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THE EFFECT OF LOCATION ON THE COMBUSTION CHAMBER FOR THE TOXICITY EXHAUST IN SELF-IGNITION ENGINE URSUS 4390

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Abstract

As a part of the research work done on the engine URSUS 4390 which aimed at increasing power while reducing exhaust gas emissions, intake channels in the head, shape of the combustion chamber and compression ratio were modified. Proper injection equipment was selected and atomizer nozzles were constructed. In the first phase of the research, toroidal combustion chamber was located in factory design location. In the article there are presented results of exhaust gas emissions in selected operating points of engine URSUS 4390 for various positions of experimental combustion chamber. An innovative method of changing the position of the combustion chamber related to the piston axis was developed. A rotating insert with eccentrically extruded combustion chamber was mounted in piston axis. Rotation of the insert by a given angle resulted in displacement of combustion chamber around the axis of rotation. For each particular position of combustion chamber, concentration of toxic flue gas components and smoke index was measured at full load with rotational speed of 1400 and 2000 rpm. Proposed piston construction with rotating insert allowed to significantly decreasing duration of the research, which aimed at verification of combustion chamber relative location to injector and inlet nozzle. This way the necessity of construction of new sets of pistons and lapping them each time was avoided. As a result of the work, 11 locations of combustion chamber were tested. The study allowed picking the position of combustion chamber, which guarantees lowest emissions of toxic flue gas components.

Keywords: *piston engine, diesel, combustion chamber*

1. Introduction

Combustion chamber selection process in a compression-ignition engine must take into account several aspects. These are shape of the chamber, compression ratio, injector location, injector holes size and arrangement as well as air turbulence and many others [2, 3, 4, 5]. Computer analysis gives answers or hints to some of them [6]. Research on prototypes is used for verification of previously done assumptions. After selection of inlet channel shapes, position of valves and location of injectors, all changes are very expensive and result in creating a new cylinder head. Other features left to change are shape, dimension and location of combustion chamber as well as modifications of the atomizer [7]. In the paper, there are presented results of optimization between positions of experimental combustion chamber and the outlet of 4-hole atomizer nozzle. Tests were done on the engine URSUS 4390 [1]. In this engine, the default position of combustion chamber is shifted by 3 mm from piston axis in transverse direction and 2.4 mm in engine longitudinal direction.

2. Research method description

An insert with a combustion chamber eccentrically placed in the piston was designed. Rotation of the insert by a given angle resulted in displacement around piston axis. For subsequent positions of combustion chamber, toxicity tests were done by measuring power, smoke index and toxic exhaust gas components concentration at full load for rotational speeds of 1400 and 2000 rpm. Usage of this method has shortened the research process and lowered its costs.

In a traditional method of testing, every change would require construction of new piston set and spending 50 hours on lapping the engine.

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 purpose of the modification was to increase engine power and decrease flue gas toxicity.

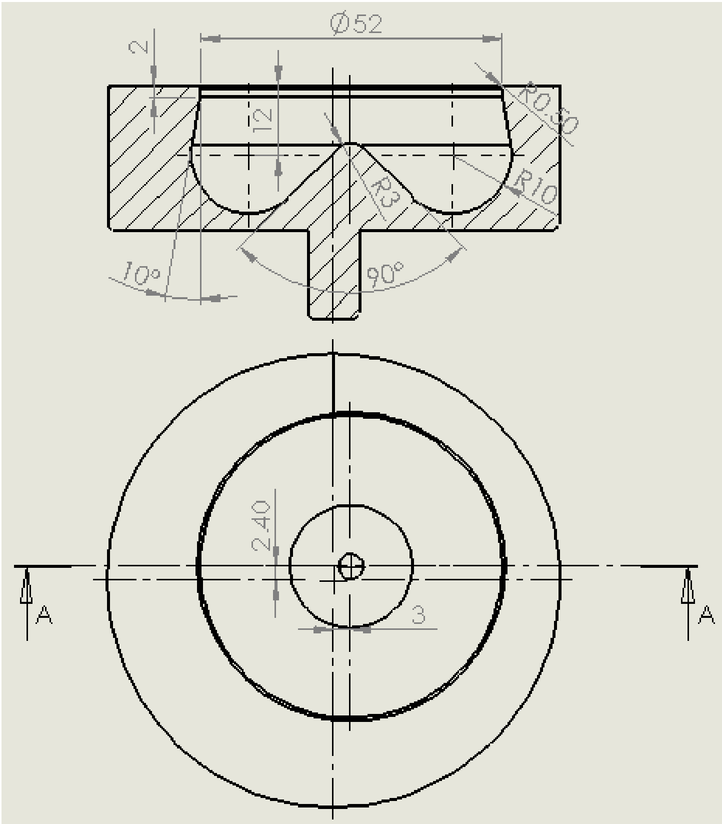

Fig. 1. Shape and location of combustion chamber in the insert

Change of combustion chamber location required disassembling of the piston, unscrewing locking nut, rotating the insert by given angle, tightening the nut. Relative location of injector and combustion chamber is presented in Fig. 2-4.

3. Research results

The research began with measurements for default placement of combustion chamber. Later tests were done for subsequent positions obtained by rotating the insert in piston. In fig. 5 there is presented the location of insert after revolution by +15° and range of displacement for all examined positions.

Rotation of insert by +15° resulted in changing the position of combustion chamber from piston axis from 3 mm up to 3.52 mm in transverse direction and from 2.4 mm down to 2 mm in longitudinal direction.

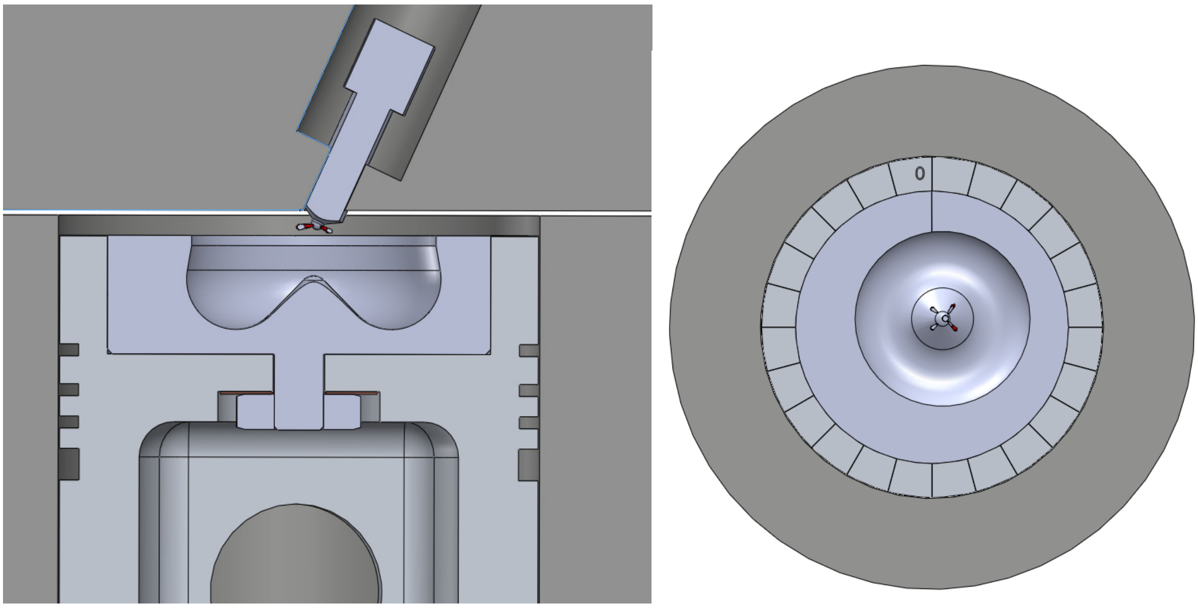

Fig. 2. Position of combustion chamber and atomizer nozzle at the moment of injection start (cross section in the piston axis)

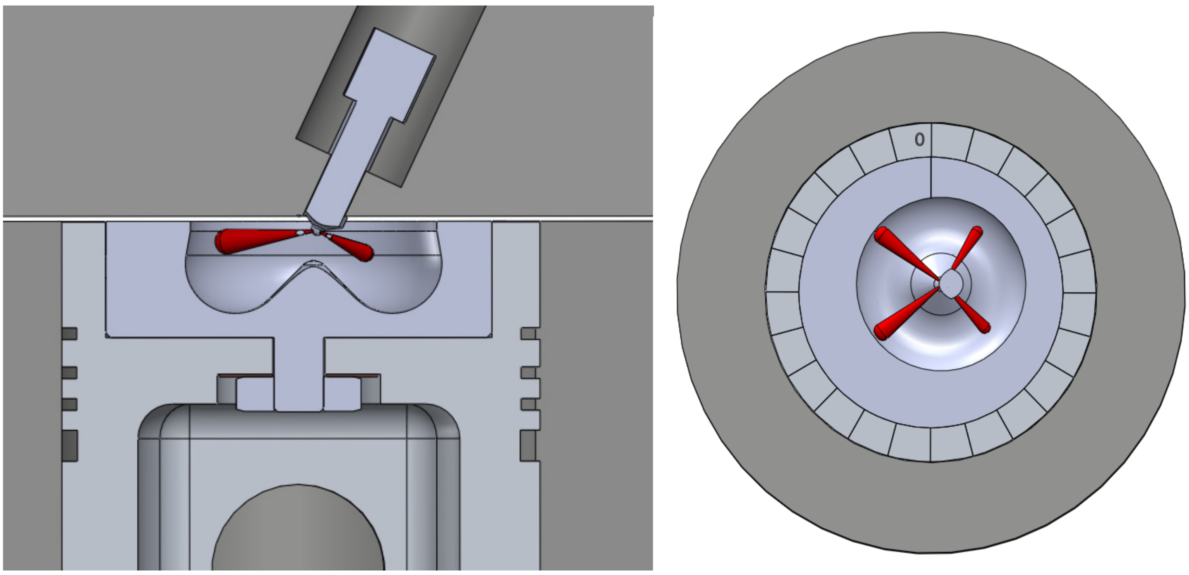

Fig. 3. Position of combustion chamber, atomizer nozzle and fuel streams at UDC (cross section in the piston axis)

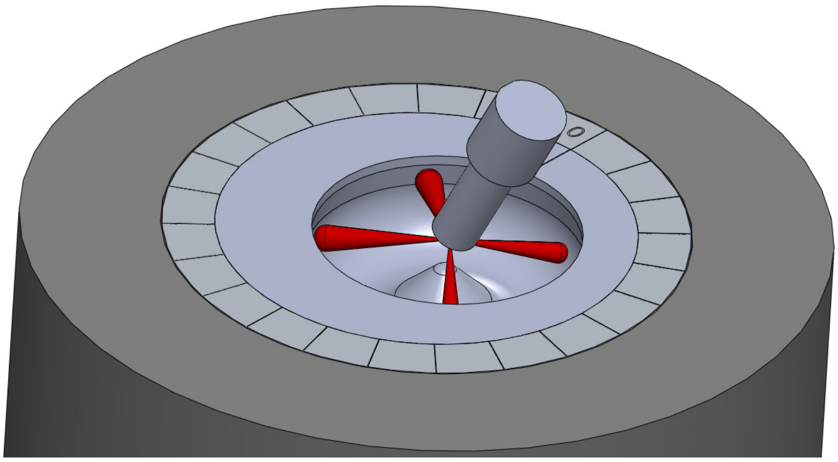

Fig. 4. Perspective view of fuel streams position in combustion chamber

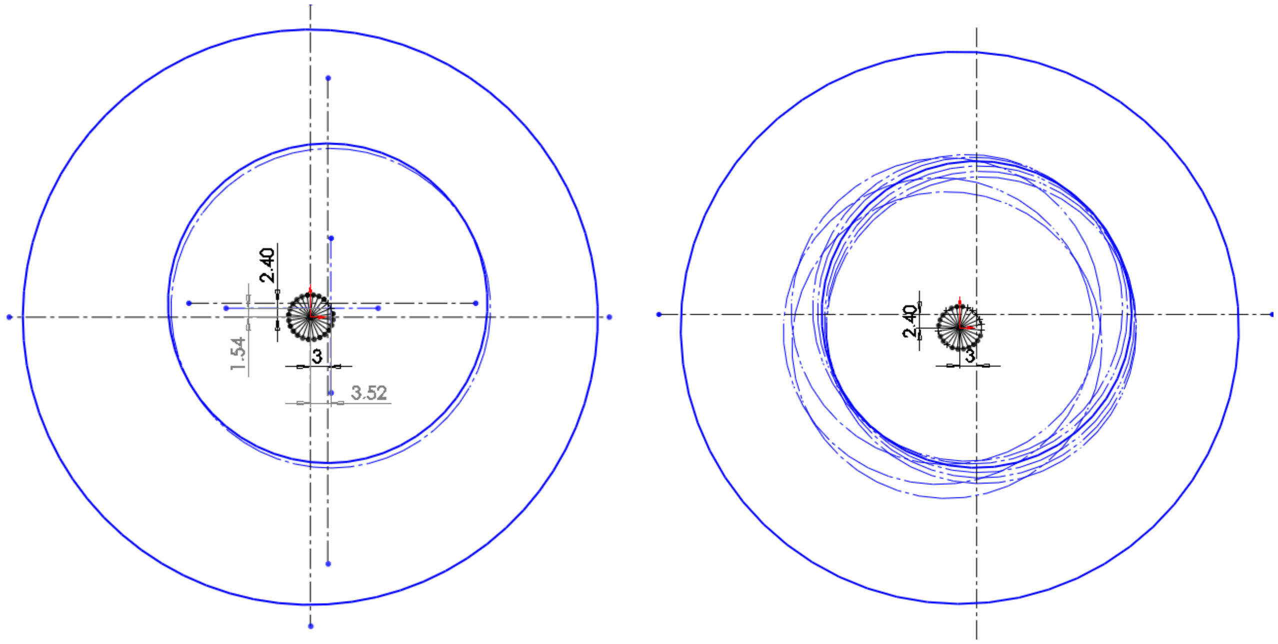

Fig. 5. Change of combustion chamber position after rotation by +15° and range of all combustion chamber position changes

Tab. 1. Measurement results for concentration of CO, CH, NO_x and smoke index for different setups of combustion chamber

Angle	N [1/min]	CO [ppm]	HC [ppm]	NO_x [ppm]	D [°B]
0	2000	1733	92	1054	3.8
	1400	8031	95	1248	5.7
–15	2000	2119	77	759	4.4
	1400	7700	88	1001	6.2
–30	2000	3264	72	908	5.0
	1400	9419	76	1071	6.3
–90	2000	4371	225	624	5.6
	1400	5594	167	976	5.8
–150	2000	4632	64	647	6.2
	1400	6853	92	1053	6.4
+15	2000	1976	72	786	4.2
	1400	1157	92	3923	4.9
+30	2000	1914	55	795	4.2
	1400	3781	67	1187	5.0
+45	2000	2001	63	815	4.4
	1400	3837	71	1232	5.2
+75	2000	1753	65	1029	4.2
	1400	7070	59	1249	6.0
+120	2000	2535	85	654	3.5
	1400	7563	106	1046	5.9
+165	2000	3957	63	781	5.3
	1400	9200	86	1134	6.3

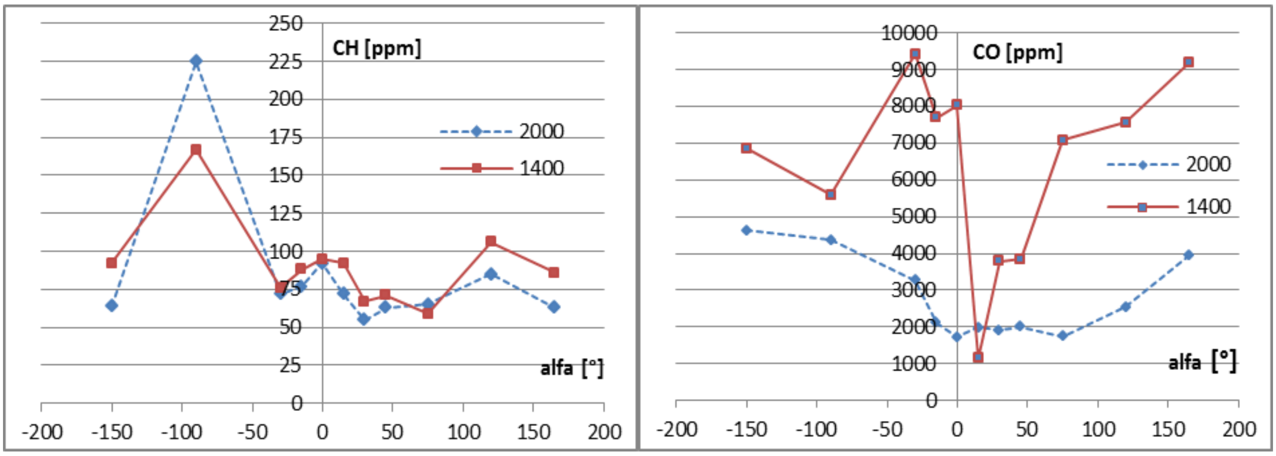

Fig. 6. Concentration of CH and CO as a function of combustion chamber angular position

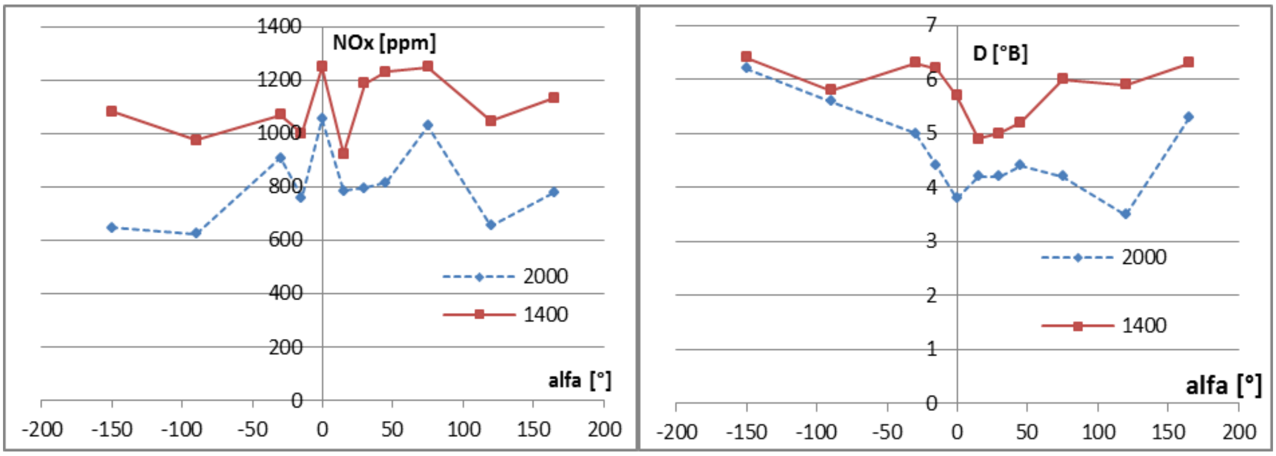

Fig. 7. Concentration of NO_x and smoke index as a function of combustion chamber angular position

A favourable trend for almost all analysed parameters can be observed during rotating the combustion chamber clockwise by small angles.

Graphs depicting changes in parameters in the range of angle displacement are presented in Fig. 8 and 9. Analysis of graphs indicates beneficial changes of toxic flue gas components concentration at displacement of +15°.

In Tab. 2 percentage, changes are presented for toxic exhaust gas components emissions after angular displacement of combustion chamber by +15°.

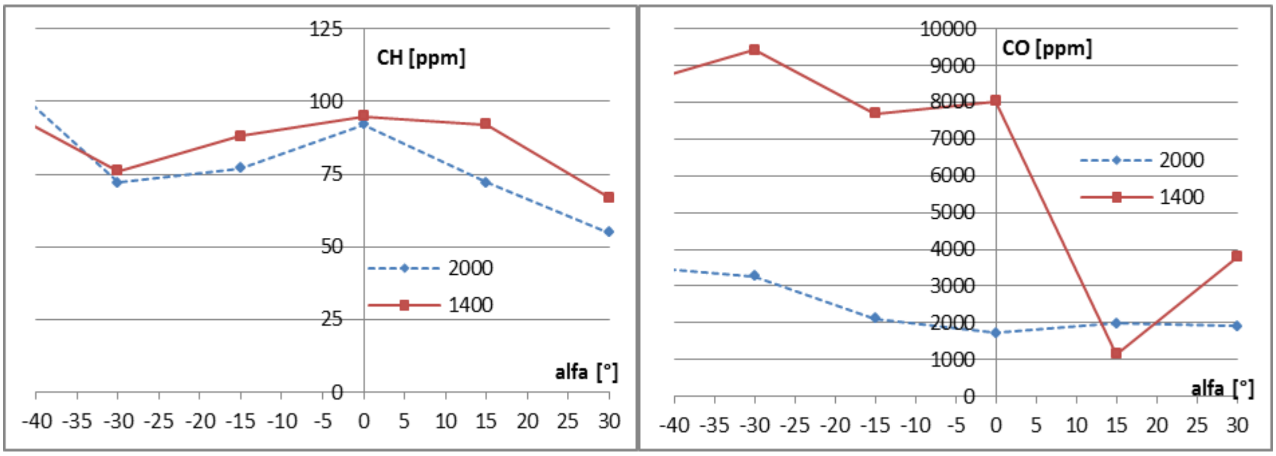

Fig. 8. Concentration of CH and CO in narrow range of combustion chamber displacement angle

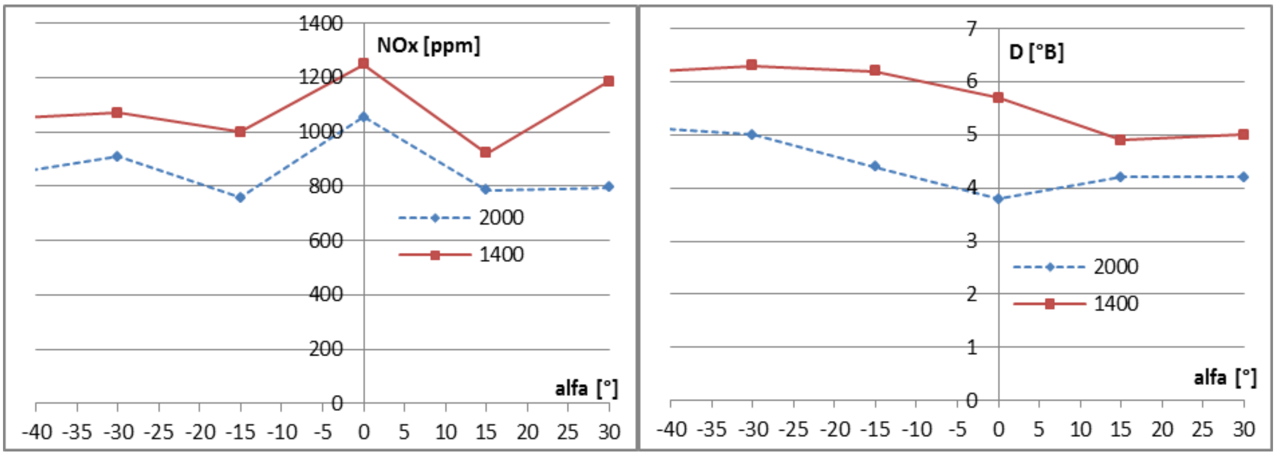

Fig. 9. Concentration of NO_x and smoke index in narrow range of combustion chamber displacement angle

Tab. 2. Comparison of concentrations of CO, CH, NOx and smoke index

Angle	2000				1400			
	CO	CH	NO_x	*D*	CO	CH	NO_x	*D*
0	1733	92	1054	3.8	8031	95	1248	5.7
15	1976	72	786	4.2	1157	92	923	4.9
%	14%	–22%	–25%	11%	–86%	–3%	–26%	–14%

4. Summary

a) As a result of rotating the piston by +15° a significant decrease of all measured emissions (CO, CH, NO_x and *D*) for 1400 rpm was observed.
b) For measurements done for 2000 rpm concentrations of CH and NO_x decreased. CO concentration increased by 14% and smoke index by 11%.
c) Proposed method of changing combustion chamber position is many times cheaper and faster method than traditional methods consisting of fabrication of complete pistons.

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