing Control Strategy

The start-stop system closing control strategy can be divided into subjective and objective levels: when the driver wants to close the start-stop system subjectively, he/she can close the start-stop system only by pressing the system closing button. If one of these conditions is met: the driver is not wearing a seatbelt, or engine hood is not closed, or the BSG system is faulty, the start-stop system automatically stops working, and the vehicle condition is the same as that without a start-stop system. The start-stop system closing control strategy is shown in Figure 2.

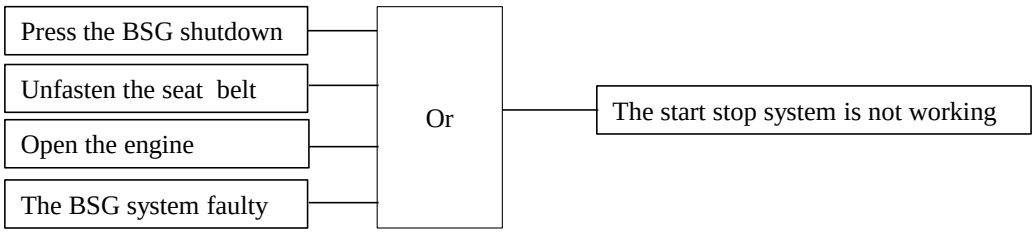

Fig. 2 The block diagram of start-stop system shutdown control

The Automatic Engine Stopping Control Strategy

When the driver encounters traffic lights or needs long-stay parking, the start-stop system can play a role and achieve automatic engine shutdown only when all of the following conditions are met. The automatic engine stoping control strategy is shown in Figure 3.

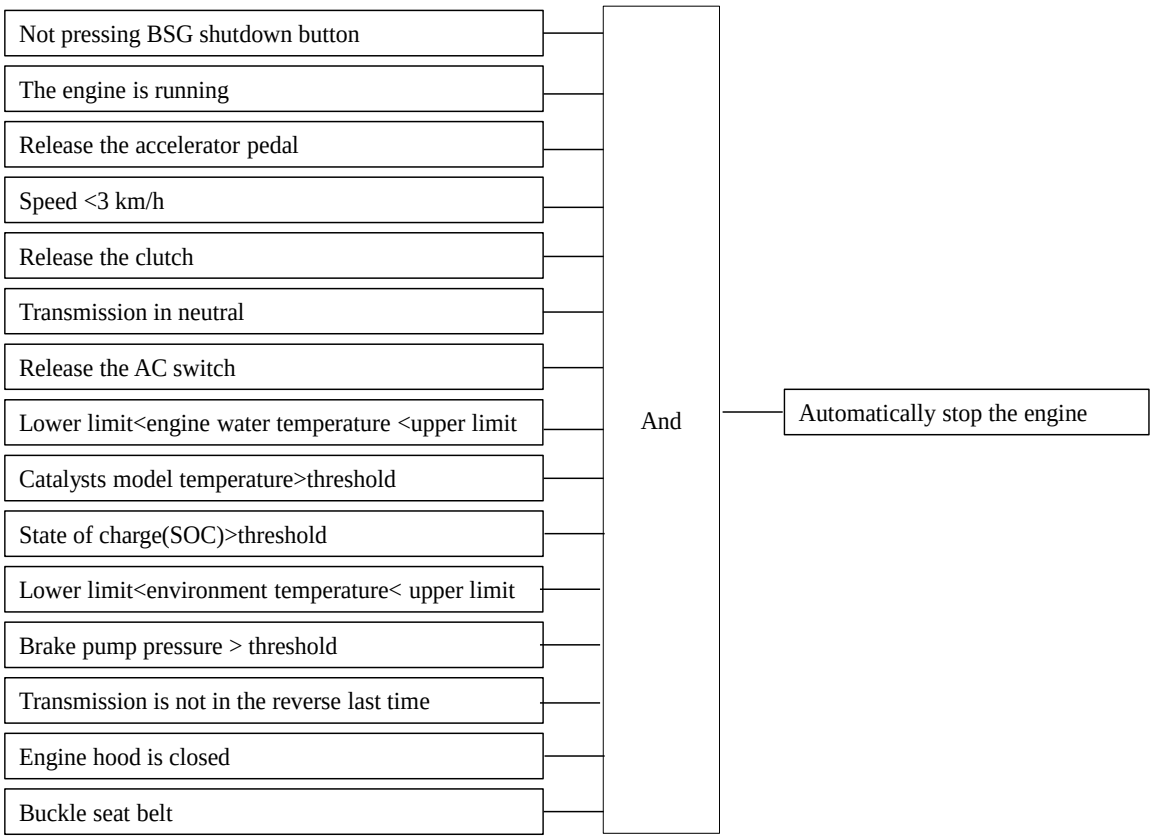

Fig. 3 The block diagram of automatic engine stopping control

The Automatic Engine Starting Control Strategy

When the driver waits for the traffic lights and needs to start the vehicle again, if one of these conditions is met: the start-stop system stops the vehicle, or engine hood is closed, or the driver is wearing a seatbelt, the start-stop system automatically starts working. The automatic engine starting control strategy is exhibited in Figure 4.

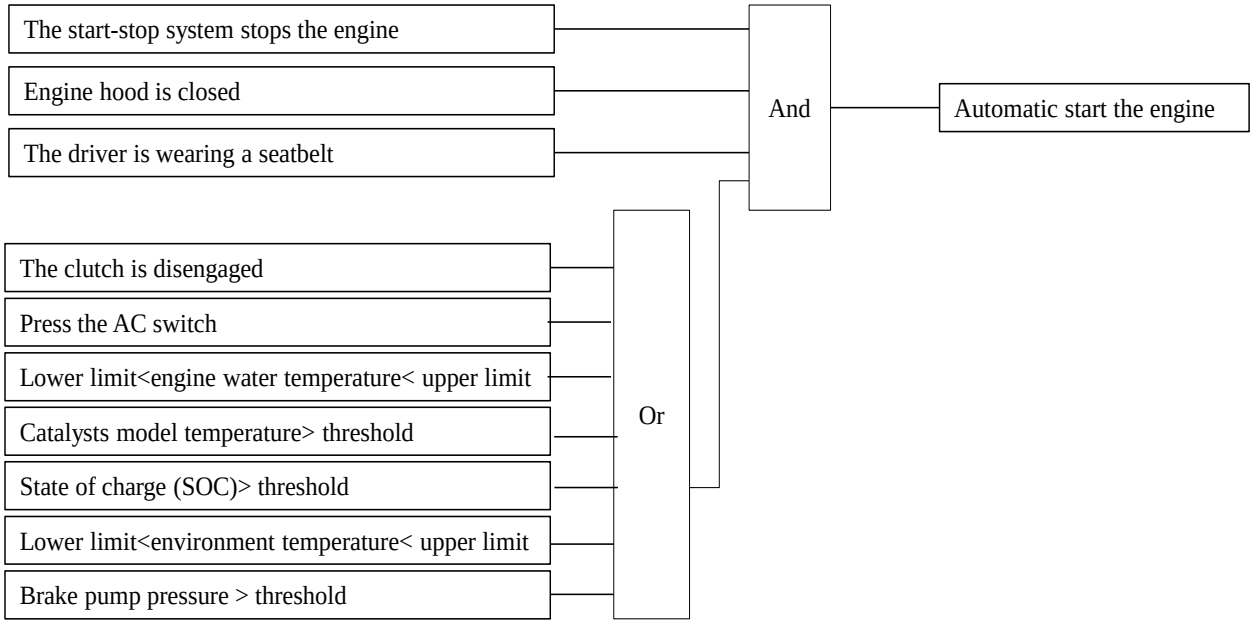

Fig. 4 The block diagram of the automatic engine starting control strategy

After the vehicle development, in order to ensure that the vehicle works stably and securely, rigorous vehicle inspection and evaluation should be carried out, including function acceptance indicators and inspection of boundary conditions.

Vehicle Acceptance Indicators are Displayed in Table 1

Table 1 BSG vehicle acceptance

Security and functional testing	Pass	Not pass
Start the vehicle using the ignition key		
Cold start functions normally		
Unlock the driver's seat belt, safety lamp blinks		
Engine hood is open and safety lamp blinks		
Reverse function is operating normally		
Battery charge functions normally		
BSG shutdown switch functions normally		
Automatic parking light is operating normally		
Automatic parking light 1Hz is flashing normally		
Start-stop security indicator is operating normally		
Start-stop security indicator 1Hz is flashing normally		
Neutral switch is operating normally		
Start-stop is operating properly		
Start-stop system vehicle road testing		
Fuel consumption test results in integrated operating condition		
Cold start testing results		

Vehicle Boundary Testing is Shown in Table 2.

Table 2 Vehicle boundary conditions test

Automatic stopping boundary conditions			
Boundary conditions	Calibrata ble	Boundaries	Current settings
Minimum cooling water temperature limit	Yes	-40- 140℃	>21℃
Vehicle activating start-stop function	Yes	-40-140℃	<110℃
Activation speed for automatic start-stop function	Yes	0- 140km/h	>6km/h
Maximum road speed for automatic stopping	Yes	0-140km/h	<2km/h
Outside temperature exceeds a value	Yes	-40-140℃	>-10℃
Air conditioning starts and outside temperature is low	Yes	-40-140℃	<35℃
Engine hood is closed	No, switch	Start-stop system works, must be closed	Activation
Fasten seat belt	No, switch	Start-stop system works, must be fastened	Activation
Neutral selection	No, switch	Start-stop system works, must be in neutral	Activation
The last choice is forward gear	No, use	Start-stop system works,	Activation

	the reverse switch	the last choice must be forward gear	
The start-stop system enabling	No, switch	Chosen by the driver	Activation
Trouble-free code	No, switch	Trouble-free is activated	Activation
Catalyst temperature exceeds a value	Yes	-50-1000℃	138℃
Vehicle stops automatically when battery SOC is less than a certain value	Yes	0 - 100 %	<40%
The engine is in the idle state	Yes	0-7000rpm	<1400rpm
Brake pump pressure is larger than a value	Yes	0-100kpa	>10kpa
Normal starting boundary conditions			
Engine hood is closed	No, switch	Start-stop system works, must be closed	Activation
Fasten seat belt	No, switch	Start-stop system works, must be fastened	Activation
Neutral selection	No, switch	Start-stop system works, must be in neutral	Activation
Release/depress the clutch	No, switch	The driver depresses the clutch and starts the engine	Activation
The start-stop system enabling	No, switch	Chosen by the driver	Activation
Trouble-free code	No, switch	Trouble-free is activated	Activation
Automatic starting boundary conditions			
Engine hood is closed	No, switch	Start-stop system works, must be closed	Activation
Fasten seat belt	No, switch	Start-stop system works, must be fastened	Activation
Neutral selection	No, switch	Start-stop system works, must be in neutral	Activation
Release/depress the clutch	No, switch	Trouble-free is activated	Activation
The start-stop system enabling	No, switch	Chosen by the driver	Activation
Automatic starting -Meet the above conditions and meet any of the conditions below			
Vehicle stops automatically when battery SOC is less than a certain value	Yes	0 - 100 %	<30%
The minimum speed to automatically activate start function	Yes	0 - 140km/h	>6km/h
Brake pump pressure is larger than a value	Yes	0-100kpa	>10kpa
The ignition key is turned to the starting position	No, switch	No	No

Conclusion

A start-stop vehicle is developed in accordance with the BSG start-stop vehicle control strategy proposed in this paper, and the aforementioned vehicle examination and evaluation test indicators are used for evaluation, and the vehicle design satisfies the requirements. Exhaust emissions and fuel-consumption tests of a vehicle with a BSG start-stop system were performed in the rotating hub, and the results show a 5% reduction in fuel consumption for the motor, and a 12% decline in fuel consumption when the experiments were carried out in urban areas.

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