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ENGINE OPTIMIZATION MECHANISM IN TERMS OF USING VARIABLE COMPRESSION RATIO

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Abstract: *This article presents the main engine optimizations performed on the windows and rotating cylinder jacket distribution in order to implement variable compression. When modifying continuous geometric compression ratio during engine operation, the variation of the maximum cylinder pressure and forces require both crank mechanism, and rotating cylinder distribution. Given this distribution cylinder jacket was redesigned to obtain a high resistance to engine operation MDR-2 with a compression ratio of 10:1. Also, changes were made and the piston so that will be obtained a variation of the compression ratio between 8.5:1 and 10,2:1.*
Keywords: *rotating cylinder jacket, piston, variable compression ratio*

1. INTRODUCTION

Distribution system through windows and rotating cylinder jacket of MDR-2 engine offers as in Lotus Omnivore concept [1], the possibility of a reduced value for the volume of the combustion chamber. This is mainly due to the elimination valves. Also, the study of MDR-2 engine to implement variable compression solution is justified by a relatively simple terms, for combustion chamber volume change and implicitly of geometric compression ratio. It consists in moving the cylinder head from the engine block through a mechanism mounted eccentrically. Optimizations to the MDR-2 engine consist in changes made to the piston with Heron chamberand installing metallic bushes with Mo for improving and redesigning the cylinder seal rotary distribution jacket.

2. MODIFICATION THE PISTON

Engine tests realized on a shirt distribution, in which we used several types of cylinder head (Figure 1) and piston (Figure 2), led by choosing an optimal architecture variants chamber. Thus, it was found that MDR-2 engine work properly when it was used a variant of the piston combustion chamber delimited by Heron chamber and cylinder head with corresponding recesses windows intake, exhaust or cylinder.
To obtain a range of values of the geometric compression ratio available for this variation , primarily been some changes to the engine block, cylinder head and piston. Was obtained as an interval between 8,7:1 and 10,2:1
ε_v control mechanism will work to change the volume of the combustion chamber and hence the geometric compression ratio (continuously) during engine operation, taking into account the information provided by some sensors on operating conditions (load and speed).
Volumetric compression ratio of 8,7:1 baseline is given by the total volume of the combustion chamber and cylinder V_c V_S, unit, which can be determined by the relations:

$$V_c = V_{Heron} + V_c^{'} + 4 \cdot V_d = 81267{,}668 \quad [\text{mm}^3] \tag{1}$$

were:

$$V_{Heron} = \frac{® \cdot D_H^2}{4} \cdot h_H = \frac{® \cdot 68^2}{4} \cdot 16{,}6 = 58695{,}819 \ [\text{mm}^3]$$

Is the volume of combustion chamber from piston ,
were: h_H = 16,6 [mm] – hight of combustion chamber from piston ;
D_H = 68 [mm] – diameter of Heron combustion chamber ;

$$V`_c = \frac{\pi \cdot D^2}{4} \cdot h = \frac{\pi \cdot 97^2}{4} \cdot 0{,}8 = 5911{,}849 \quad [\text{mm}^3]$$

Is Is the volume of combustion chamber from piston caracterized from space between the cylinder head and piston;

unde: h = 0,8 [mm] – distance between cylinder head at PMS position ;
D = 97 [mm] – diameter of cylinder;
V_d = 16660 [mm^3] – volume of a cylinder head venting

$$V_S = \frac{\pi \cdot D^2}{4} \cdot S = 628133{,}962 \quad [\text{mm}^3] \qquad (2)$$

were: D = 97 [mm] – diameter of a cylinder;
S = 85 [mm] – piston stroke.

Figure 1: Types of cylinder head for MDR-2 engine

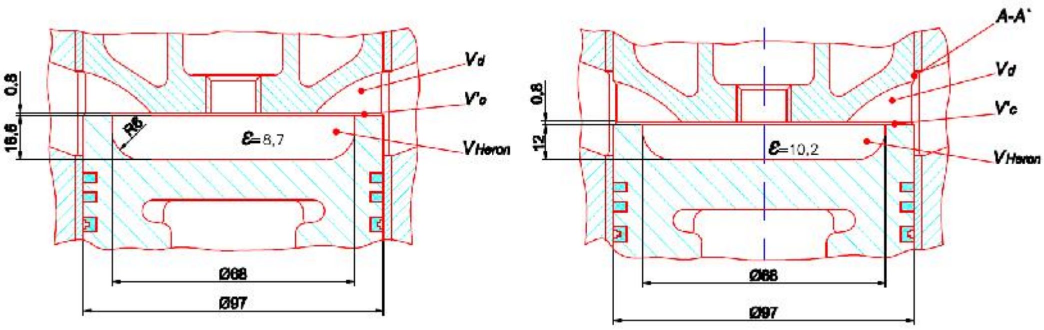
Figure 2: Types of piston for MDR-2 engine

Because $V_{Heron} > V`_c$, to obtain the value of geometric compression ratio 10,2:1, it is more convenient to change the piston chamber height. Thus, reducing by 4.6 mm height of Heron combustion chamber (Figure 3), the total volume of the combustion chamber V_c will increase, since the distance h in a position of piston and cylinder head PMS will increase by the same length. In this case, h_H = 12mm and h = 5.4 mm and total volume of the combustion chamber will be:

$$V_c = V_{Heron} + V_c' + 4 \cdot V_d = 98555{,}067 \quad [\text{mm}^3] \qquad (3)$$

It should be noted that the reduction in piston height 4.6 mm, lead by changing the position of PMS, and hence the unit cylinder V_S. Thus, for S = 80.4 we have::

$$V_S = \frac{\pi \cdot D^2}{4} \cdot S = 594140{,}83 \quad [\text{mm}^3] \qquad (4)$$



a) b)

Figure 3: Architecture combustion chamber engine used for MDR-2:
a) initial – ε_v = 8,7; b) after modfication – ε_v = 10,2

Can be verified by a simple calculation that under these conditions, geometric compression ratio is 7:1. This is due to the increase in the distance between the piston and cylinder head from h = 0.8 mm at h = 5.4 mm. To return to baseline changes were made to the engine block and cylinder head. Thus, decreasing by 4.6 mm height of the piston chamber was offset by two plane-parallel corrections to the contact surfaces of the engine block and cylinder head: the first of these, the upper surface of the cylinder, 0.6 mm, and the second with 4mm at the base of the cylinder head (cylinder contact surface).
Because $V_{Heron} > V`_c$ (figure 3), if the distance between the cylinder head and piston remain constant (after reduction of height in Heron chamber), combustion chamber volume will decrease. Thus, for h = 0.8 mm, h_H = 10mm and S = 80.4 mm we have:

$$V_c = V_{Heron} + V_c' + 4 \cdot V_d = 64561{,}935 \quad [\mathrm{mm}^3] \tag{5}$$

$$V_S = \frac{\text{®} \cdot D^2}{4} \cdot S = 594140{,}83 \quad [\mathrm{mm}^3] \tag{6}$$

$$\text{£}_v = \frac{V_c + V_S}{V_c} = 10{,}2 \tag{7}$$

Evolution of geometric compression ratio of the reduced height of the piston Heron chamber, when the distance h = 0.8 mm (Figure 3) remains constant (given above maintenance), can be seen in Table 1.

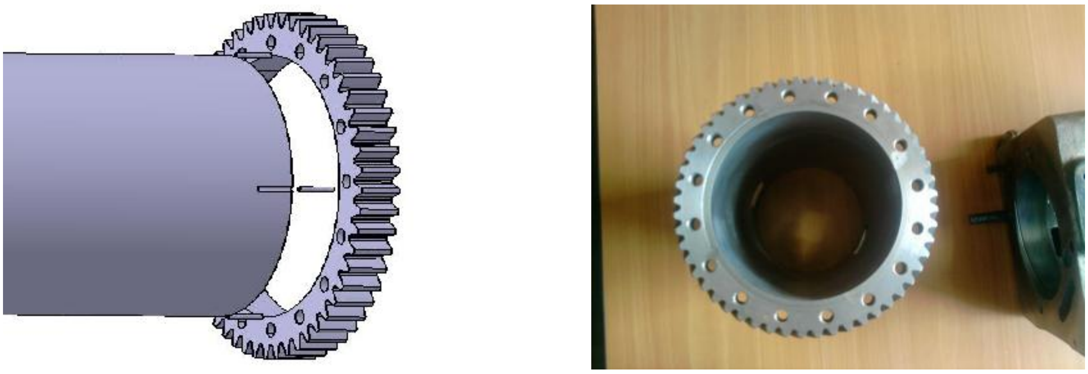
Table 1: ε_v variation depending on the height of the piston combustion

h_{Heron} [mm]	S [mm]	V_{heron} [mm^3]	4 x Vd [mm^3]	V_s [mm^3]	V_c [mm^3]	$V_c + V_S$ [mm^3]	ε_v
16,6	85	58695,819	16660	628133,962	81267,668	709401,630	8,73
15,4	83,8	54337,802	16660	619266,188	76909,651	696175,840	9,05
13,6	82	47800,776	16660	605964,528	70372,625	676337,153	9,61
13	81,4	45621,767	16660	601530,641	68193,616	669724,258	9,82
12	80,4	41990,086	16660	594140,830	64561,935	658702,765	10,20
11,6	80	40537,414	16660	591184,905	63109,263	654294,168	10,37
10,4	78,8	36179,396	16660	582317,132	58751,245	641068,377	10,91
9,6	78	33274,051	16660	576405,282	55845,901	632251,184	11,32

With 4mm cylinder head correction, corresponding recesses four inlet, exhaust or cylinder, will move to the inside of the combustion chamber with the same distance (segment *A-A`* figure 4.26-b). Although there were no changes in the operation of the engine, this movement adversely affects gas exchange because changes occur on sections passing through the gas distribution windows. Given this drawback, modification of the cylinder head must be a minimum, it can be experimentally determined and if it has several types of cylinder head. One way to solve this problem is rectified beam discharges, but this has also resulted in increasing their volume. In this paper, research has been conducted to model the cylinder head without V_d volume changes (Figure 3), in the future will be studied also how the segment *A-A`* or rectification discharges influence the processes of intake and engine exhaust .

3. THE ROTATIVE JACKET MODIFICATION

Although MDR-2 engine was designed based on constructive parameters series engines produced in our country (SR-211, L-25), for rotating cylinder jacket, a new model was not possible to use the present type of cylinder jacket in motors above. This was mainly due to distribution of cylinder jacket size (eg L = 208.5 mm) exceeding quotas cylinders manufactured in series L-25 engine. Therefore, we used a jacketed cylinder engine fitted to Mercedes-Benz propelled T2 / L, with the following characteristics: L = 222.5 mm; D_{ext} = 103mm, D = 97mm
Particular attention was given to way in which the distribution windows are positioned to gear teeth with the distribution system after assembly and fixing the two components. It should be noted that changing gear with one tooth position leads to a variation of the angle of closing/opening windows distribution of approximately 5^o. Thus, between the extreme positions of the windows distribution (in terms of circle arc length circle by which they operate) and the gear teeth is not indicated to exists differences compared to the original model.

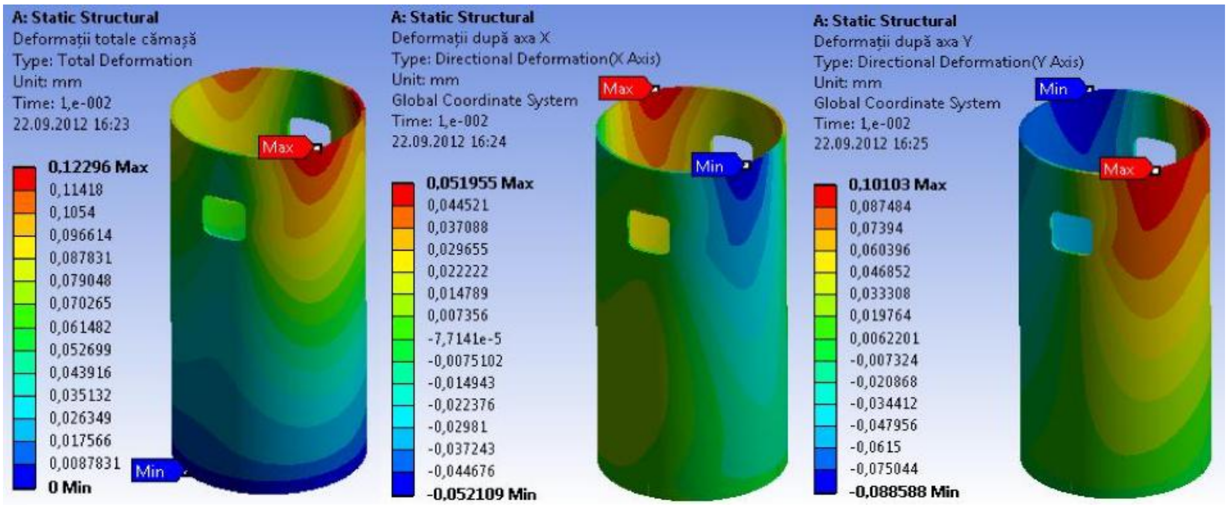


a) b)

Figure 4: The modification of the MDR-2 engine distribution jacket a motorului a) model 3D; b) physical model

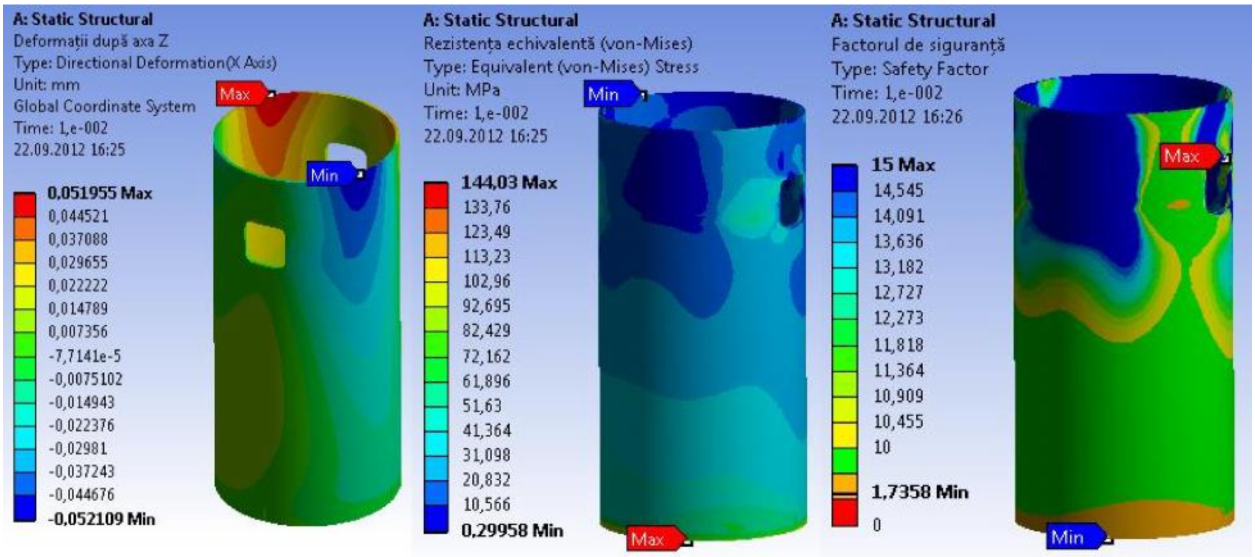
From the point of view of the wall thickness of the distribution jacket, reducing it would have the effect of increasing the maximum strains by X and Y axes and hence the failure of diametrically clearance between the jacket and the cylinder. For 1mm reduction of outer diameter to rotating jacket, in Figure 5, it can be fallow the maximum strains by X and Y axes, which obviously, are no longer falls within the clearance above mentioned. This reduction to outer diameter would be possible with further processing performance at the cylinder level namely reaming throughout its length for mounting a metal bushing with Mo, as was done for the channel inlet / outlet area. Clearly, the inner diameter of the cylinder obtained from these changes must be adequate to satisfy the 0,15mm medium clearance between the jacket and cylinder.

The operation of engine with compression ratios with values above the 10,2:1, is necessary to increase the wall thickness of the rotating jacket, given the increase considerable pressure in the cylinder. To increase with 1mm the outer diameter when geometric ratio of compression is 11,6:1, in Figure 6, the maximum strains values can be followed by the X and Y axes. Certainly, this time too, additional changes are needed at the cylinder level (similar to those described above) to be provided in the end, the 0,15mm medium clearance between the jacket and cylinder.



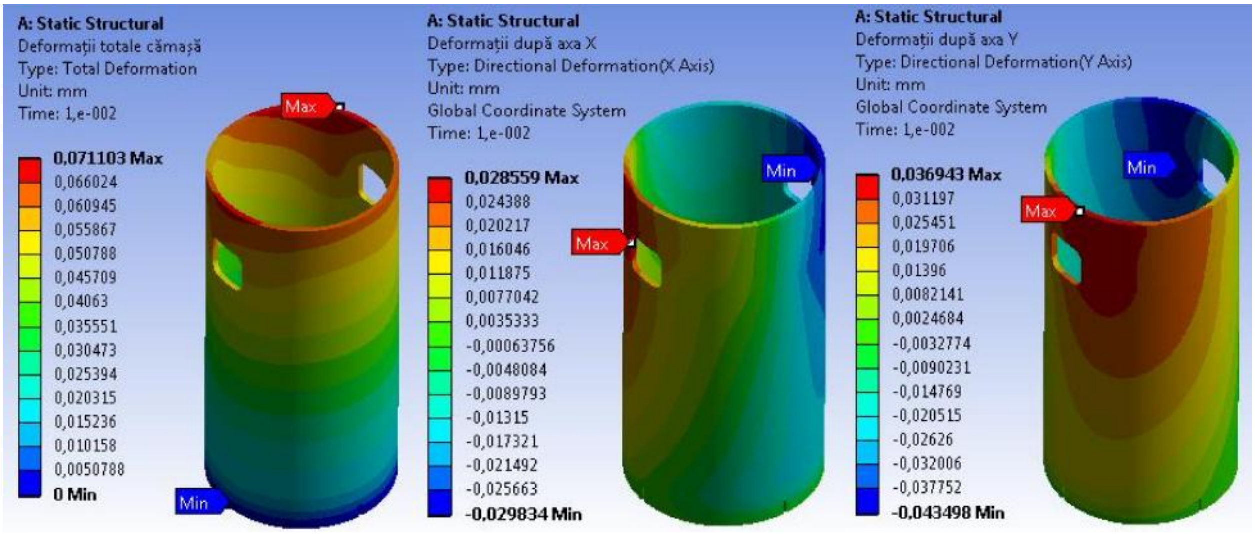
a) b) c)

Figure 5: The results of the distribution jacket with 1mm reduction of the outer diameter: a) total deformations; b) deformations by the *X* axis; c) deformations by the *Y* axis;



a) b) c)

Figure 6: The results of the distribution jacket with 1mm reduction of the outer diameter: a) deformations by the *Z* axis; b) equivalent strains; c) safety factor



a) b) c)

Figure 7: The maximum deformations with the 1mm increase of the D_{ext} jacket and ε_v from 10,2:1 to 11,6:1: a) total; b) by the *X* axis; c) by the *Y* axis.

4. CONCLUSIONS

Following research ìt was found that MDR-2 engine work properly when it was used a variant of the combustion chamber delimited by Heron chamber piston and cylinder head with releases corresponding to admission windows, respectively evacuation from the cylinder.

To obtain a range of values of the compression geometric ratio available for this variation first was realized some changes to the engine block, cylinder head and piston. So, was obtained an interval between 8,7:1 and 10,2:1. Finite element analysis performed with ANSYS reflects the possibility of accomplishing a distribution jacket with thinner walls, maintaining the engine operation in parameters. For operation with a compression ratio higher than 10:1 is required rotating jacket with thicker walls, given the maximum cylinder pressure corresponding to the higher compression reports.

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