

Research on Control Strategy of Oxygen-rich Intake Based on MAP of Gasoline Engine

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Abstract: Oxygen-enriched intake is the new way to achieve energy conservation and emissions reduction, the volumetric fraction of inlet oxygen enrichment is not stable when using membrane oxygen enrichment and oxygen cylinders, it is difficult to fully grasp the target component of the actual working condition of the engine and its performance parameters under the condition of oxygen-enriched air inlet; Current research method of control parameters of the engine working mainly in the fuel injection control, ignition control, EGR control, etc., in respect of admission control has not conducted the related research, however, it has not conducted the related research in respect of admission control. Therefore, this article uses the single cylinder air-cooled four-stroke gasoline engine as the research object, put forward the oxygen-enriched air inlet of engine control strategy based on the MAP, and built a oxygen-enriched intake distribution system to the test engine matching the amount of oxygen volume fraction control and set up the engine bench test system, it provided the objective oxygen volume fraction of oxygen-enriched intake for the stability of engine, and implements the oxygen-enriched air inlet control gasoline engine; proposed a generating way for Oxygen-enriched gasoline engine air intake MAP figure. By using double three interpolation method, the combination intake interpolation MAP drawing is generated. Together with the matching PWM control parameters, MAP drawing will be stored into the in the read only memory of the MC9S12DP256 microprocessors, when the engine actual operate, it accessed the actual condition of inlet oxygen volume fraction volume control and its' PWM matching control parameters directly according to the specific condition parameter values, shorten the response time and improved the control precision; Combination control strategy in the implementation of the conditions, the experiment has properties of gasoline engine, respectively mapped the torque and fuel consumption rate, HC emissions, CO and NO_x emission characteristic performance curve; With normal intake engine carries out a comparative analysis on the actual working condition, verify the combination intake MAP control strategy can improve the comprehensive performance of gasoline engine. *Copyright © 2013 IFSA.*

Keywords: Oxygen-enriched intake air, MAP, Gasoline engine, Universal characteristic.

1. Introduction

With car emission limit growing strict and engine controlling updating, the burn controlling of engine is

requested to more perfect to achieve lower emission performance, better economic efficiency and higher dynamic property. This is one of the main ways to adopt reforming air inlet component to make engine

work better during its working [1]. Reforming Oxygen and nitrogen component of engine inlet can improve the burn efficiency of engine and make all the property better. Nitrogen flame retardant composition and oxygen fuel composition are composed of the double features – inflaming retarding and combustion supporting. The double features affect the combustion controlling and emission controlling directly [2]. Therefore, reforming inlet component of engine can be active problem, also can be reactive problem. Reactive problem is the research about the special conditions, such as the plateau and cold areas, to make up for the combustion deterioration and improve its combustion. Active problem is like EGR (Exhaust Gas Recirculation) controlling, by adjusting the inlet component of oxygen and nitrogen to achieve combustion process control of engine [3].

Oxygen-enriched intake can improve the combustion temperature, shorten the ignition delay and promote the full combustion of fuel [4]. It can improve the engine power output, reduce the fuel consumption rate and improve the dynamic performance and economic performance [5]; also can reduce the incomplete combustion of CO and HC to achieve lower emissions [6]; it has an obvious influence especially on cold start, anoxic environment, and special working condition, and so on. It's the new way to realize energy saving and emission reduction [7-9]. Usually, by using the oxygen-enriched intake for the engine to adopt membrane oxygen enrichment and oxygen cylinders. But the provided oxygen-enriched intake of oxygen volume fraction is not stable, so it is difficult to fully grasp. The target component of the actual working condition of the engine and its performance parameters under the condition of Oxygen-enriched air inlet conditions [10, 11].

According to the point of controlling technology, engine is a response lag time-varying system with dynamic, multivariable, highly nonlinear. Currently, the research of the control parameters of engine is mainly in the fuel injection controlling, ignition controlling, EGR controlling, and so on. But inlet controlling is not conducted for this moment [12-14].

Under different operating conditions, the basic MAP is the combined parameters with ignition advance angle and pulse width to make the engine achieve the best working. The initial MAP is the key to get mass data by the engine bench test and vehicle road test. After filtering and statistical analysis, we can get all kinds of MAP data control table [15, 16]. At present, the MAP data of engine is mainly including initial ignition advance angle MAP and initial pulse width MAP. But the initial inlet fraction of inspire is not conducted now.

Therefore, this article used the single cylinder air-cooled four-stroke gasoline engine as the research object, based on the oxygen-enriched intake control strategy put forwarded by the MAP, according to the actual working condition of the engine test, through

real-time query the initial MAP figure of the inlet oxygen volume fraction and release control instruction to accurately control the intake of oxygen volume fraction, to ensure that the engine under the condition of target components of oxygen-enriched intake can complete stability controlled burning, thus, on the premise of ensuring emission performance is not obvious deterioration to optimize the dynamic performance and economic performance, and achieve the goal of energy conservation and emissions reduction finally.

2. Controlling System Building of Oxygen-enriched Inlet

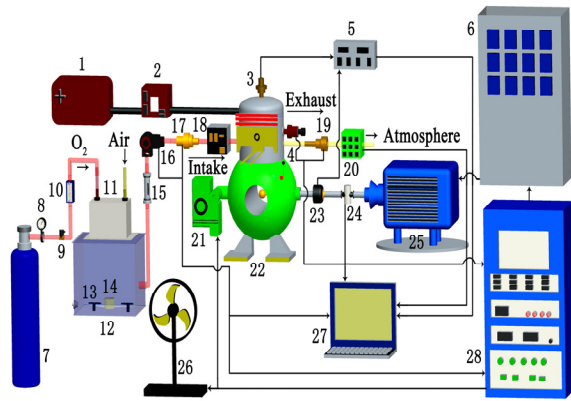
2.1. To Construct a System of Distribution

Using Oxygen-enriched inlet system is to test the Oxygen-enriched inlet of the engine equipped with target oxygen volume fraction. Oxygen cylinder supply the industry oxygen with 99.2 % purity and 13 ± 0.5 MPa pulse to make the pulse decrease to standard atmospheric pressure by oxygen cylinder pressure reducer to get into re-mixed space. The remixed space is another inlet combined with atmosphere. Using many mix-fans is to re-mix the industry oxygen and atmosphere, then getting into the plenum chamber to be mixed completely. Using Oxygen flow meter and oxygen flow control valve is to make industry oxygen inlet and oxygen inlet parameters better. Then, after it forms the mix inlet with the target oxygen-enriched, by the way of naturally inspire, to supply to the experiment engine.

2.2. Set Up the Bench Test System

The bench test system for oxygen-enriched intake of engine is made up of the air cooling four stroke single cylinder gasoline engine, the intelligent distribution system, the fuel tank, the fuel consumption instrument, the combustion analyzer, the gas analyzer, the incremental encoder, the rotational speed, the torque sensor, the dc electric dynamometer, the cylinder pressure sensor, the cylinder temperature sensor, the throttle position sensor, the air intake temperature sensor, the exhaust temperature sensor, the temperature hygrometer, the throttle actuator, the cooling fan, the electric control cabinet and motor automatic measurement and the control system, and so on. The structure of oxygen-enriched air inlet of engine bench is as shown in Fig. 1.

Test engine QJ125-27 a1-1 type single point, single cylinder, four stroke, gasoline engine, the electronically controlled fuel injection system for air-cooled cooling way, starting way as the electric starter, its key technical parameters see Table 1.



1 - the fuel tank, 2 - smart fuel consumption, 3 - cylinder pressure sensor, 4 - cylinder temperature sensor, 5 - Combustion Analyzer, 6 - control cabinet, 7 - oxygen bottles, 8 - oxygen bottle pressure reducer, 9 - oxygen flow control valve, 10 - oxygen flow meter, 11 - pre-mixing chamber, 12 - with the gas chamber, 13 - gas mixing fan, 14 - temperature hygrometer, 15 - gas flow meter, 16 - throttle position sensor, 17 - in take temperature sensor, 18 - oxygen analyzer, 19 - exhaust gas temperature sensor, 20 - exhaust gas analyzer, 21 - throttle actuator, 22 - engine, 23 - incremental encoder, 24 - speed torque sensor, 25 - DC Electric Dynamometer, 26 - cooling fan, 27 - monitor and collection system, 28 - engine automatic monitoring and control system.

Fig. 1. Structure diagram of bench test system.

Table 1. The key technical parameters of engine test.

Parameters	Index
Cylinder diameter route/mm	56.5×49.5
Displacement/mL	124
Compression ratio	9:1
Fuel	93#Gasoline
Max power/kW	7.5/(7500 r/min)
Rated power/kW	6.5/(6500 r/min)
Max torque/(N·m)	8.5 (5500 r/min)
Max Speed/ r/min	8500

2.3. Design of Measure-control System

Measurement and control system by using oxygen flow control valve to control access to the flow of industrial pure oxygen in the process of the mixing chamber and the flow velocity, use oxygen flowmeter measurement in industrial pure oxygen flow rate, in the process of the mixing chamber by using temperature hygrometer measuring temperature and humidity in air chamber, by the test of gas flowmeter measurement for gasoline engine of rich oxygen mixed gas, by the test of oxygen analyzer measurement for gasoline engine's actual oxygen-enriched intake of oxygen volume fraction value, use of oxygen-enriched intake monitoring system according to the actual working condition of the engine test real-time query MAP figure and release control instruction; by the test of dc electric dynamometer measuring the output power of the gasoline engine, by using the incremental encoder and combustion analyzer to measure the moment of

combustion heat release, using intelligent fuel consumption instrument measuring oil consumption and oil consumption rate, using the torque speed sensor, cylinder pressure sensor, throttle position sensor, air intake temperature sensor, cylinder temperature sensors, exhaust temperature sensor measurement test of gasoline engine respectively.

3. Method of Processing Oxygen-enriched MAP Table

3.1. The Confirming Method of MAP Table Condition

According to the technology parameters of tested gasoline engine, in the condition of the actual operation of the engine, this article selects eight speed points, as 1500 r/min, 2500 r/min, 3500 r/min, 4500 r/min, 5500 r/min, 6500 r/min, 7500 r/min, 8500 r/min; and also six throttle opening, they are 0 %, 20 %, 40 %, 60 %, 80 %, 100 %, so there are all 48 operating conditions.

3.2. Interpolation Method of Air-inlet MAP Table

We can run the engine, then separate all of the throttle opening conditions with six equal, speed points with 8 equal. Therefore, the condition is 6×8 grid plane with speed points. The condition of plane is made of the network by bisectrix. So there are 6×8 grid, also 48 kinds of condition points. In the working of engine, according to the quadratic spline interpolation, the air-inlet oxygen value is α_o out of the 48 conditions. Interpolation calculation principle is shown in Fig. 2.

Fig. 2 can illustrate there are 5 points on the MAP grid. Point 1 and point 4 are MAP data of the test. Every point is fit to parameter speed point, throttle opening and oxygen-inlet value. Point 5 stands for the condition of the actual operating of the engine. The condition is not belong to all of the 48 conditions. According to the speed point of double-axis and the parameters of throttle opening, it can use three interpolation optimization methods to check the oxygen inlet value.

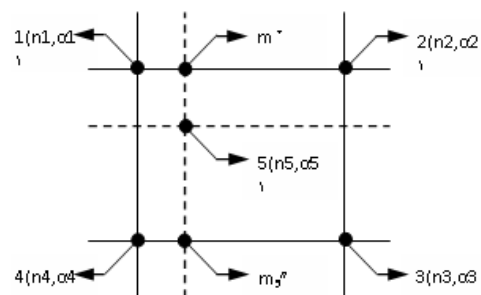


Fig. 2. Interpolation calculation principle of Oxygen-enriched intake MAP.

The calculation stage is as below:

1) To checking the MAP grid strict of the 5 condition, that is confirming the four conditions of the engine speed point n_5 and throttle opening α_5 .

2) Interpolation on throttle opening α_1 and α_2 , then it can get α'_{05} . The interpolation calculation form is as below

$$\alpha'_{05} = \frac{\alpha_{02}(\alpha_5 - \alpha_1) + \alpha_{01}(\alpha_2 - \alpha_5)}{\alpha_2 - \alpha_1}, \quad (1)$$

In the form, α'_{05} - after one interpolation, the air-inlet oxygen value of point 5 is %;

α_{02} , α_{01} are the oxygen inlet value of point 1 and point 2, %;

α_{02} , α_{01} are the throttle opening of point 1, point 2 and point 5, %.

3) Interpolation on throttle opening α_3 and α_4 , getting α''_{05} , the form is as below

$$\alpha''_{05} = \frac{\alpha_{03}(\alpha_5 - \alpha_4) + \alpha_{04}(\alpha_3 - \alpha_5)}{\alpha_3 - \alpha_4} \quad (2)$$

In the form, α''_{05} - after two interpolation, the air-inlet oxygen value of point 5, %;

α_{03} , α_{04} are the oxygen inlet value of point 3 and point 4, %;

α_{03} , α_{04} are the throttle opening of point 3 and point 4, %.

4) Interpolation on n_1 and n_4 , getting α_{05} , the interpolation form is as below

$$\alpha_{05} = \frac{\alpha'_{05}(n_4 - n_5) + \alpha''_{05}(n_5 - n_1)}{n_4 - n_1} \quad (3)$$

In the form, α_{05} - after three interpolation, the air-inlet oxygen value of point 5, %;

n_1 , n_4 , n_5 are the speed point of point 1, point 4 and point 5, %.

After getting the oxygen inlet value of α_{05} for the point 5 conditions, using double three interpolation methods to check the oxygen inlet value $\alpha_{01}(n_1, \alpha_1)$ - from point 1 to point 4 of the MAP.

To calculate every grads of the MAP $\frac{\delta m}{\delta n}$, $\frac{\delta m}{\delta \alpha}$ and

$\frac{\delta^2 m}{\delta n \cdot \delta \alpha}$. According to Formula (1) - (3), we can get the grads of point 5 condition (n_5, α_5) , then according to the grads, we can get the oxygen inlet

value $\alpha_{05}(n_5, \alpha_5)$. After that, we can get all of the oxygen inlet value controlling of the whole conditions.

3.3. The Distribution Proportion of Matching

Air intake MAP figure is an operating condition plane xoy which made up of rotational speed- load conditions, it corresponding to each point of the air intake control parameter z to form a three-dimensional stereogram, it's Coordinate parameters including the speed of the axis x , load of the axis y and the inlet control parameters of the axis z . The x axis coordinate parameters of engine speed (r/min). The scope of its coordinates is from 1500 r/min to 8500 r/min. The minimum scale is 1000 r/min; Select the throttle opening (%) as the y coordinate parameters. The scope of its coordinates is 0 % - 100 %. The minimum scale is 20 %; Inlet oxygen volume fraction (%) degree of oxygen-enriched intake can accurate the characterization of the engine, use it as the coordinates of the parameter of axis z . Due to high volume fraction of oxygen in oxygen-enriched intake will cause the engine detonation. The output torque instability and a series of problems such as deterioration of NO_x emissions. So relative to oxygen volume fraction of 21 % of normal intake. This article select 22 % - 26 % of the distribution ratio, set the intake MAP figure of z axis coordinate range as 21 % - 27 %, and the minimum scale as 1 %.

Engine air inflow and air intake calculation formula for oxygen volume fraction is:

$$Q = \eta \times \frac{V}{2} \times n \quad (4)$$

where Q is the Engine air inflow, L/min; η is the Engine filling coefficient, the scope of overhead valve engine is 0.75 - 0.85, this article select 0.85 as the filling volume coefficient value of the test with gasoline engine; V is the engine volume, L; N is the engine speed, r/min.

The calculation formula of oxygen volume fraction of the engine intake is

$$\lambda_o = \frac{Q_{O_2}}{Q} = \frac{Q_{O_2}}{Q_{O_2} + Q_{\text{air}}} \quad (5)$$

where λ_o is the intake of oxygen volume fraction, %;

Q_{O_2} is the pure oxygen flow in the inlet, L/min;

Q_{air} is the air flow in the inlet, L/min.

Assuming volume fractions for oxygen in the normal air is 21 %, based on the engine capacity and different speed conditions, the calculation formula of

the pure oxygen demand under the control requirements the Objective oxygen volume fraction is:

$$Q_{O_2} = \frac{V}{2} \times n \times \frac{\lambda_o - 21\%}{1 - \lambda_o} = \frac{Q \times (\lambda_o - 21\%)}{1 - \lambda_o} \quad (6)$$

As the air flow in the engine air intake is not easy to accurate measurement, so according to the Formula (4) - (6) is derived, of inlet oxygen volume fraction derived formula is:

$$\lambda_o = \frac{Q \times 21\% + Q_{O_2}}{Q + Q_{O_2}} \times 100\% \quad (7)$$

The max control error for the distribution system is not allowed more than $\pm 1.5\%$, average error no more than $\pm 0.5\%$. Making the matching result of all the conditions form PWM matching data by double-axis, then put it in MCMC9S12DP256

mini processor USB to be used in the operating processing directly.

4. Gasoline Oxygen-enriched Inlet Strategy Based on MAP

4.1. Combined Controlling Strategy

The combined controlling strategy of gasoline engine is combined with dynamic MAP, economy MAP and emission MAP. That is the whole conditions with emission air inlet MAP, economy air inlet MAP condition and dynamic air inlet MAP. Along with the number of throttle opening, it can be combined with a whole MAP picture. For the combined number, please check the Table 2.

Table 2. Picture of combined air inlet initial MAP.

Built-up sequence	The name of working condition	The opening range of the throttle (%)	The types of MAP figure
1	Idling condition	0	Discharge type inlet initial MAP figure
2	Small load condition	0~20	Discharge type inlet initial MAP figure
3	Partial load condition	20~80	Economical inlet initial MAP figure
4	Big load condition	80~100	Dynamic type inlet initial MAP figure
5	Full load mode	100	Dynamic type inlet initial MAP figure

4.2. Achieving the Controlling Process

Determined by the working condition of 48 nodes after interpolation optimization for 8 times of interpolation points, the working condition of 384 interpolating points, combination intake interpolation MAP diagram is shown in Fig. 3. 48 of the condition node optimal inlet oxygen volume fraction control quantity to see Table 3, PWM control parameters matching values see Table 4, the corresponding period and conduction time single cycle control quantity to see Table 5.

By PC principal computer of monitoring system, we can restore the combined inlet interpolation MAP in Fig. 3 and PWM controlling parameters of correspond cycle and single cycle on-time in Table 5 into MC9S12DP256 mini processor ROM. When engine is working, we can judge the processing condition of engine, along with rotate speed of sensor and Integrity of the opening of the door. Based on the target of combined oxygen-enriched controlling, checking combined inlet value MAP to get the basic controlling of oxygen inlet value. MC9S12DP256 mini processor need to do the appointment, matching PWM controlling parameters. Then it can control the

flow meters of industrial purity oxygen and stabilize the controlling target. To achieve the oxygen-enriched inlet of stabilizing oxygen value is to achieve the gasoline combined controlling of oxygen-enriched.

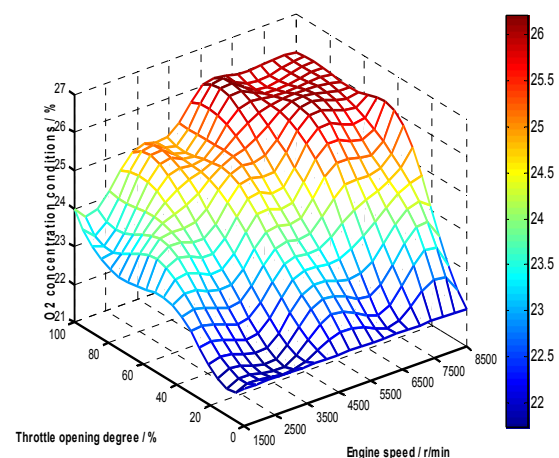


Fig. 3. Combined inlet interpolation MAP.

Table 3. Combined inlet MAP controlling parameter.

Integrity of the opening of the door (%) Rotate speed (r/min)	0	20	40	60	80	100
1500	22	22	23	23	23	24
2500	22	22	23	24	24	24
3500	22	22	23	24	25	25
4500	22	23	24	25	25	25
5500	22	23	24	25	26	26
6500	22	23	25	26	26	26
7500	22	24	25	26	26	26
8500	22	24	26	26	26	26

Table 4. Combined matching of inlet MAP controlling.

Integrity of the opening of the door (%) Rotate speed (r/min)	0		20		40		60		80		100	
	Fraction of inspire (%)	Duty ratio (%)	Fraction of inspire (%)	Duty ratio (%)	Fraction of inspire (%)	Duty ratio (%)	Fraction of inspire (%)	Duty ratio (%)	Fraction of inspire (%)	Duty ratio (%)	Fraction of inspire (%)	Duty ratio v
1500	22	1.82	22	2.00	23	2.32	23	2.55	23	2.67	24	2.94
2500	22	1.94	22	2.19	23	2.44	24	2.67	24	2.89	24	3.11
3500	22	2.19	22	2.38	23	2.67	24	2.76	25	3.06	25	3.29
4500	22	2.29	23	2.53	24	2.75	25	2.95	25	3.18	25	3.41
5500	22	2.31	23	2.74	24	2.82	25	3.22	26	3.50	26	3.76
6500	22	2.40	23	2.94	25	3.25	26	3.44	26	3.87	26	4.13
7500	22	2.50	24	3.22	25	3.50	26	4.12	26	4.29	26	5.43
8500	22	3.47	24	4.47	26	5.08	26	5.69	26	6.83	26	7.64

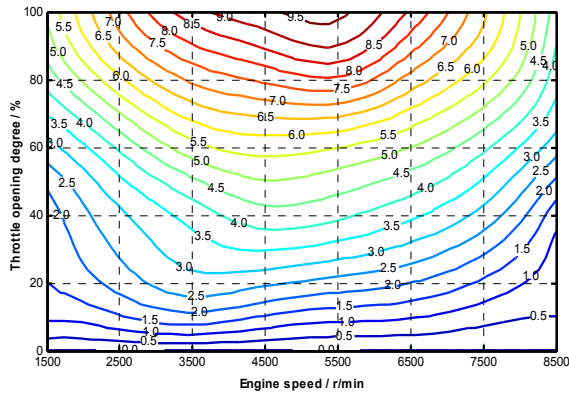
Table 5. Combined period and single cycle time of inlet MAP controlling.

Integrity of the opening of the door (%) Rotate speed (r/min)	0		20		40		60		80		100	
	Cycle T (ms)	On-time t (ms)	Cycle T (ms)	On-time t (ms)	Cycle T (ms)	On-time t (ms)	Cycle T (ms)	On-time t (ms)	Cycle T (ms)	On-time t (ms)	Cycle T (ms)	On-time t (ms)
1500	1100	20	1050	21	950	22	1100	28	900	24	850	25
2500	1800	35	1050	23	900	22	1050	28	900	26	900	28
3500	1600	35	1050	25	900	24	1050	29	850	26	850	28
4500	1400	32	950	24	800	22	950	28	850	27	850	29
5500	1300	30	950	26	850	24	900	29	800	28	850	32
6500	1250	30	850	25	800	26	900	31	750	29	800	33
7500	1200	30	900	29	800	28	850	35	700	30	700	38
8500	1500	52	850	38	650	33	650	37	600	41	550	42

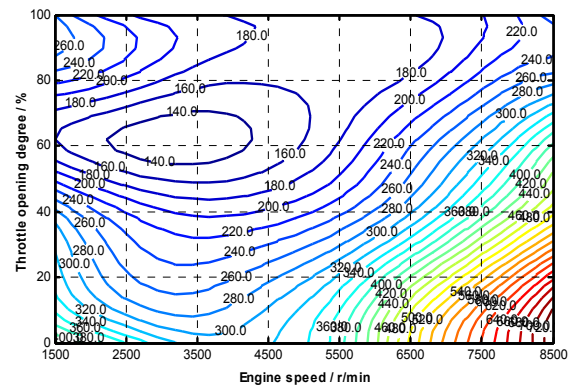
4.3. Analysis of the Control Effect

MAP does gasoline engine performance, fuel economy and emissions of confirmatory tests separately. Using MATLAB7.0 drawing program to draw the torque, fuel consumption rate and HC emissions, CO and NO_x emission characteristic performance curve as shown in Fig. 4. Of which, Fig. 4 (a) is the torque characteristic performance curve. Fig. 4 (b) is the fuel consumption rate characteristic performance curve, Fig. 4 (c) is the HC

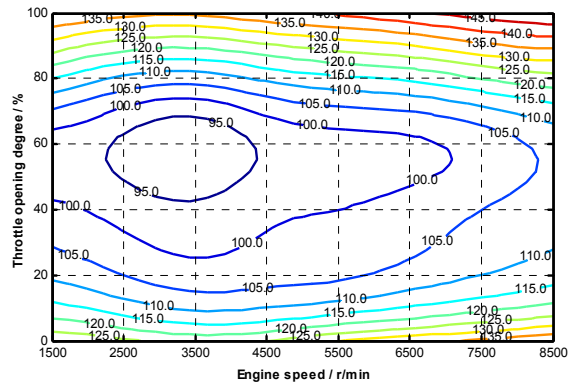
emission characteristic performance curve. Fig. 4 (d) is the CO emission characteristic performance curve. Fig. 4 (e) is the NO_x emission characteristic performance curve. Will be based on the MAP control effect with normal oxygen-enriched intake air intake engine work actual situation, this paper compares and analyzes the torque contrast results see Table 6, the rate of fuel consumption and HC contrast results see Table 7, CO and NO_x contrast results see Table 8.



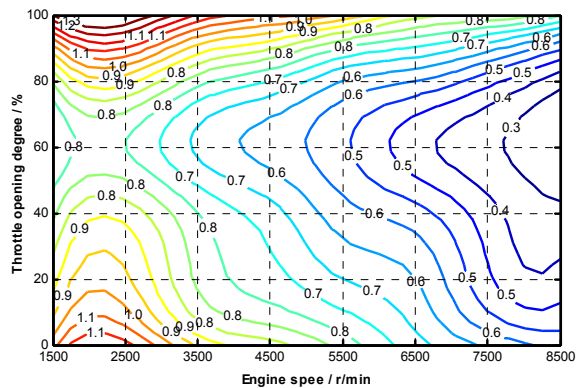
(a) The torque characteristic performance curve.



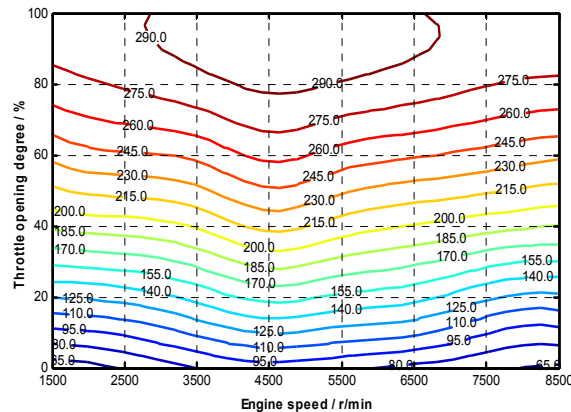
(b) Fuel consumption rate characteristic performance curve.



(c) HC emission characteristic performance curve.



(d) CO emission characteristic performance curve.

(e) NO_x emission characteristic performance curve.

Note: curve in Fig. (a) on the figures show that the torque value, the unit is n. m, in Fig. (b) curve on numerical figures show that the fuel consumption rate, the unit is g/kW.h., in Fig. (c) curve on the Numbers of HC emissions, unit for 10^{-6} , in Fig. (d) curve on the Numbers of CO emissions, unit for %; in Fig. (e) curve on the Numbers of NO_x emissions, unit is 10 to 6.

Fig. 4. Universal characteristic curve of engine based on the MAP control.

Can be seen from Table 6 - Table 8, combination intake MAP control can guarantee the comprehensive performance of gasoline engine, keep the throttle opening is 50 %, 75 % and 100 %, the average torque growth rate is 10.13 %, 8.95 % and 15.04 %; Keep the speed as 2000 r/min and 3000 r/min, the average fuel consumption rate decline rate is 10.12 % and 11.03 %, HC emissions of the average decline rate is

9.97 % and 10.89 %, CO emissions of the average decline rate is 12.46 % and 10.23 %, NO_x an average growth rate of 6.31 % and 6.14 %. Combination intake MAP control strategy, therefore, to improve the test engine performance and fuel economy, and to a certain extent, improve its emissions, improves the performance of the gasoline engine and improved.

Table 6. Inlet MAP compared with normal intake of torque control.

Performance index Inlet conditions	Throttle percentage (%)	Torque		
		MAX (N·m)	The max growth rate (%)	Average growth rate (%)
Combination intake MAP control	50	4.8	9.09	10.13
	75	6.7	8.06	8.95
	100	9.5	15.85	15.04
Normal admission	50	4.4	0	0
	75	6.2	0	0
	100	8.2	0	0

Table 7. Inlet MAP control compared with the normal intake rate of fuel consumption and HC.

Performance Index Inlet conditions	Rotate speed (r/min)	Fuel consumption rate			HC emission		
		Minimum value (g/kW·h)	The lowest value drop/growth (%)	The average value drop/growth (%)	Minimum value ($\times 10^{-6}$)	The lowest value drop/growth (%)	The average value drop/growth (%)
Combination intake MAP control	2000	174	10.77	10.12	103	-10.43	-9.97
	3000	159	9.66	11.03	95	-11.21	-10.89
Normal admission	2000	195	0	0	115	0	0
	3000	176	0	0	107	0	0

Table 8. Intake MAP control compared with normal intake of CO and NO_x.

Performance Index Inlet conditions	Rotate speed (r/min)	CO			NO _x		
		Minimum value (%)	The lowest value drop/growth (%)	The average value drop/growth (%)	Minimum value ($\times 10^{-6}$)	The lowest value drop/growth (%)	The average value drop/growth (%)
Combination intake MAP control	2000	0.80	-11.11	-12.46	70	6.06	6.31
	3000	0.75	-9.64	-10.23	73	5.80	6.14
Normal admission	2000	0.90	0	0	66	0	0
	3000	0.83	0	0	69	0	0

Note: the NO_x rate is the growth rate, so set it as positive value; and CO rate is the drop rate of numerical, so set the CO rate as a negative value in the table; and set the value of CO and NO_x as positive.

5. Conclusions

1) Constructed an Oxygen-enriched air inlet gas distribution system to test engine matching target oxygen volume fraction control and set up the engine bench test, it is able provides target oxygen volume fraction of oxygen enriched air intake to test stability of engine, implements the oxygen-enriched air inlet control gasoline engine. In the whole test process, oxygen-enriched intake measurement and control system can work stable and maximum control error should not more than $\pm 1.5\%$, average error is not more than $\pm 0.5\%$; maximum response time should less than 6 s, the average response time should not more than 5 s.

2) Adopting three interpolation to check the efficiency, based on this condition to suggest forming method of gasoline oxygen-enriched MAP. Then making the combined oxygen-enriched inlet value MAP and PWM matching controlling parameters to store in MC9S12DP256 mini processor USB. When

the engine is working, we can get the oxygen inlet value and PWM matching controlling parameters by the parameters of the working conditions. It can make the engine achieve the controlling combustion, also can decrease the time and improve the controlling.

3) Validated the control effect of universal characteristic test under the condition of combination control strategy, and compared with normal intake engine carries out a comparative analysis on the actual working condition, found when keep the throttle opening as 50 %, 75 % and 100 %, the average torque growth rate is 10.13 %, 8.95 % and 15.04 %; Keep the speed as 2000 r/min and 3000 r/min, the average fuel consumption rate decline rate is 10.12 % and 11.03 %, the average decline rate of the HC emissions is 9.97 % and 10.89 %, the average decline rate of the CO emissions is 12.46 % and 10.23 %, NO_x an average with growth rate of 6.31 % and 6.14 %.

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