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THE INFLUENCE OF THE SHAPE OF THE COMBUSTION CHAMBER ON EXHAUST GASES TOXICITY IN T370 ENGINE

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Abstract

An important issue in construction of combustion chamber in compression-ignition engines is proper selection of its shape and size. Both features are dependent on several factors such as fuel injector location and angle, spray atomizer selection (amount of holes, their diameter and angular position), location of inlet valve and air turbulence. By doing research on prototype engine T370, an analysis of influence of combustion chamber size and its modifications going towards lip construction on flue gas toxicity was done. The diameter and depth of combustion chamber was being changed while maintaining the same compression ratio. After that, a modification of tested combustion chambers was made by creating so called "lip", which aim was to create a swirl of injected fuel in the vertical plane. To visualize the changes in swirl, a numerical analysis of fuel injection into combustion chamber was made. In discussed study, emission tests were performed according to ECE-R49. During the research six combustion chambers with diameters 60, 63 and 66 mm (and their modification) were investigated. Tests were performed for several types of injectors and different injection timing. However, for analysis of combustion chamber size the results are presented for the same injectors but with optimized injection timing.

Keywords: *diesel engine, combustion chamber, geometry, toxicity*

1. Introduction

A major problem in the design of the combustion chamber in self-ignition engine is an individual choice of its shape and size [1]. Both features depend on various factors such as the location and the position of the angle of the injector, the selection of the atomizer (number and diameter of the holes and their angular position), the position of the intake valve and a swirl of air [2, 3, 4, 5]. Computer analysis gives answers or hints to some of them [7]. Research on prototypes is used for verification of previously done assumptions [6].

Doing the research on a prototype engine T370, we have carried out the analysis of the combustion chamber size and its modifications reaching towards the chamber "lip" on the toxicity of exhaust gases [8].

2. Preliminary research

Engine T-370 by design was equipped with injection pump P74 and turbocharger B65 with exhaust vent and combustion chamber with diameter of 57 mm. In engine test stands, it achieved following results:

- maximum power 79.4 kW/2400 rpm,
- maximum torque 390 Nm/1400 rpm,
- specific fuel consumption at N_{max} 232 g/kWh,
- minimum consumption 218 g/kWh,
- emissions of toxic exhaust gas components according to ECE-R49 (Tab. 1).

New injectors and intercoolers were used in the engine. After the modifications, the following results were obtained in test ECE-R49 (Tab. 2).

Tab. 1. Emission of CO, HC, NOx according ECE-R49 for T370 engine – design version

Emissions	CO [g/kWh]	HC [g/kWh]	NOx [g/kWh]
ECE R 49	2.02	2.20	14.55

Tab. 2. Emission of CO, HC, NOx according ECE-R49 for T370 engine – modified version

Emissions	CO [g/kWh]	HC [g/kWh]	NOx [g/kWh]
ECE R 49	1.85	1.04	8.6

3. Test of engine with new combustion chambers

In the next, stage of the research three new versions of cylinders with experimental combustion chambers with diameters of 60, 63 and 66 mm (Fig. 1-3). Depth of combustion chambers was adjusted to keep constant compression ratio of value about 17. Tests were performed for several types of injectors and different injection timing. However, for analysis of combustion chamber size the results are presented for the same injectors but with optimized injection timing.

The results of the best emission tests for different combustion chambers are presented below. In the table calculation of ratio between chamber depth and its diameter (*h*/*D*) and combustion chamber surface area is also presented.

Tab. 3. Comparison of CO, HC, NO_x emissions for combustion chambers with diameters 60, 63, 66 mm

Chamber	α [°CA]	CO [g/kWh]	HC [g/kWh]	NO_x [g/kWh]	D_M/D_N [°B]	h/D [–]
60	10	1.9	0.79	8.5	0.9/1.9	0.36
63	11	2.1	0.83	10.0	0.65/1.8	0.32
66	12	2.2	0.8	12.5	0.65/1.6	0.28

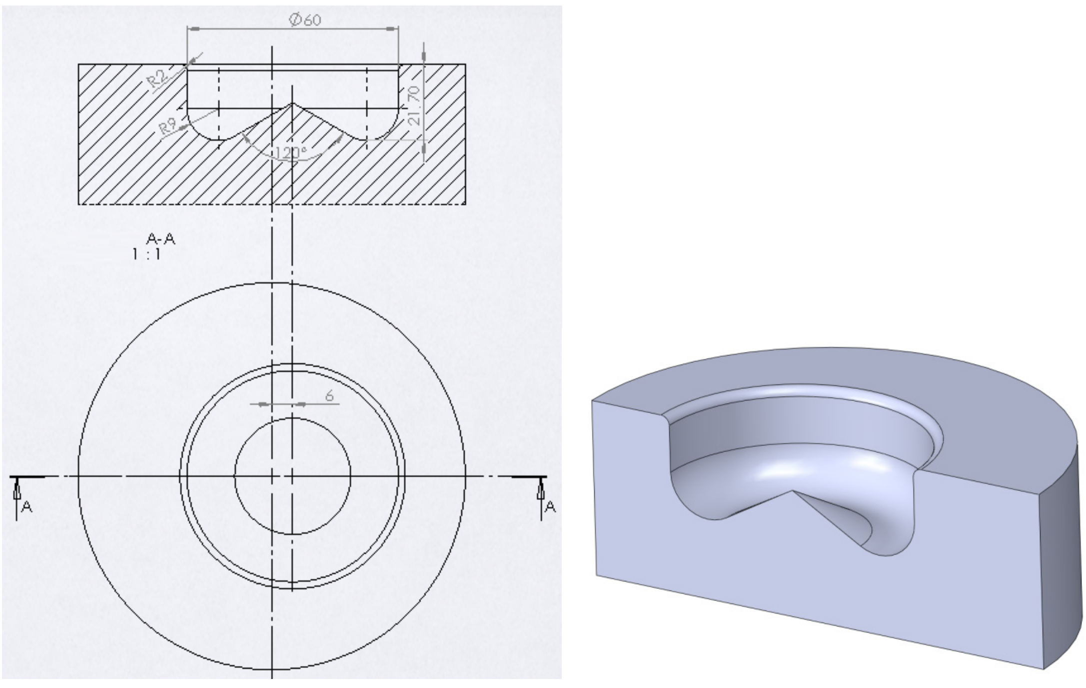

Fig. 1. Combustion chamber "60" picture and view

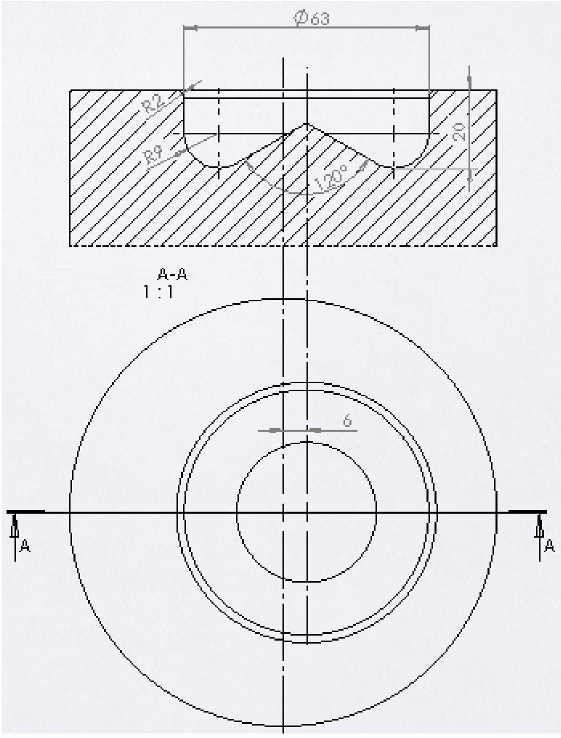

Fig. 2. Combustion chamber "63" picture

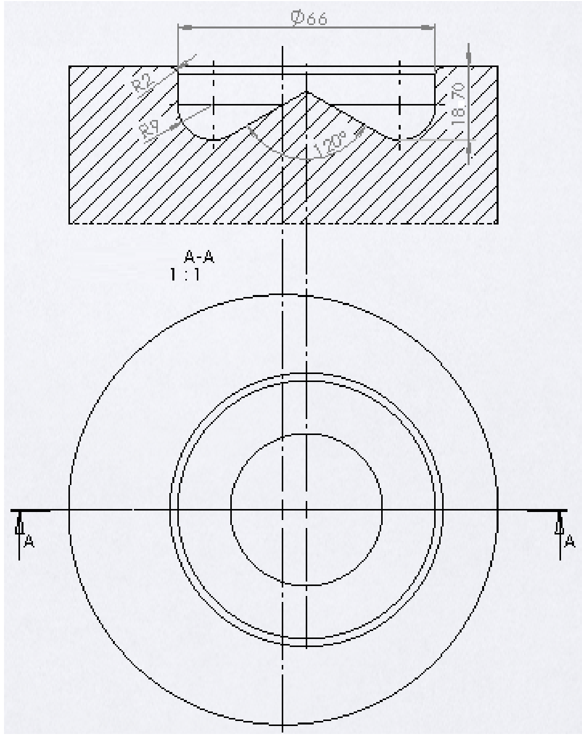

Fig. 3. Combustion chamber "66" picture

In next stage, a modification of combustion chamber shape was made by introducing inclination of chamber walls and thus obtaining a lip effect to force swirl of injected fuel in vertical plane. Geometries of the combustion chambers with marked modifications are shown in Fig. 4 and 5. Tests of chamber 66w were abandoned due to not satisfactory results at first measurement points of the toxicity test. Taken undercut both chambers at an angle of 10 degrees and a radius of 9 mm.

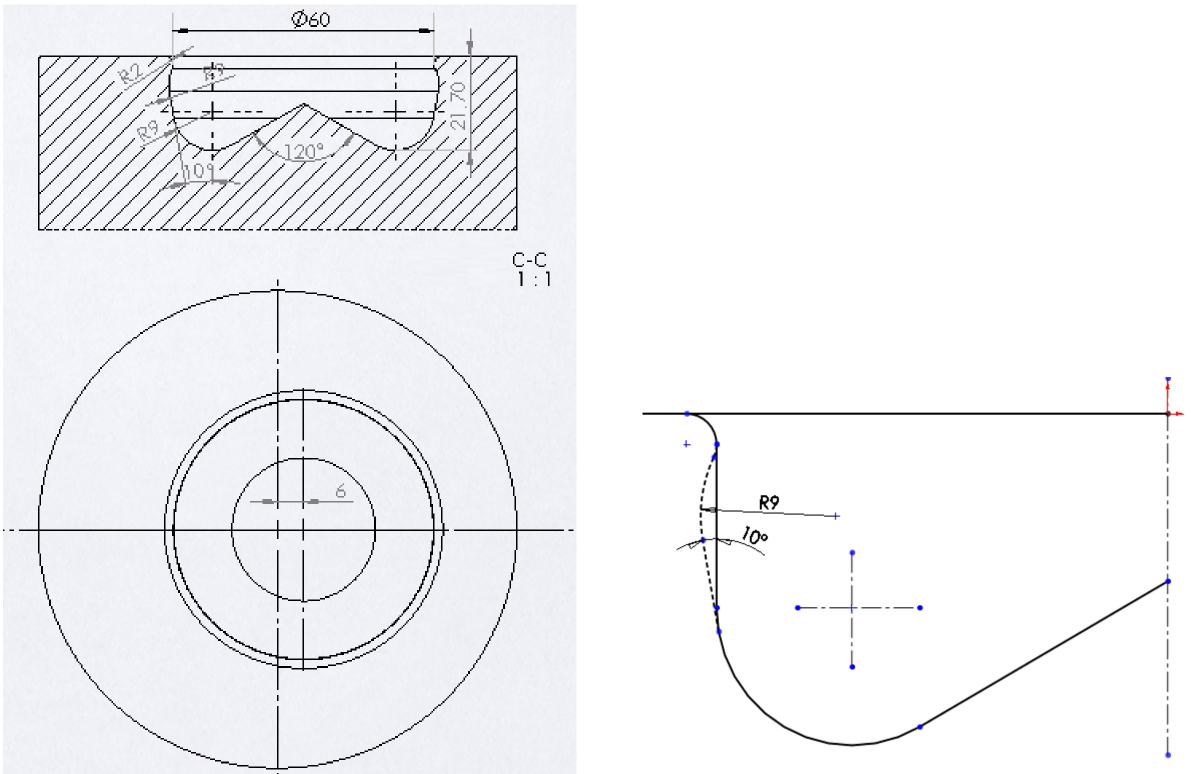

Fig. 4. Picture of chamber "60w" with marked changes from chamber "60"

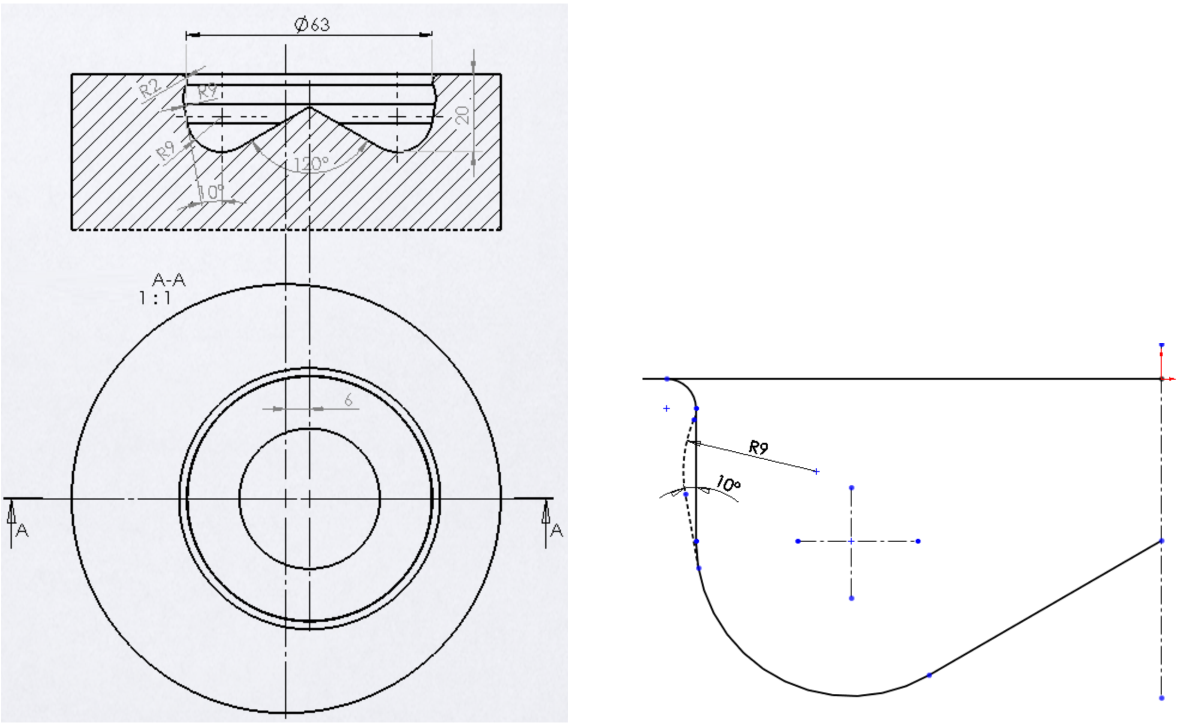

Fig. 5. Picture of chamber "63w" with marked changes from chamber "63"

For combustion chambers with diameter of 60 mm numerical computations of injected fuel velocity distribution were done. Influence of air turbulence in horizontal plane caused by shape of inlet channel was not taken into account.

Analysis has confirmed the assumption of lip's strong influence on fuel swirl. In chamber without the lip, it is visible that streams are bouncing from the cylindrical chamber's wall.

Tab. 5. Comparison of CO, HC, NO_x emissions for modificated combustion chambers "60w" and "63w"

Chamber	α [°CA]	CO [g/kWh]	HC [g/kWh]	NO_x [g/kWh]	D_M/D_N [°B]	h/D [–]
60	10	1.9	0.79	8.5	0.9/1.9	0.36
60w	5	1.66	0.89	6.77	0.7/1.5	0.36
63	11	2.1	0.83	10.0	0.65/1.8	0.32
63w	8.5	1.72	0.71	6.96	0.7/1.5	0.32

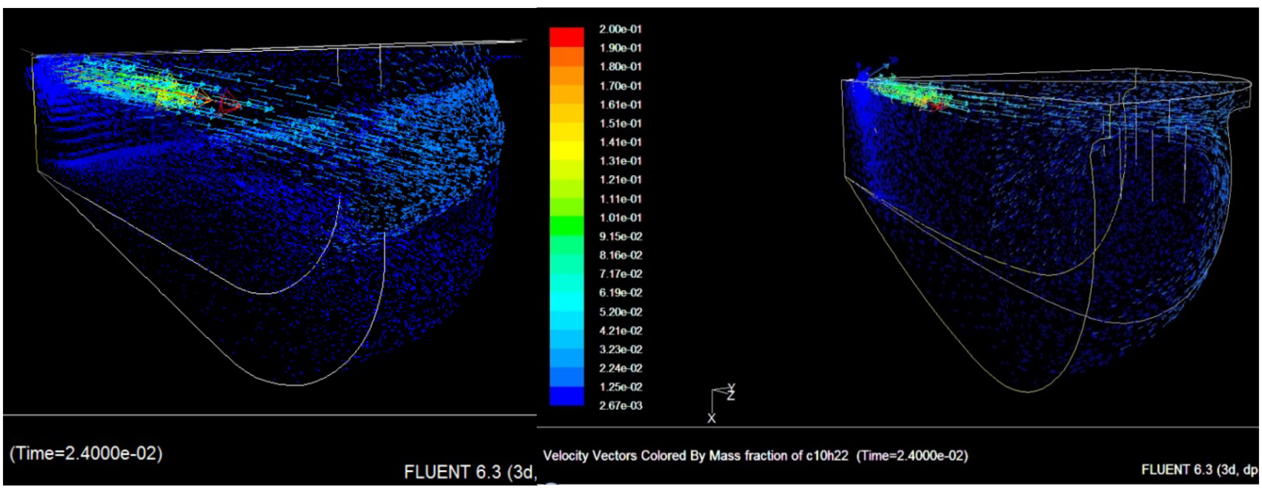

Fig. 6. Distribution of injected fuel streams into channels "60" and "60w" – 3D view

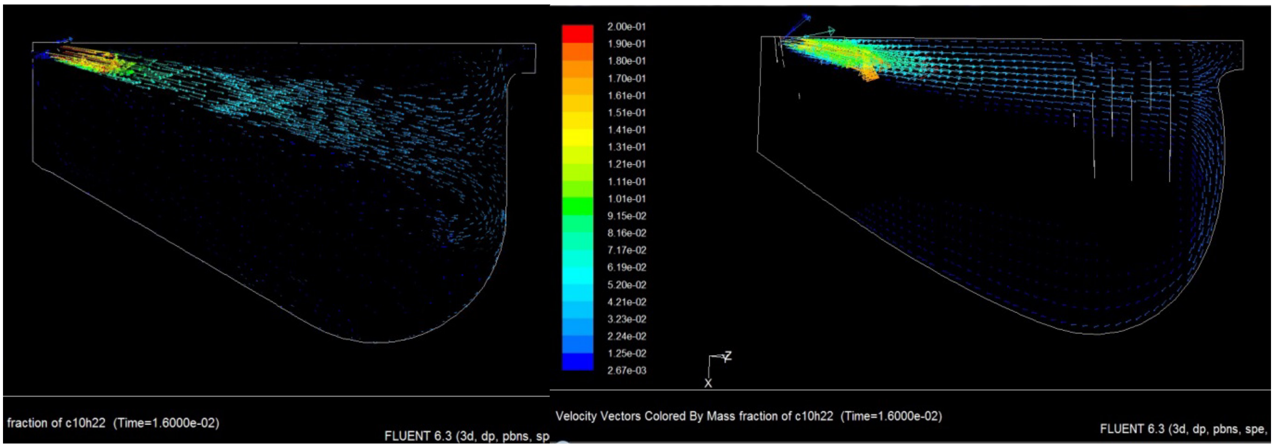

Fig. 7. Distribution of injected fuel streams into channels "60" and "60w" – 2D view

4. Summary

In tested engine T370 3 types of experimental combustion chambers with varying *h*/*D* ratio and same compression ratio were investigated. Reduction of combustion chamber diameter with increasing its depth at the same time (increasing *h*/*D* ratio) gave following results during emissions tests:

a) small drop of CO emission – 15%,
b) practically unchanged HC emission,
c) drop of NO_x emission by 50%,
d) raise of smoke-developed index by 15%.

For two chambers of diameters 60 and 63 mm, shape modification was made by creating a lip. This modification caused following effects.

a) drop of CO emissions (12-18%) and NO_x emissions (30-32%),
b) decrease of smoke-developed index by 20% on average.

The study has confirmed that combustion chamber should have a compact shape and that it is beneficial to construct them with highest *h*/*D* ratio (for minimization of surface)

Small changes in shape of combustion chamber can have significant influence on level of emissions of toxic flue gas components.

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