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Acceleration performance test of gasohol vehicle under low environmental temperature conditions: a case study in Harbin, China

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Gasohol is one of renewable clean alternative energies, which is widely used around the world. In fact, the gasohol had been raised to use Gasohol in 9 provinces of China since 2001. However, it was merely promoted the closed use in Heilongjiang Province since November 1, 2004. Moreover, this issue aroused an extensive discussion and controversy. Especially in the cold winter, some users reflect that the use of gasohol can create some disturbing problems, i.e., environmental pollution is further accelerated, condensation dripping water detection problem from exhaust pipe is increased and the acceleration performance of vehicle is decreased. In order to deal with it, presently, some scholars have addressed condensation dripping water detection and fuel economy issues under low environmental temperature conditions. However, they pay little attention to acceleration performance test and experiment issues of gasohol vehicle under low environmental temperature conditions. Taking the Harbin city as a case study, this work designs acceleration performance experiments for gasohol and gasoline vehicles with the same working conditions. Moreover, based on experiments data, taking interval acceleration time and distance as evaluation parameters, this work evaluates and compares the acceleration performance of gasohol and gasoline vehicles. Under low environmental temperature conditions, the results denote that the gasohol vehicle has a better acceleration performance than gasoline vehicle in the low speed region. Otherwise, the gasohol vehicle has a worse acceleration performance than gasoline vehicle in the low speed region. This result can help decision makers to perform better judgments when using the gasohol vehicle.

Keywords: Acceleration performance, gasohol, low environmental temperature, Harbin of China.

INTRODUCTION

Due to the increasing demand for energy and stringent air pollution regulations, nations worldwide are actively researching and developing alternative clean fuels. Gasohol is one of them used for vehicles (Balat and Balat, 2009; Rossilo-Calle and Corte, 1998). Some studies have assessed the feasibility of employing ethanol as an additive in automobile engine fuel due to its high octane value (Najafi et al., 2009) and the ability of ethanol to increase the octane value of gasoline (Hsieh et al., 2002; Yücesu et al., 2006). In addition, in order to vary the effectiveness of using the ethanol, its related operating performance issue has been addressed. For example, Yang et al. discuss the effect of ethanol-blended gasoline on emissions of regulated air pollutants and carbonyls from motorcycles (Yang et al., 2012). Chen et al., 2011 discuss the cold-start emission problem of an SI engine using ethanol-gasoline blended fuel. Graham et al., 2008 discuss the emission issue from light duty gasoline vehicles operating on low blend ethanol gasoline and E85. Kiani et al., 2010 predicts the performance and exhaust emission in SI engine using ethanol- gasoline blends using artificial neural networks. Wu et al., 2004 investigate the effect of air–fuel ratio on SI engine performance and pollutant emissions using ethanol-gasoline blends. Costa and Sodré, 2011 present

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the compression ratio effect on an ethanol/gasoline fuelled engine performance. Schifter et al., 2011 discuss the combustion and emission behavior for ethanol-gasoline blends in a single cylinder engine. Kar et al., 2010 discuss the organic gas emission problem from a stoichiometric direct injection spark ignition engine operating on ethanol-gasoline blends.

Based on the above overview, researchers have addressed operating performance issues of ethanol/gasoline in detail. They pay little attention to the operating performance issue under low environmental temperature conditions. In fact, the gasohol had been raised to use Gasohol in 9 provinces of China since 2001. However, it was merely promoted the closed use in Heilongjiang Province since November 1, 2004. Moreover, this issue aroused an extensive discussion and controversy. Especially in the cold winter, some users reflect that the use of gasohol can create some disturbing problems (http://wenku.baidu.com/view/1c2f730cbb68a98271fefadc.html), i.e., environmental pollution is further accelerated, condensation dripping water detection problem from exhaust pipe is increased and the acceleration performance of vehicle is decreased, etc. In order to test these matters, Tian et al., 2012 analyze condensation dripping water detection problem from exhaust pipe of gasohol vehicle under low temperature conditions. In addition, Kaufman et al., 1981 discuss the fuel economy of gasohol vehicle under low temperature conditions. However, they do not focus on the acceleration performance issue. To analyze the acceleration performance test of gasohol vehicle under low environmental temperature conditions, it is necessary to introduce and design its acceleration performance experiment. Acceleration performance test and experiment of gasohol vehicle under low environmental temperature conditions, to the best of our knowledge, have not been addressed before.

The structure of this paper is organized as follows: in Section 2, the acceleration performance test and experiment are designed. In Section 3, the acceleration performance test data for gasohol and gasoline vehicles is obtained and measured, respectively. In addition, their results are compared and analyzed. In Section 4, a discussion is presented to analyze our results. Finally, section 5 concludes our work and describes our future research steps.

Experiment materials and procedures

Taking the POLO car of Shanghai Volkswagen (engine displacement is 1.6 L) as an experimental vehicle, its acceleration performance test for gasohol vehicle under different low environmental temperature conditions is executed. The used equipment is CTM2002A/B vehicle comprehensive test instrument.

The test vehicle is POLO type and its engine displacement is 1.6L. In addition, its transmission is manual and the used test equipment is CTM2002A/B vehicle comprehensive test instrument. Technical parameters of test vehicle are shown in Table 1.

In addition, main technical parameters of test vehicle engine are shown in Table 2.

In addition, technical parameters of CTM2002A/B vehicle comprehensive test instrument are shown in Table 3.

Test vehicles, test equipment, installation and test road section are shown in Figure 1. In addition, road section is straight and clean and test is executed in the same road section repeatedly; the range of environmental temperature is -20□～0□.

In addition, according to the relevant provisions listed in "vehicle acceleration test method" (GB/T12543-2009) (http://www.langlang.cc/2313485.htm), the detailed experiment procedures are presented next.

(1) Vehicle is accelerated from the stationary state to 100*km*/*h* at a full throttle condition. Note that the start acceleration process makes acceleration performance maximum and wheel slip minimum. In addition, the section of manipulation of clutch and shift time should make the acceleration performance optimal. But it should not exceed the rated speed of the test vehicle engine and the driving time of this process is recorded.

(2) It should be noted that super acceleration performance experiment is added in "vehicle acceleration test method" (GB/T12543-2009) (Kaufman et al., 1981), namely the acceleration of experiment 60*km*/*h*--100*km*/*h*. Speed should be controlled within range of 58*km*/*h*~60*km*/*h* before the vehicle is accelerated and keep this condition not less than 2*s*. In addition, shift operation of the transmission should not be executed and the driving time of this process is recorded.

EXPERIMENT RESULT AND ANALYSIS

In order to compare the acceleration performance systematically, road tests of E10 gasohol and 93# gasoline under different low environmental temperatures are executed and compared, i.e., -20□、-15□ and -5□.

1) Comparison of experimental results at -20℃ temperature

At -20 □ environmental temperature, acceleration performance tests for gasohol and gasoline vehicles from 0 *km*/*h* to 100 *km*/*h* are executed and compared. During the experimental process, acceleration time and acceleration distance at different speeds are collected, i.e., 20*km*/*h*, 40*km*/*h*, 60*km*/*h*, 80km/*h* and 100*km*/*h*. In addition, based on obtained experimental data, taking 20*km*/*h* as a speed interval, interval acceleration time Δt and interval acceleration distance Δs of each speed interval are calculated. The results of Δt and Δs for gasohol and gasoline vehicles are shown in Table 4. In

Table 1. Test vehicle technical parameters

Vehicle technical parameter	Indicator
Rank	Small cars
Body structure	Hatchback with 5 doors and 5 seats
L×W×H(*mm)*	3916×1650×1465
Engine	1.6L/76kW/inline four-cylinder
Transmission	5-speed / manual
The maximum speed(*km/h*)	188
Oil consumption(*L*/100*km*)	9.2/5.6/6.9 (Urban/suburban/ Integrated)
Acceleration time of 0-100km/h(*s*)	11
Wheelbase(*mm*)	2460
Front track(*mm*)	1435
Rear track(*mm*)	1425
Curb Weight(*kg*)	1143
Fuel tank capacity(*L*)	45
Minimum ground clearance(*mm*)	108
Minimum turning radius(*m*)	5.3
Driven approach	Pre-precursor
Front suspension type	McPherson-independent suspension
Rear suspension type	Trailing arm torsion beam semi-independent suspension
Chassis structure	State Ⅳ

Table 2. Main technical parameters of test vehicle engine

Vehicle technical parameter	Indicator
Engine Model	EA111
Displacement (*L*)	1.6
Cylinder volume (*cc*)	1598
Work	Naturally aspirated
Number of cylinders (*a*)	4
Cylinder arrangement form	line
The number of valves per cylinder (*a*)	4
Valve structure	Dual overhead
Compression ratio	10.5:1
Maximum power(*Kw/rpm*)	77/5000
Maximum torque(*N·m/rpm*)	155/3800
Power per liter(*Kw/l*)	48.12
Fuel	93 gasoline
Fuel supply method	Electronically controlled fuel injection
Emission standards	State Ⅳ

Table 3. technical parameters of CTM2002A/B vehicle comprehensive test instrument

Project	Parameter	Indicator
Technical performance indicators	System power consumption	25
	Built-in power	DC 9.6V (1.2Vnickel-cadmium; the number of battery is 8)
	External power supply	DC12V
	Standard 9-pin RS232 interface	(3 foot signal output ,3 foot signal input, 5 foot signal Ground) 9600 baud, data bits 8, stop bits 1, no parity
	Use temperature	0-40 ℃
	Ambient humidity	30-80%

Table 3. Continued

Main test items	Sliding test	Sliding velocity, sliding distance and sliding time		
	Brake test	Muzzle velocity of the brake, brake distance, brake time, the maximum deceleration, the average deceleration, the average deceleration MFDD (fully issued)		
	Speed experiments	Distance test, test time, average speed (minimum steady speed, the maximum stable speed)		
	Accelerated test	Acceleration distance, acceleration time to accelerate the end of speed and shift start and end of the speed, distance, time		
	Constant fuel consumption	Test range, test time, average speed, constant speed, fuel consumption (100km), hour fuel consumption		
	Accelerate fuel consumption	Accelerate the terminal velocity, the test distance, the test time, average speed, acceleration fuel consumption, hours and fuel consumption		
	Condition of fuel consumption	Distance test, test time, average speed of 100km hour fuel consumption		
	Traction test	Distance test, test time, average speed, traction, traction power, turn, slip rate, hours, fuel consumption, fuel consumption		
Test range, resolution and accuracy	Speed	0 ~ 300 t	0.1 km/h	1%
	Distance	0 ~ 99999.999 m	1 mm	1%
	Time	0 ~ 9999.9999 s	0.1 ms	1%
	Deceleration	0 ~ 9.9 m/s^2	0.1 m/s^2	1%
	MFDD	0 ~ 9.99 m/s^2	0.01 m/s^2	1%
	Hundred kilometers (displayed value)	0 ~ 999.999(l/100)*km*	0.001 (l/100)*km*	1%
	Hour fuel consumption (displayed value)	0 ~ 999.999 l/*h*	0.001 l/*h*	1%
	Traction (expandable up to 60kN)	0 ~ 65535 *N*	10 *N*	3%
	Traction power	0 ~ 999.99 *Kw*	0.01 *Kw*	3%
	Number of revolutions	0 ~ 5000.00 *r*	1/12 *r*	3%

Table 4. Interval acceleration time and interval acceleration distance of gasoline and gasohol vehicles at -20℃

Speed interval (*km*/*h*)	Interval acceleration time Δt (*s*)		Interval acceleration distance Δs (*m*)	
	93gasoline	**E10 gasohol**	**93gasoline**	**E10 gasohol**
0~20	3.72	2.76	9.85	5.69
20~40	3.39	2.87	30.29	18.02
40~60	4.18	3.71	59.57	45.96
60~80	5.43	5.71	107.03	89.69
80~100	6.69	7.27	168.86	192.75

(*a*) Connection diagram of external fuel supply system (*b*) Test road section

(*c*) Speed sensor (*d*) External oil supply system for fuel tank

Figure 1. Test vehicle and test road section

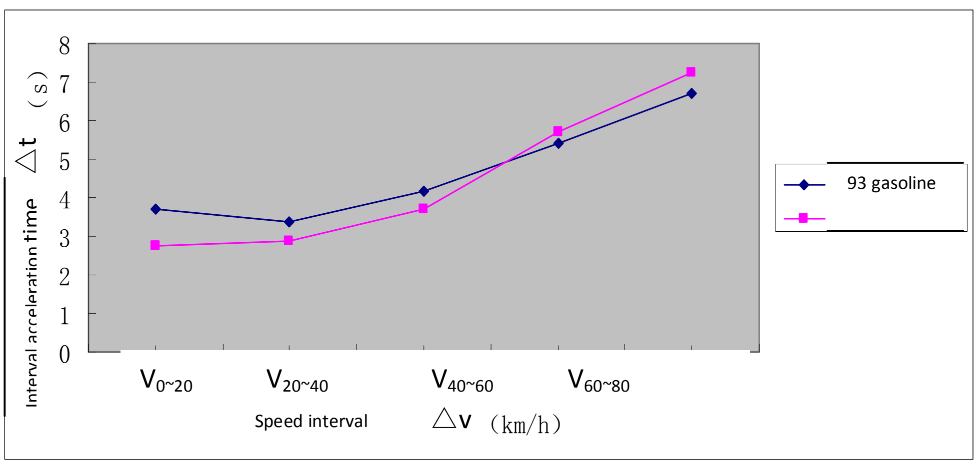

Figure 2. Comparison chart of interval acceleration time for gasoline and gasohol at -20℃

order to ensure the accuracy of result, the actual data is the average value of 6 times measure results at the same conditions.

From Table 4, at -20 ℃ environmental temperature, the comparison chart of interval acceleration time and interval acceleration distance for gasoline and gasohol is shown in Figures 2 and 3, respectively.

From Table 4 and Figure 2, at the environmental temperature of -20 ℃, the acceleration time of gasohol vehicle is less than one of gasoline vehicle when vehicle speed is less than 60*km*/*h*. It denotes that gasohol has a better acceleration performance during this condition. In addition, we can find that a “turning point” exists in the speed interval of 60*km*/*h*~80*km*/*h*. After this point, the

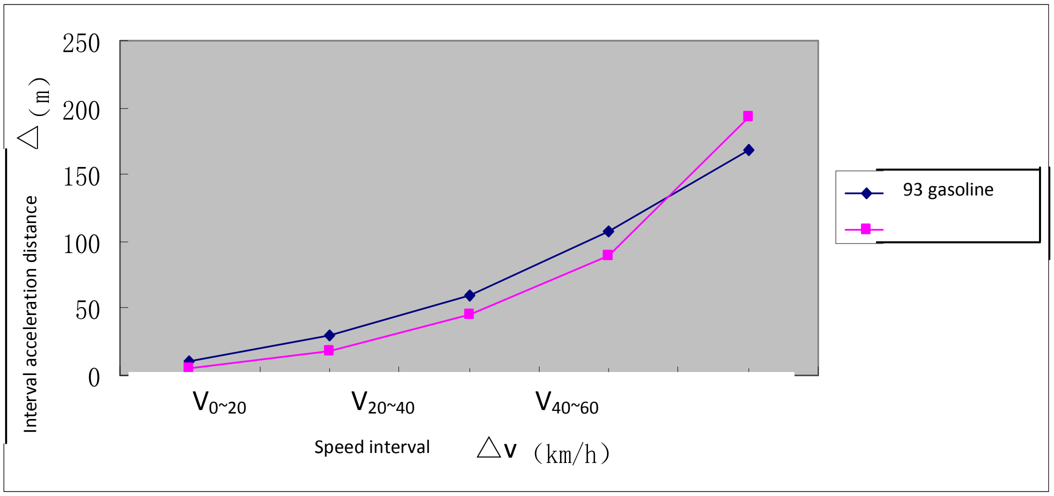

Figure 3. Comparison chart of interval acceleration distance for gasoline and gasohol at -20℃

Table 5. Interval acceleration time and interval acceleration distance of gasoline and gasohol vehicles at -15℃

Speed interval (*km*/*h*)	Interval acceleration time(*s*)		Interval acceleration distance (*m*)	
	93 gasoline	**E10 gasohol**	**93gasoline**	**E10 gasohol**
0~20	2.13	1.21	8.12	4.31
20~40	3.79	3.05	28.71	16.25
40~60	4.12	3.97	58.24	43.72
60~80	4.81	4.74	104.94	91.99
80~100	6.44	7.14	169.12	190.77

acceleration time of gasoline vehicle is less than one of gasohol vehicle. That is, gasoline shows a better acceleration performance after this point.

From Table 4 and Figure 3, at the environmental temperature of -20 □, the acceleration distance of gasohol vehicle is less than one of gasoline vehicle when vehicle speed is less than 80*km*/*h*. It denotes that gasohol has a better acceleration performance during this condition. In addition, we can find that a "turning point" exists in the speed interval of 80km/h~100km/h. After this point, the acceleration distance of gasohol vehicle is greater than one of gasoline vehicle. That is, gasoline shows a better acceleration performance after this point.

2) Comparison of experimental results at -15℃ temperature

Similarly, based on the above the experimental procedure and calculation method, at -15℃ temperature, interval acceleration time Δt and interval acceleration distance Δs of each speed interval for gasoline and gasohol vehicles are calculated as shown in Table 5.

From Table 5, at -15 □ environmental temperature, the comparison chart of interval acceleration time and interval acceleration distance for gasoline and gasohol is shown in Figures 4 and 5, respectively.

From Table 5 and Figure 4, at the environmental temperature of -15 ℃, the acceleration time of gasohol vehicle is less than one of gasoline vehicle when vehicle speed is less than 80*km*/*h*. It denotes that gasohol has a better acceleration performance during this condition, moreover, as the increase of the vehicle speed, the acceleration time of gasohol vehicle is closely to one of gasoline vehicle. In addition, we can find that a "turning point" exists in the speed interval of 80*km*/*h*~100*km*/*h*. After this point, the acceleration distance of gasohol vehicle is greater than one of gasoline vehicle. That is, gasoline shows a better acceleration performance than the gasoline after this point.

From Table 4 and Figure 5, at the environmental temperature of -15 □, the acceleration distance of gasohol vehicle is less than one of gasoline vehicle when vehicle speed is less than 80*km*/*h*. It denotes that gasohol has a better acceleration performance during this condition. In addition, we can find that a "turning point" exists in the speed interval of 80*km*/*h*~100*km*/*h*. After this point, the acceleration distance of gasohol

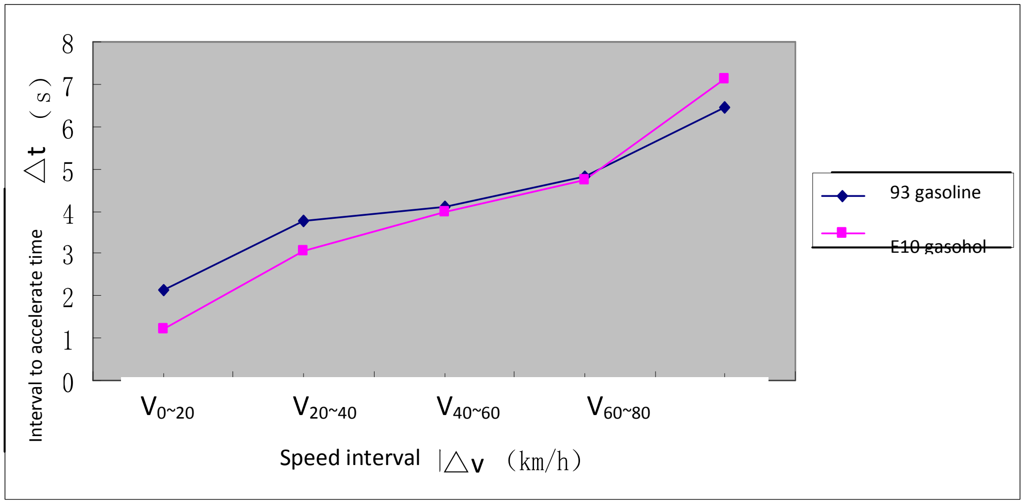

Figure 4. Comparison chart of interval acceleration time for gasoline and gasohol at -15℃

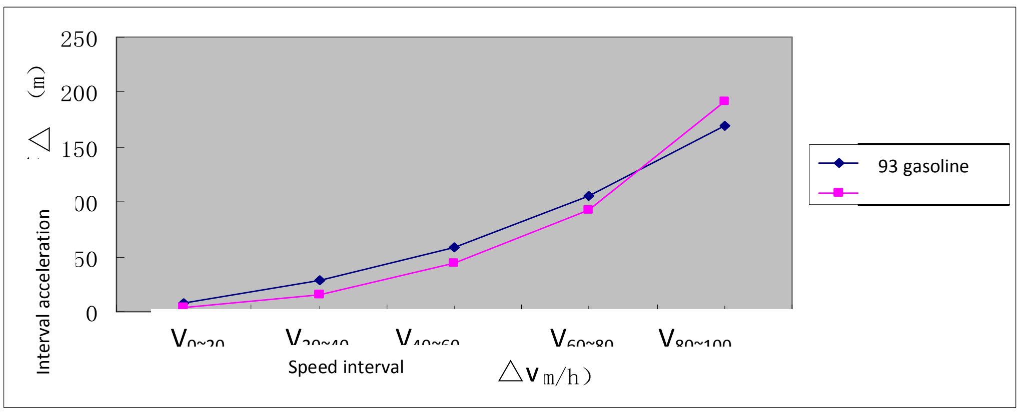

Figure 5. Comparison chart of interval acceleration distance for gasoline and gasohol at -15℃

vehicle is greater than one of gasoline vehicle. That is, gasoline shows a better acceleration performance after this point.

3) Comparison of experimental results at -5℃ temperature

Similarly, based on the above the experimental procedure and calculation method, at -15℃ temperature, interval acceleration time Δt and interval acceleration distance Δs of each speed interval for gasoline and gasohol vehicles are calculated as shown in Table 6.

From Table 6, at -5 □ environmental temperature, the comparison chart of interval acceleration time and interval acceleration distance for gasoline and gasohol is shown in Figures 6 and 7, respectively.

From Table 5 and Figure 6, at the environmental temperature of -5 ℃, the acceleration time of gasohol vehicle is less than one of gasoline vehicle when vehicle speed is less than 60*km*/*h*. It denotes that gasohol has a better acceleration performance during this condition. In addition, we can find that a “turning point” exists in the speed interval of 60*km*/*h*~80*km*/*h*. After this point, the acceleration time of gasohol vehicle is greater than one of gasoline vehicle. That is, gasoline shows a better acceleration performance than the gasoline after this point.

From Table 5 and Figure 7, at the environmental temperature of -5 ℃, the acceleration distance of gasohol vehicle is less than one of gasoline vehicle when vehicle speed is less than 80*km*/*h*. It denotes that gasohol has a better acceleration performance in the low speed region. In addition, we can find that a “turning point” exists in the speed interval of 80*km*/*h*~100*km*/*h*. After this point, the acceleration distance of gasohol vehicle is greater than one of gasoline vehicle. That is,

Table 6. Interval acceleration time and interval acceleration distance of gasoline and gasohol vehicles at -5℃

Target speed (*km*/*h*)	Interval acceleration time(*s*)		Interval distance	acceleration
	93 gasoline	E10 gasohol	93 gasoline	E10 gasohol
0~20	1.72	1.05	6.41	3.27
20~40	2.42	2.12	27.75	14.74
40~60	3.61	2.75	56.08	43.56
60~80	4.18	4.26	107.08	90.06
80~100	7.14	7.79	162.53	188.76

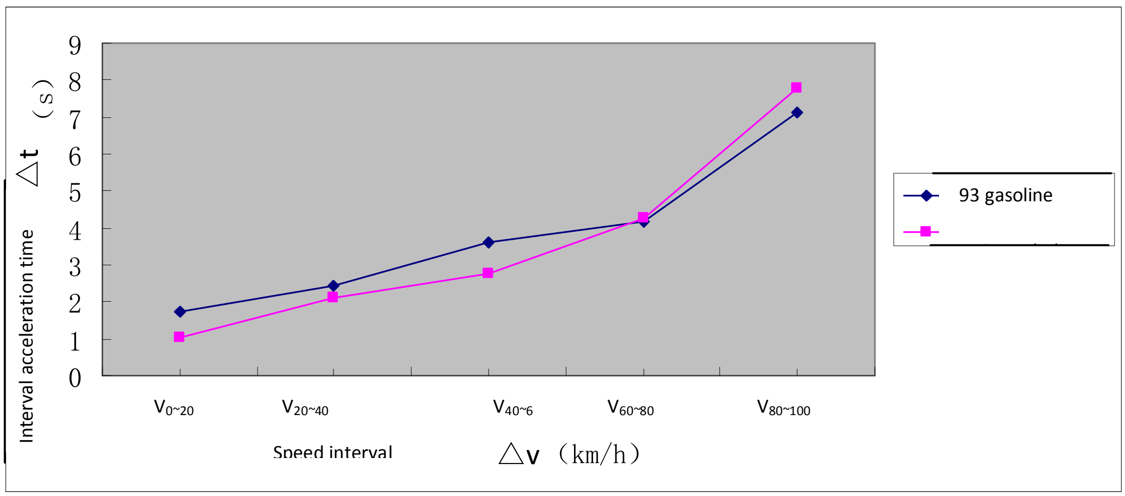

Figure 6. Comparison chart of interval acceleration time for gasoline and gasohol at -5℃

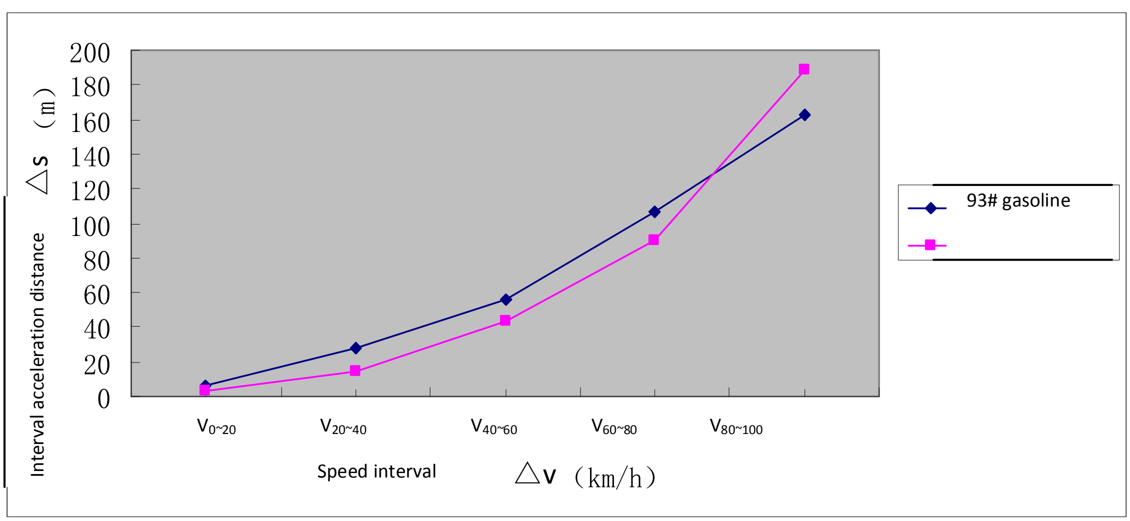

Figure 7. Comparison chart of interval acceleration distance for gasoline and gasohol at -5

gasoline shows a better acceleration performance than the gasoline in the high speed region.

DISCUSSIONS

Based on comparative experiment results of 93# gasoline and E10 gasohol vehicles under different low environmental temperatures, i.e., -5℃、-15℃ and -20℃, there are difference in acceleration performance between 93# gasoline and E10 gasohol. The overall trends are summarized as follows: in the low-speed region, the acceleration performance of E10 gasohol is slightly better than one of the 93# gasoline. However, in the high-speed region, the acceleration performance of 93# gasoline is slightly better than one of the E10 gasohol. The above phenomenon appears due to the following reason, namely, in the process of vehicle acceleration test and at the full load condition of the engine, the rotary speed of engine is different in low and high peed regions. The detailed reasons can be presented as follows: in low speed region, the engine has higher volumetric efficiency and E10 gasohol has better evaporation, which is conducive to the complete combustion. Additionally E10 gasohol has faster flame propagation speed, and as a result, E10 gasohol has a better acceleration performance in the low speed region. Otherwise, in high speed region, as increases of intake pressure and rotary speed, the volumetric efficiency of the engine is decrease, and as a result, the better evaporation and faster flame propagation speed of E10 gasohol are not be performed. Thus E10 gasohol does not show a better acceleration performance in the high speed region.

CONCLUSIONS

Due to the increasing demand for energy and stringent air pollution regulations, nations worldwide are actively researching and developing alternative clean fuels. Gasohol is one of the widely renewable alternative fuels used for vehicles. Especially in the cold winter, some users reflect that the use of gasohol can create some disturbing problems, i.e., environmental pollution is further accelerated, condensation dripping water detection problem from exhaust pipe is increased and the acceleration performance of vehicle is decreased. To do so, this work is presented and its contribution is concluded as follows:

(i) This work proposes an acceleration performance experiment and test issues of gasohol vehicle under low environmental temperature (-20℃ --0 ℃) conditions.

(ii) Taking the Harbin city as a case study, this work designs acceleration performance experiments for gasohol and gasoline vehicles with the same working conditions. According to experiments data, taking interval acceleration time and distance as evaluation parameters, this work evaluates and compares the acceleration performance of gasohol and gasoline vehicles.

(iii) Based on the experiment results, the following conductive and instructive conclusion is obtained, i.e., under low environmental temperature conditions, the gasohol vehicle has a better acceleration performance than gasoline vehicle in the low speed region. Otherwise, the gasohol vehicle has a worse acceleration performance than gasoline vehicle in the low speed region. This can are used to guide decision makers in making right decisions to optimize operating performance of the gasohol vehicle.

There exits some limitations with the proposed method. Firstly, in order to further test the result, experimental data of different types of vehicles should be collected. In addition, we should extend the experiment data under the ultra-low temperature conditions to better use the gasohol vehicle.

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