

# NOVEL ALLOY FOR MODERN IC ENGINE PISTON APPLICATION

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## Introduction

Investigations to improve the combustion piston engines are leading to improve the working process performance by increase of its parameters, especially the average temperature of the thermodynamic cycle. This increases the demands on the elements surrounding the engine combustion chamber, mostly pistons, which already belong to the very stressed structures. Another requirement of environmental standards posed on internal combustion engines used to power automobiles is the low level of noise emitted to the environment.

The noise decrease can occur through the decrease of clearances mainly in the crank-piston system, particularly between piston and cylinder, which are its principal source. These expectations cannot be gratified without a essential progress in perfecting of the engine parts design and the quality of materials applied in their manufacture.

Such solution is the application of new composite materials.

The composite materials presently determine the most promising and developing itself group of materials to the piston applications of internal-combustion engines.

## Experimental

### Materials

The new piston consists of two parts manufactured of standard and composite materials. Table 1 contains the basic parameters of investigated materials and for the comparison the parameters of the standard material.

Chemical composition of short fiber with Al<sub>2</sub>O<sub>3</sub> was following, in the mass percentage: 96% Al<sub>2</sub>O<sub>3</sub>, 4% SiO<sub>2</sub>.

As the binder the colloidal silica was used in quantity 5%. The volume of fibers in the insert was 22±2% by volume. Bending strength of the insert was 0.5 MPa.

The thermal conductivity in direction parallel to the fibers: 0.45 for 300°C, 0.42 for 500°C, 0.39 for 700°C and 0.38 W/mK for 900°C. In perpendicular direction eligibly: 0.17, 0.18, 0.18 and 0.18 W/mK.

The ceramic inserts served to the reinforcement of composite piston upper parts (near the crown zone).

Fig. 1 presents the performs of two kinds, and Fig. 2 presents the schema of pistons with inserts.

Table 1: Parameters of materials on pistons.

Parameter	Composite AK12/22% Al <sub>2</sub> O <sub>3</sub>	Standard Silumin Ak12
Density, g/cm <sup>3</sup>	2.711	2.721
Electric conductivity, MS/m	11.5-11.8	18.0-19.0
Thermal conductivity, W/m·K	90.5	150.5
Thermal expansion coefficient, x10 <sup>-6</sup> /K	18.51	21.86
Young modulus, GPa	90-94	73-75
Tensile strength, MPa	330-345	310-320
Hardness, HB	175-190	120-130
Yield point [N/m <sup>2</sup> ]: 10 <sup>8</sup>	2.89	2.25
Specific heat [J/kg·K]	1010	960
Poisson number [-]	0.22	0.28

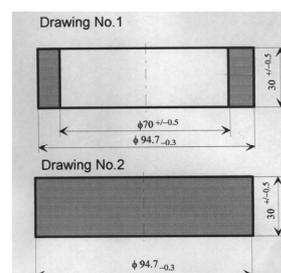


Fig. 1: Drawings of the inserts for a local pistons reinforcements.

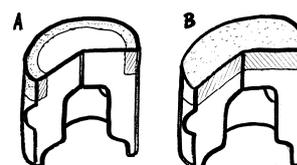


Fig. 2: Schemas of a installed local piston reinforcements with composite ceramic inserts of two types.

Fig. 3 presents the example of composite piston pressed in liquid state, reinforced locally with composite.

### Apparatus and Procedures

Researched samples had cube shape with the length of the edges equal to 10 mm. Samples were applied to variable thermal cycles loads according to a special program.

The specimens from the materials with properties given in Table 1 were assembled on the thin,

susceptible to deformations tapped tubes, within which the thermocouples Ni-Cr-Ni were mounted.



Fig. 3: Composite piston locally reinforced.

The changes of temperature within each specimen were recorded with the help of the acquisition system on the base of the PC computer. As a result of the measurements, were specified initially the guidelines of design changes going in the direction of the number of thermocouples increase in the event of a measuring chamber full load, the sealing of the heating chamber, in order to equal the measuring error based on the temperature deviation from the average temperature to the value of  $\pm 15^{\circ}\text{C}$ .

### Results and Discussion

The results of investigations of the two materials thermal shocks are presented on Fig.4.

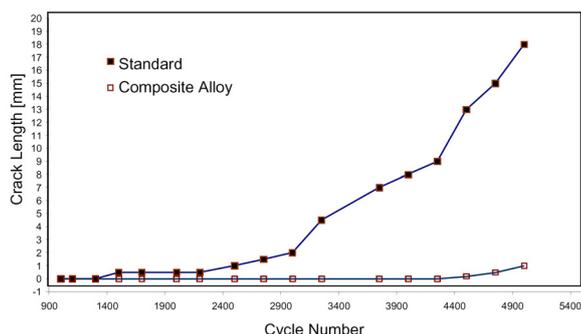


Fig. 4: The resistance of investigated materials on thermal shocks.

The microstructure of the two materials presents Figs. 5 and 6. The exemplary of temperature distribution in composite piston presents Fig. 7.

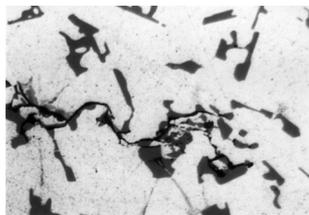


Fig. 5: The microstructure of standard alloy AK 12 after investigations of the material resistance on thermal shocks. Magn. 500x.

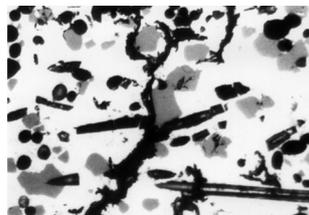


Fig. 6: The microstructure of composite alloy after investigations of the material resistance on thermal shocks. Magn.500x.

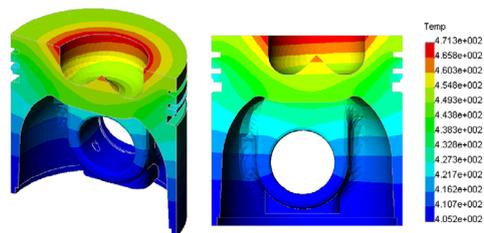


Fig. 7: Temperature distribution [K] in composite piston.

### Conclusion

Experimental verification of manufactured composite pistons in the engine proved the larger exhaust temperature for about  $20\text{-}70^{\circ}\text{C}$ , in comparison with the engine with standard pistons (that gives the greater effectiveness of turbo charging application), proved the lowering of a individual volume of gases blow-bys to the crankcase, the lowering of noise level, larger resistance on thermal loads.

The positive effect of composite pistons usage is the lowering level of the solid particles emission and the combustible matter in exhaust as a result of the rise of a working process average temperature.

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