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THE INFLUENCE OF THE SIZE AND SHAPE OF THE "CENTRAL BODY" OF A COMBUSTION CHAMBER ON THE TOXICITY OF THE EXHAUST GASES IN THE URSUS 4390 ENGINE

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Abstract

This work is the third part of the articles published on the effects of the shape and position of the combustion chamber in piston compression diesel engines on the toxicity of exhaust gases. In two previous articles presented at the KONES 2015 conference, the impact of position of the combustion chamber in relation to position of the injector, and the influence of the shape of the chamber (diameter, depth, lip on the CO, HC and NOx emissions was analysed. In the current article, the shape of the "central body" in a combustion chamber is analysed. "Central body" is the protrusion located in the central part of a toroidal combustion chamber. Subsequent modifications to the basic combustion chamber consisted of reducing the size of this protrusion. The study involved four versions of combustion chambers. Modifications caused a slight decrease in the compression ratio, which could have an impact on the unambiguousness of the results, as the effect of changes in shape of the "central body". However, to maintain a constant compression ratio would require a change in diameter or depth of the chamber cavity, which would obscure the obtained results with even greater impact. Emission tests in discussed study were performed according to ECE-R4. During the tests, the completion of the engine and the engine settings were not changed.

Keywords: *combustion engines, toxicity, combustion chamber*

1. Introduction

The design of a diesel engine must ensure both established, very good engine parameters (power, torque, fuel consumption), and meet the stringent requirements constraining the emission of toxic exhaust gases (CO, CH, NOx and PT). The design of a combustion chamber, its shape and position, is one of the factors responsible for both of the aspects mentioned above [1, 8]. The changed aspects may be diameter, chamber depth; pitches angles of the walls, lip shape, geometry of the torus in case of toroidal chamber [2-4, 7].

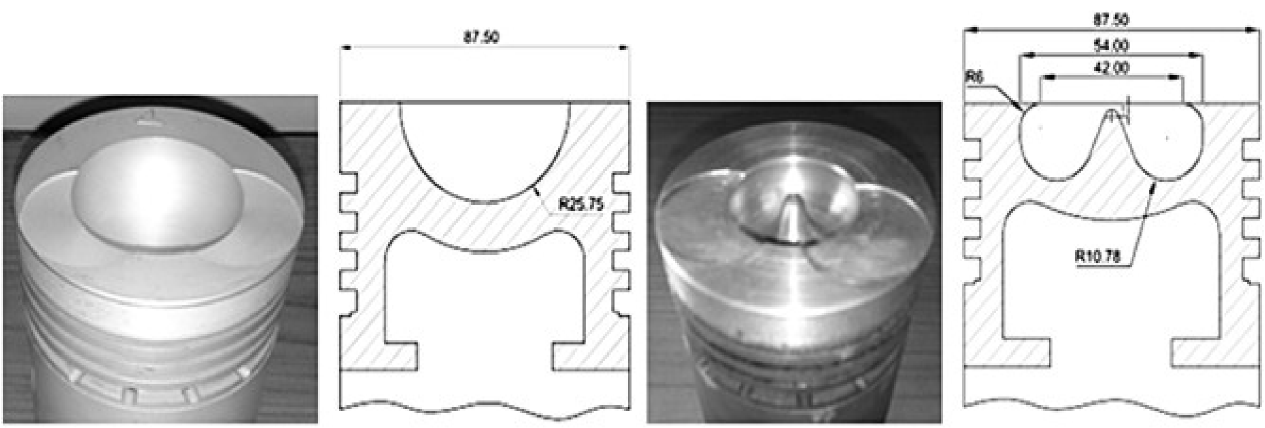

Fig. 1. Examples of studied combustion chambers [1]

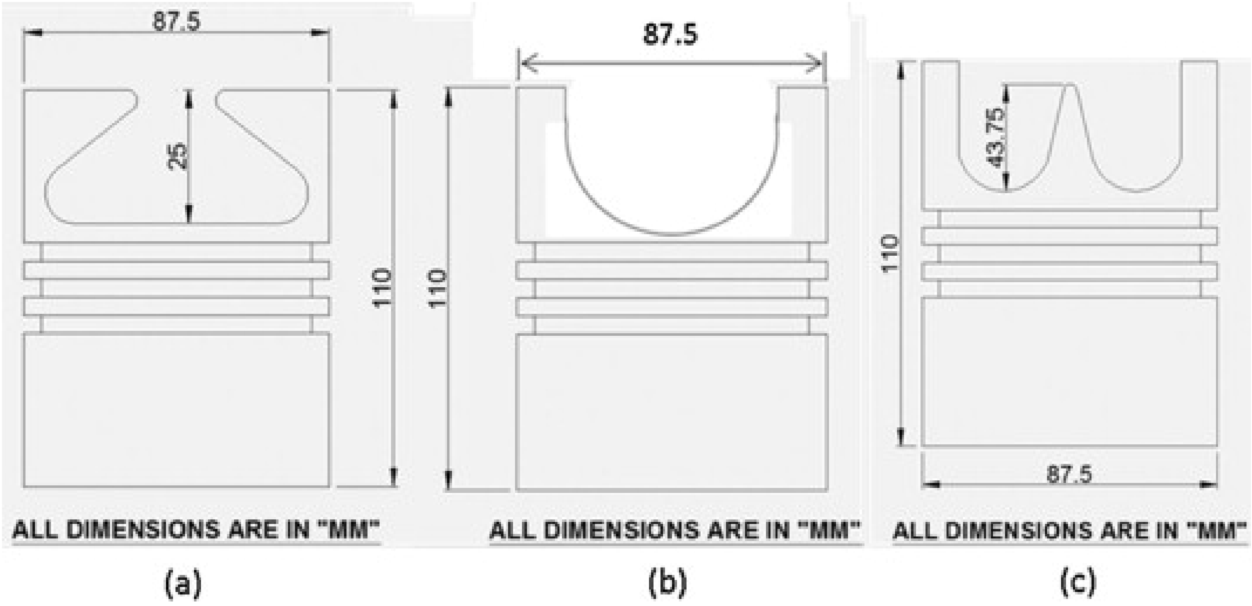

Fig. 2. Examples of studied combustion chambers [2]

In articles "The Influence of the Shape of the Combustion Chamber on Exhaust Gases Toxicity in T370 Engine" [6] and "The Effect of Location the Combustion Chamber for the Toxicity Exhaust in Self Ignition Engine Ursus 4390" [5] presented on KONES 2015 conference, analysis of the impact of selected design factors on the toxicity of diesel engine exhaust gases was shown.

This article focuses on the influence of the shape and size of "central body" in the combustion chamber on the toxicity of exhaust gases. The study was conducted on an experimental Ursus 4390 engine equipped with the same injection equipment (Lucas) and identical injectors (Bosch, with 22 MPa of opening pressure). Changes in the shape of the combustion chamber were introduced in order to minimize the impact of other factors on the toxicity of exhaust gases (compression ratio).

Toxicity tests were performed in accordance with ECE R49 rev. 2 regulations. In addition, smoke opacity was measured at points of maximum torque and rated power.

2. Research on engine with experimental combustion chamber

The engine URSUS 4390 was licensed by Perkins – it was a counterpart of engine A4.236. It was an atmospheric 4-cylinder engine with direct injection:

- Diameter/stroke 98.43/127 mm,
- Displacement 3865 cm^3,
- Compression ratio 17,
- Power 44.5 kW,
- Torque 234 Nm/1400 rpm.

The research began with testing the Ursus 4390 engine equipped with a combustion chamber of the shape presented in Fig. 3. Location of the chamber was identical to the factory chamber, which means offset about 3.18 mm from the piston axis in the transverse direction of the engine.

Tab. 1. Results of ECE R49 test for the engine with combustion chamber „55"

	ε	CO	CH	NOx	$D_{Mo/Ne}$
	[-]	[g/kWh]	[g/kWh]	[g/kWh]	[°B]
Chamber „55"	17.45	7.00	1.24	10.73	3.8/2.7

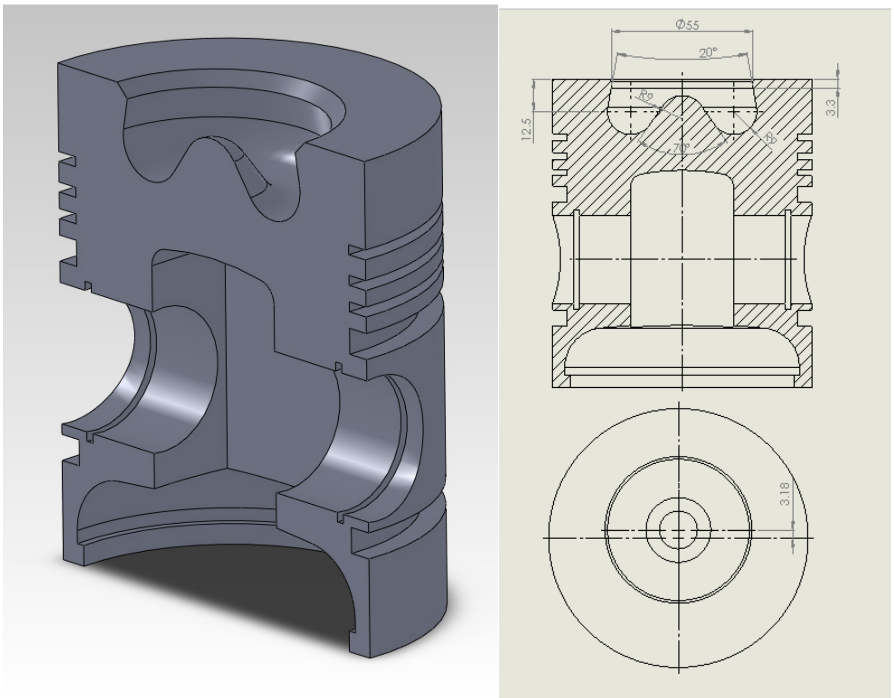

Fig. 3. The position and shape of the combustion chamber„55"

In the next stage, the central body was reduced according to Fig. 4.

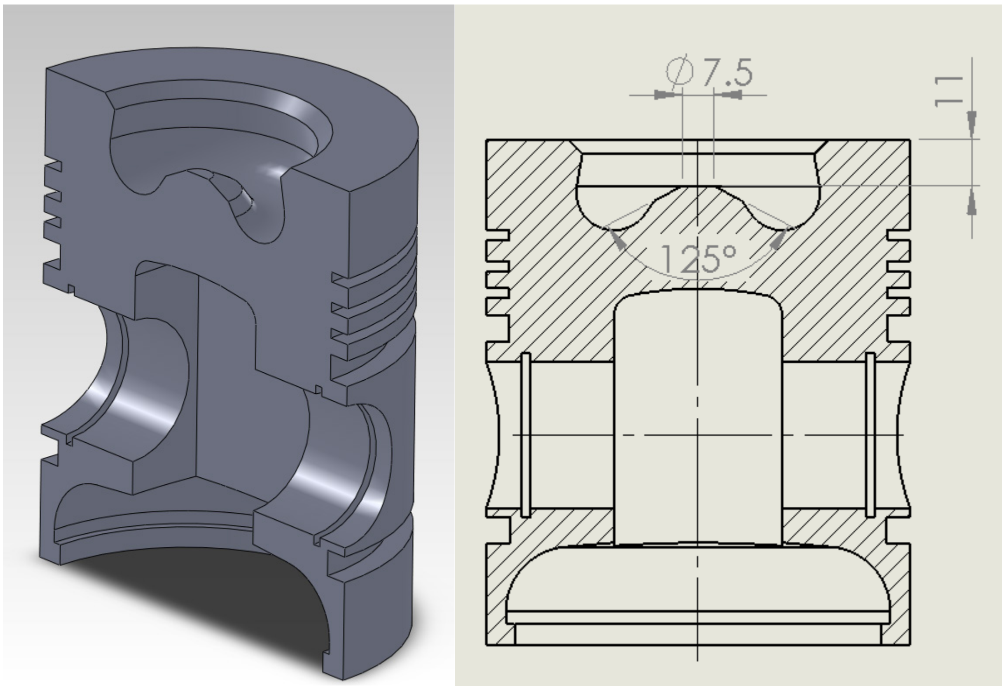

Fig. 4. The shape of the chamber „55a"

Following results were obtained in the toxicity tests.

Tab. 2. Results of ECE R49 test for the engine with combustion chamber „55a"

	ε	CO	CH	NOx	D
	[-]	[g/kWh]	[g/kWh]	[g/kWh]	[°B]
Chamber „55a"	17.2	5.42	2.06	11.28	3.1/2.2

In the next stage, the central body was rounded, as shown in Fig. 5.

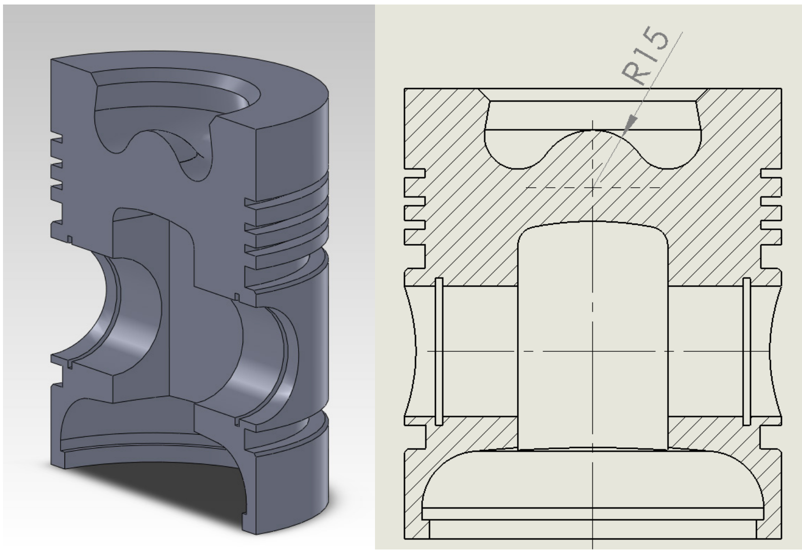

Fig. 5. The shape of the chamber „55b”

Tab. 3. Results of ECE R49 test for the engine with combustion chamber „55b”

	ε	CO	CH	NOx	D
	[-]	[g/kWh]	[g/kWh]	[g/kWh]	[°B]
Chamber „55b”	17.1	5.05	1.30	11.71	2.3/1.9

Consistently, the central body was reduced by reducing the radius of curvature.

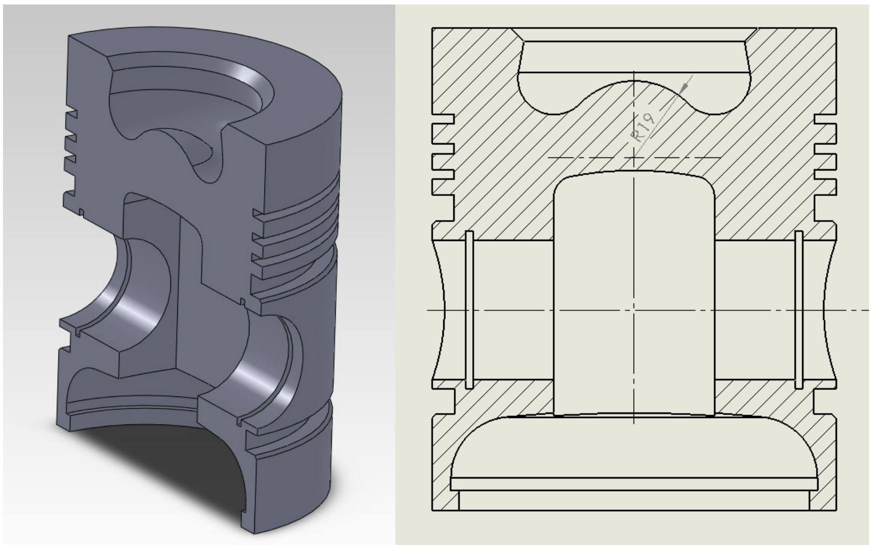

Fig. 6. The shape of the chamber „55c”

Tab. 4. Results of ECE R49 test for the engine with combustion chamber „55c”

	ε	CO	CH	NOx	D
	[-]	[g/kWh]	[g/kWh]	[g/kWh]	[°B]
Chamber „55c”	16.8	5.05	1.30	12.05	2.3/1.8

3. Summary of the test results

The figure below summarizes the changes that were introduced in subsequent modifications of the chambers.

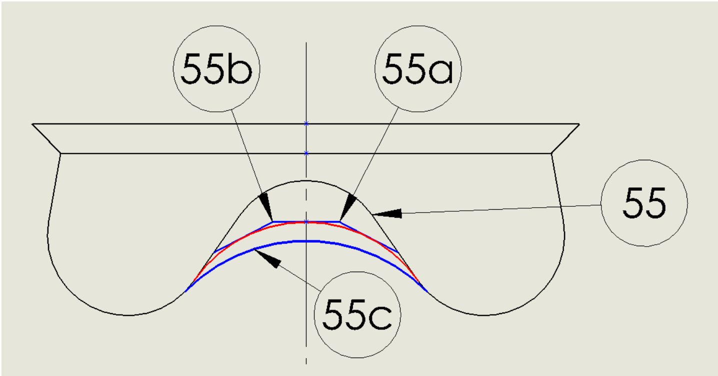

Fig. 7. The scope of the changes introduced to the shape of the „central body"

Tab. 5. Summary of the toxicity tests results

	ε	CO	CH	NOx	D
	[-]	[g/kWh]	[g/kWh]	[g/kWh]	[°B]
Chamber „55"	17.5	7.00	1.24	10.73	3.8/2.7
Chamber „55a"	17.2	5.42	2.06	11.28	3.1/2.2
Chamber „55b"	17.1	5.05	1.30	11.71	2.3/1.9
Chamber „55c"	16.8	4.95	1.32	12.05	2.2/1.8

4. Conclusions

1. Research carried out on a modified engine allowed to determine the impact of changes in the shape (size) of the central body of combustion chamber on the toxicity of exhaust gases.
2. Reducing the central body resulted in:
   - Reducing CO emissions by 29%,
   - Reducing the exhaust gases opacity (on average) by 38%,
   - Increasing NOx emissions by 12%.
3. Central body should not have sharp edges.
4. The changes affect the magnitude of compression ratio, which could have influenced the obtained results as a secondary factor.

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