Stratified Charge Combustion in the Special Chamber of the IC Piston Engine

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Abstract

To satisfy the requirements of the latest standards of emission from the automobile engines (for example, EURO-2 standards) it is required to apply the three-way catalytic converter, which not only increases its initial cost of the car by an order of 2000-4000 $, but also promotes the increase of fuel consumption by 10-15%. In this connection the development of effective combustion process ensuring the operation of the IC engine on lean mixtures ($\lambda_1 \approx 1,5$) on basic working modes, is rather actual. By carrying out of deep fundamental researches and numerous experiments significant progress was obtained to solve this problem.

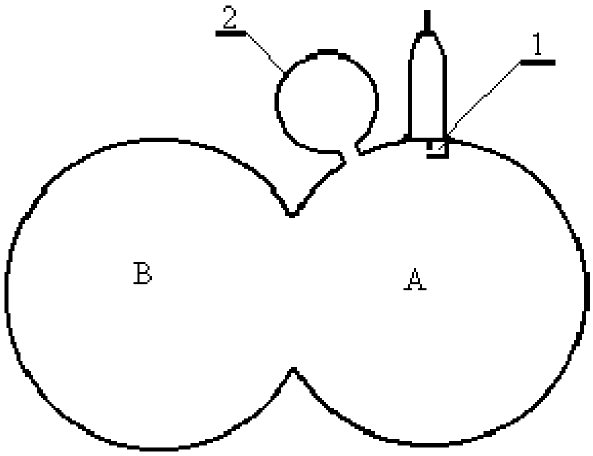

Fig.1. Principal scheme of combustion chamber for multi-stage combustion process of deeply stratified charge. 1-spark plug, 2-turbulizer

Schematic diagram of combustion chamber (CC) for executing combustion of the lean mixture is shown on Fig.1. CC has the form like "∞", so it is possible to create two axial vortices (swirls) of similar intensity but opposite directions of rotation. The swirl A consists of rich mixture (λ_1= 0.5-0.7). Spark plug 1 and pre-chamber turbulizer 2 are located close to this area. The swirl B consists of air ($\lambda = \infty$). The equality of torque of these swirls doesn't allow mixing of rich charge and air until combustion process starts. This makes possible the formation of deeply stratified charge in the cavity of CC. So at all loading conditions rich mixture is ignited around the spark plug electrode. After ignition at θ_1= 10-20 the flame is moving to the center of cavity by swirls A and thus ensures the burning of rich mixture only (with a λ_1). As the consequence of combustion of the rich charge the pressure increases and flame transfer from cavity A to the cavity B. Running in tangential direction to swirls A and B at first the torch of burning gases turbulizes and ignites the rich part of stratified mixture (I stage of combustion process), then it transfers unburned products to cavity B by gasodynamical process. After this the afterburning of partially reacted products of the rich charge take place in cavity B (II stage of combustion process).

The turbulizer ensures the burning of stratified charges in two swirls. It is thus executing two main functions. First, its accelerates the burning of rich charge (λ_1=0.5¸0.7) by generating turbulence (otherwise, in ordinary conditions, the rich charge would burn with low velocity). Second function of the turbulizer is to transport partially burned products to the air zone (cavity B) for completion of combustion.

Thus, two-stage combustion process of fuel-air mixture is achieved: at first in the rich part, in the main part of the central zone of CC (torch action zone) and then in the lean burn zone. High efficiency of combustion and low emission of pollutants is thus carried out in spark ignition engines. Additionally, detonation firmness of this process almost abolishes the engine requirements of high fuels octane number. This allows to apply optimal compression ratio (ε= 11-12) by using ordinary gasoline, kerosene, or any combustible gases (compressed or liquid) as well as the alternative fuels of synthetic origin. The high compression ratio gives possibility to increase of fuel efficiency and engine's power.

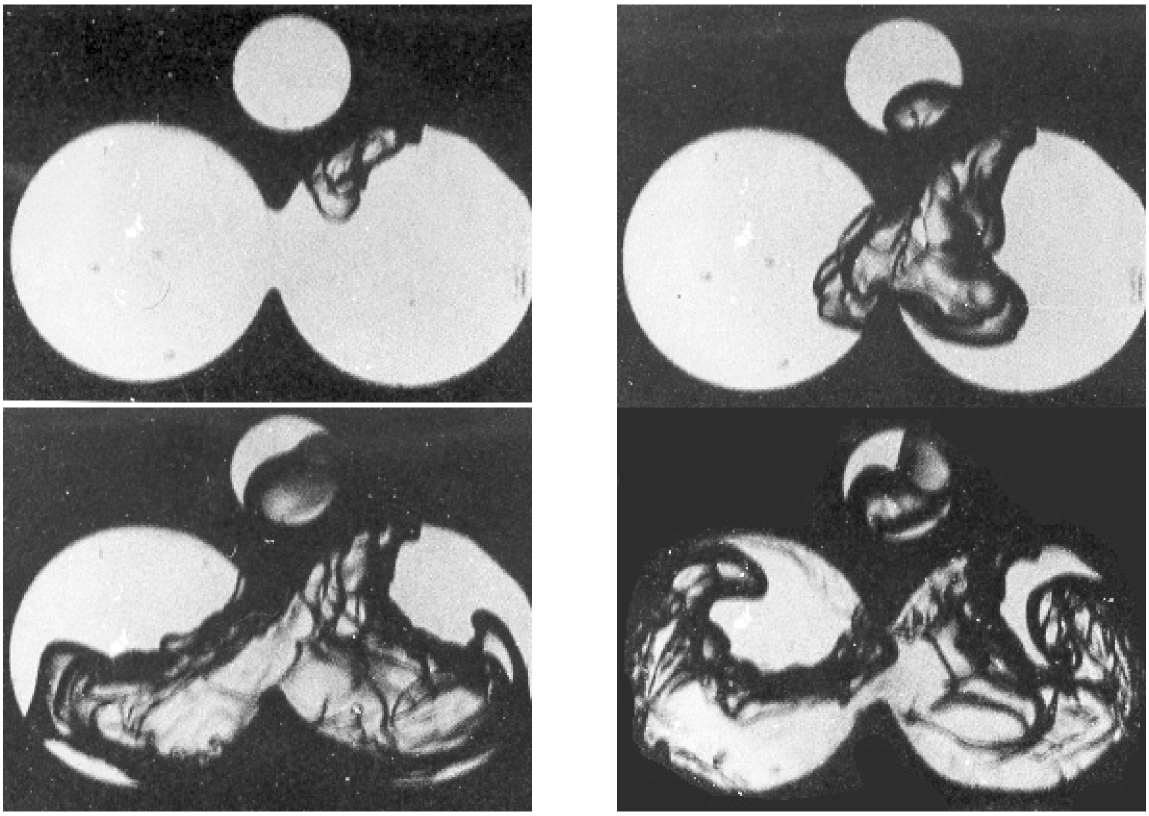

Fig.2. Schlieren pictures of staged combustion process of stratified charge in the oppositely rotated swirls.

Modeling research of such combustion were carried out at the research constant volume test chamber. Typical pictures showing flame propagation in modeling chamber with opposite rotating swirls is presented at Fig.2. It can be clearly seen that flame first propagate inside the cavity occupied with reach mixture and then transfer to other cavity.

Bench tests of the experimental 4-cylinder and 2-valve engines GAZ (S/D'/92 nun), VAZ (S/D,/76 mm), MeMZ (S/Df/76 mm) and 4-valve research single cylinder engine showed that using this combustion system:

1) compression ratio can be increased up to its optimal values (ε=11-12) by using the normal gasoline only (octane number of 90-93),

2) possibility of the effective work of the engine with the fuel-air mixture in the range of λ= 0.96-2.5. Engine works very stable even at the very lean charge (λ==3.0-3.5);

3) specific effective fuel consumption under all condition decreases by 10-15 % and the power increases by 5 - 7 %,

4)emission of unburned hydrocarbons CH_x does not exceed 20-50 ppm and carbon oxide (CO) does not exceed 0.2-0.3 % under the idling conditions. The maximum emission of nitrogen oxide (NO) takes place on the nominal engine load and does not exceeds 1000-1200 ppm, and at main exploitation loads NO emission does not exceed 500-600 ppm.

The elaborated engine was tested also at the road conditions in the automobile GAZ-31029. Following results was obtained: automobile without using the catalyzer satisfies EURO-2 standard. Moreover, the fuel economy was improved in the city conditions and on the highway while using the low octane gasoline A-76 (octane number of the fuel is 76 according the motor method) instead the gasoline AI-93 (octane number of the gasoline is 93 according the research method).

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