Stratified Charge Flame Ignite in a Gasoline Engine Conform to the Engine Operating Regimes of Indicator of Combustion Characteristics and Burn Time and their Empirical Equations

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***Abstract* – Past and present, there are many studies related to the internal combustion engine to improve performance, reduce fuel consumption and emissions. In the literature, in order to increase the efficiency of engine combustion efficiency studies are an important part. In our study, parameters of the affecting the efficiency of combustion that indicator of combustion character and burn time can be determined by experimental methods, such as the values m and Z for different types of motors are intended to be detected. For this purpose, the experimental data were processed as mathematically and According to the obtained results, the empirical equations have been created in order to calculate m and z under different load and speed in the stratified charge flame ignite gasoline engine.**

***Keywords* – Stratified Charge,Gasoline Engine, Combustion Velocity, Engine Performance.**

1. Introduction

Internal combustion engine are divided into spark ignition engine and compression ignition engine. Combustion for gasoline engines start with ignition by spark plug of air-fuel mixture into the cylinder. Diesel engines and HCCI (Homogeneous charge compression ignition) engines rely solely on heat and pressure created by the engine in its compression process for ignition. The compression level that occurs is usually twice or more than a gasoline engine. Diesel engines take in air only, and shortly before peak compression, spray a small quantity of diesel fuel into the cylinder via a fuel injector that allows the fuel to instantly ignite [1]. In its simplest form combustion are described as reaction with oxygen of substances. Combustion are divided into lean burning and complete burning in the internal combustion engine. There are many parameters which affect the formation of combustion (Speed, Inlet pressure and temperature, Amount of the residual gas, The compression ratio, The combustion chamber shape, The combustion chamber wall temperature, The ignition advance, The air excesscoefficient as). As well as constants of combustions know is very important in the engine.

As is known, the calculation method of combustion has predicted to determine suitable for burn laws of relative burning rate or mass ratio of burned fuel changes. There are many empiric formulas about depend on chemical kinetics theoretical principles equations. In order to calculate of most favorable analytical expressions related to burned fuel mass ratio was given by Russian scientist I.I.Vibe [2].

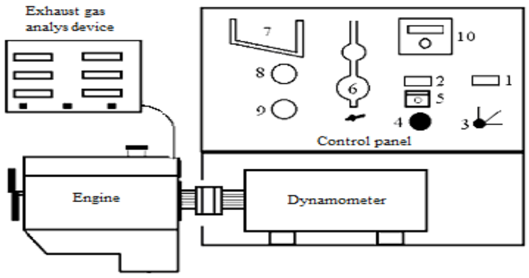
$$x = 1 - \exp\left[-6,908\left(\frac{\varphi}{\varphi_z}\right)^{m+1}\right] \tag{1}$$

The equation has included only m and $\varphi_z$parameters. $\varphi_z$from this equation has interested combustion dynamic and m has characterized quality factor. The equation of I.I.Vebe has been adopted by many scientists; therefore referred formula given engine cycle modeling is taken as a basis [3, 4, 5].

In this study main aim, burning time and indicator of burn character are determine by use mathematic model in the stratified charge flame ignite gasoline engine.

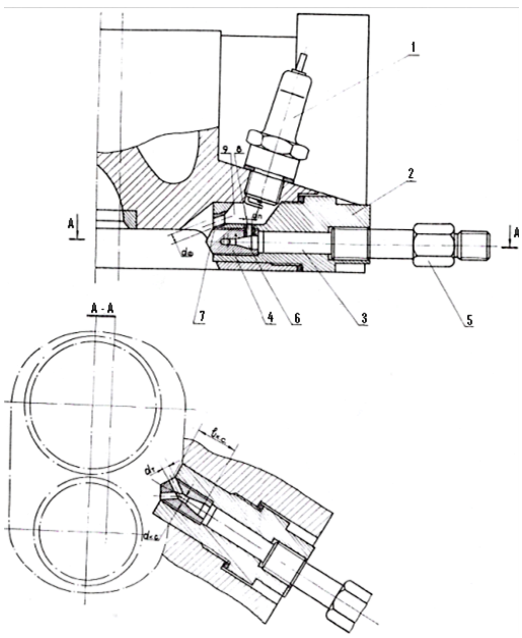
2. Material method

Experiments were conducted on a single cylinder gasoline engine. Test engine has charged with stratified principle and ignitions with flame ignite. The schematic display of the engine used in the experiments has been given in Figure 1 and its The shape of the combustion chamber appearance has been given in Figure 2 while its properties have been listed in Table 1.



1-Power indicator
2- Rotation indicator
3- Switch key
4- Emergency stop Button
5- Loading button
6- Fuel measurement tube
7- Skewed Manometer
8- Oil pressure indicator
9- Manifold vacuum indicator
10-Temperature indicator

Figure 1. Schematic view of test mechanism.



1-Spark plug, 2-Clynder hade block,
3- FB-IF injector valve, 4-injector nozzle,
5- Fastening nut, 6-Mixture chamber,
7-Flame nozzle, 8-Blower tube,
9-Precombustion chamber.

Figure 2. Combustion Chamber of TST-GAZ-24FV Engine.

Table 1. Technical features of test engine.

Type of engine	**Four-cycle, stratified charge gasoline engine**
Number of cylinders	1
Cylinder diameter x stroke (mm)	92 x 92
Cylinder volume (cm^3)	0,6115 dm3
Compression rate	8:1
Maximum power	6000 min-1’ kW
Maximum moment	3300 min-1’ Nm
Fuel system	Fuel injection
Intake valve opening advance	120(before T.D.C)
Intake valve closing delay	600 (After B.D.C)
Exhaust valve opening advance	540(before B.D.C)
Exhaust valve closing delay	180 (After T.D.C)
Fuel used	Gasoline
Injector injecting pressure	3,5 MPa
Ignition system	Mechanical ignition

Experimental Apparatus installation project basis and have been prepared in Gorky Automotive Factory in the Russia. Infra-red ray Mex -400 device was used for analysis of toxic components in the exhaust gas.

3. Equation Sets

In this case, it is required to generate the correlation between engine operating modes with together data which obtained from experiments. There is different theoretical correlation in order to calculate of m and z values for different types of engine.

The following equation was obtained as a result of processing of G.Woschni numerical combustion curve in the diesel engines [3].

$$m = m_0 \left(\frac{\varphi_{\tau_{i0}}}{\varphi_{\tau_i}} \right)^{0,5} \left(\frac{P_a}{P_{a0}} \cdot \frac{T_{a0}}{T_a} \right) \left(\frac{n}{n_0} \right)^{0,8} \qquad (2)$$

$$\varphi_z = \varphi_{z0} \left(\frac{\lambda_0}{\lambda} \right)^{0,6} \left(\frac{n}{n_0} \right)^{0,5} \qquad (3)$$

Z: Ignition delay periodic
λ : excess air coefficient
P_a, T_a : Intake finale pressure and temperature
0 : Indicates that parameter belong to nominal regime

According to literature these equations have given to determine indicate efficiency via mathematical method for only diesel engines.

A similar but simplified equations are derived by Maragopal[6].

$$m = m_0 \left(\frac{\tau_{i0}}{\tau_i} \right)^{0,38} \left(\frac{n_0}{n} \right)^{0,32} \qquad (4)$$

$$\varphi_z = \varphi_{z0} \left(\frac{\lambda_0}{\lambda}\right)^{0,54} \left(\frac{n}{n_0}\right)^{0,5} \quad (5)$$

T_{i0} : Ignition delay time.

L.A. Samsonov has achieved the following formula by use of experimental method and mathematical method for low speed marine diesel engines[7].

$$m = 0,48 - 6,877 \cdot 10^{-4} n + 0,4535 q_ç + 0,001283 P_s^p - 0,000288 T_s^p \quad (6)$$

$$\varphi_z = -31,43 + 0,1036\, n + 6325 q_ç - 0,3047 P_s^p + 0,03283 T_s^p \quad (7)$$

n: Number of crankshaft rotation
$q_ç$: The amount of fuel injected per cycle
P_s^p, T_s^p, Getting started injecting fuel into the cylinder pressure and temperature

R.M. Petricenko has been creating the following equation as a result of experimental information from diesel engine indicator diagram[8].

$$\frac{1}{m+1}\left(\varphi_z^m\right)^{0,192} = 1,09 \quad (8)$$

The following equation was purposed to determine for φ_z depending on the engine load (f) and $\vartheta = \varphi_z^0 / \varphi_z^H$ the characteristics.

$$\frac{\varphi_z}{\varphi_z^H} = 1 - (1 - \vartheta)(1 - f) \quad (9)$$

φ_z^0 : Combustion time under the nominal load condition.
φ_z^H: Combustion time under the free load condition.

As shown, all these empirical formulas of m and z are obtained experimentally for diesel engines and naturally, valid for these engines. Result of our research all these empirical equations has been not found to be suitable for our test engine for determine m and φ_z.

In order to solve this problem, the obtained experimental data is analyzed mathematically. The following equation was obtained depend on different load and rotation speed by our in order to determine m and φ_z.

$$m = m_0 \left(\frac{\lambda_0}{\lambda} \cdot \frac{n}{n_0}\right)^{0,2} \quad (10)$$

$$\varphi_z = \varphi_{z0} \left(\frac{\lambda}{\lambda_0}\right)^{1,15} \left(\frac{n}{n_0}\right)^{0,325} \left(\frac{\eta_{v0}}{\eta_v}\right)^{0,55} \quad (11)$$

$n_0 = 4500\,\text{rpm};\ \eta_{v0} = 0,82;\ \lambda_0 = 1,0;\ m_0 = 2,4$ ve $\varphi_{z0} = 68^0$ c.s.a

$\lambda = 0,9 - 1,6;\ n = 1000 - 4500\,\text{rpm};\ \eta_v = 0,40 - 0,85$
$\varepsilon \le 9$

These equations have valid under $\lambda = 0,9 - 1,6;\ n = 1000 - 4500\,\text{dev/dak};\ \eta_v = 0,40 - 0,85$ $\varepsilon \le 9$ conditions. As shown in formulation (10) m depends on only excess air coefficient and crank shaft rotation speed. This situation was shown in figure 3. Also φ_z In addition to the specified parameters depend on η_v. 11. Equation outputs are shown in Figure 4.

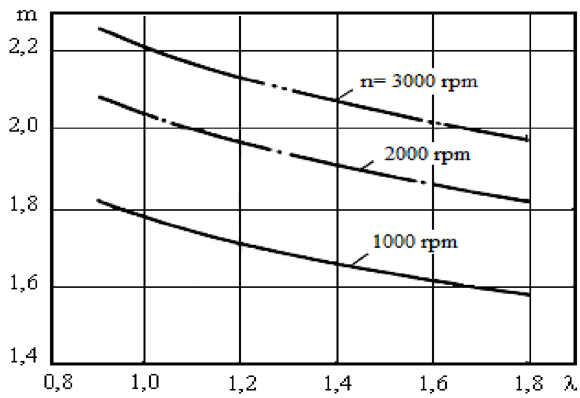


Figure 3a. Changed of m according to n and λ

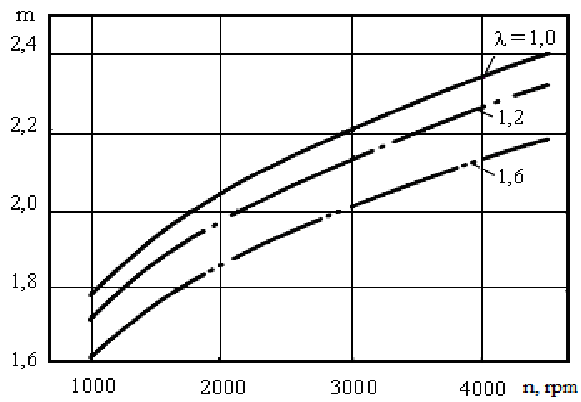


Figure 3b. Changed of m according to n and λ

Indicators of combustion character (m) are shown in figure 1a and figure 3b. As shown, the m value continuously decreased with increase of λ for different crank shaft rotate speed (1000, 2000, 3000 rpm). Moreover, this decrease λ = 0.9 to 1.2 range is faster. Combustion deceleration is associated with decrease of maximum combustion pressure (P_{max}), maximum combustion temperature (T_{max}) and maximum increase rate (Wp_{max}). As shown figure 3b m value is continuously increased with crank shaft speed and different λ (1.0, 1.2, 1.6)

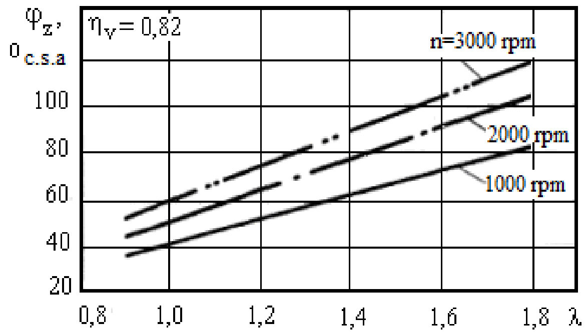


Figure 4a. Changed of φ_z according to n and λ

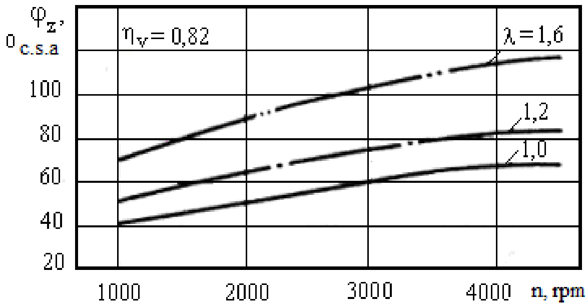


Figure 4b. Changed of φ_z according to n and λ

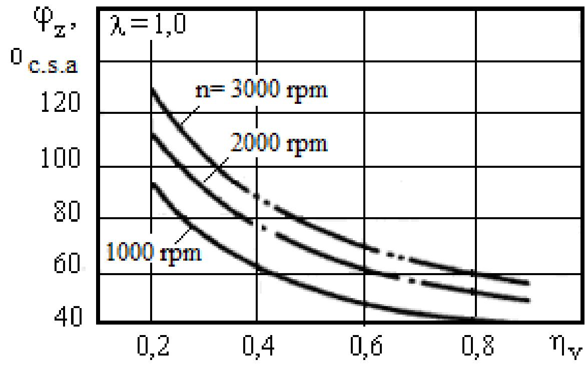


Figure 4c. Changed of φ_z according to n and η_v

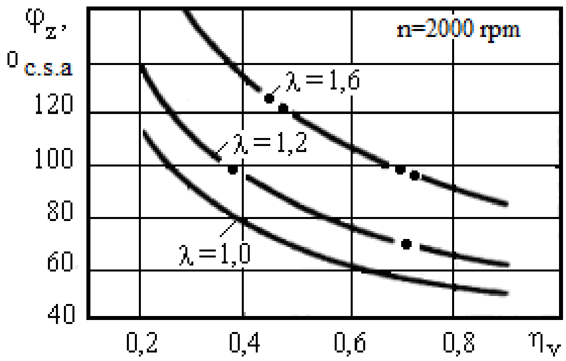


Figure 4d. Changed of φ_z according to n and η_v

As shown figure 4a and 4b, φ_z is increased with λ and crank shaft speeds. In this situation is deriving from low combustion ratio lean mixture.

4. Result and discussion

As a result of literature research, I.I. Vibe equation was shown to not suitable for fuel injection engine and flame ignition engine of φ_z. In order to solve this problem, in this study was developed new equation. m and φ_z was calculated for various engine loads and rotate speeds. Obtained data from experiments and theoretical study is compatible. It has indicated that new formulas was suitable for the calculate m and φ_z values.

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