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NUMERICAL MODELING OF THE CYLINDER-HEAD GASKET'S DISPLACEMENT FIELD, BASED ON EXPERIMENTAL DATA

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Abstract: *Durability of the internal combustion engines depends also on the behavior of the superior engine area, and especially that of the cylinder-head gasket. The cylinder-head gasket represents the elastic element that closes the engine chamber. Malfunctioning and noxious pollution on can observe, if this role is not entirely satisfied. This will lead to a non-competitive engine. The authors of this paper preoccupied themselves with the analysis of geometric factors of the superior area zone, so that a competitive engine will obtain. Taking into account the accuracy analysis of the elastic properties of the cylinder-head gasket [4], a mechanism of the deformation of cylinder-head gasket during pre-tensioning (of cylinder-head gasket mounting) and during fuel burning in the burning chamber was proposed. Based on these presumptions, the authors performed a FEM analysis of the cylinder-head gasket's displacements field.*
Keywords: *cylinder-head gasket, displacement field, experimental investigation, numerical analysis*

1. INTRODUCTION

In their previous investigations [1], the authors conceived, with several years ago, an original electric strain gage-based stand, destined to evaluate the relative displacements of the cylinder-head gasket flanged hole relative to the cylinder mirror.

This stand/device consists of two, *L*-shaped, elastic lamellas (thin steel sheet/plate), each one having a ***TER1*** and ***TER2***, half-bridge connected, electric strain gauges.

These lamellas are fixed on the rigid ring ***1*** by mean of the screws ***4***. Screws ***3*** fix the device on the "cylinder's mirror" (fig.1).

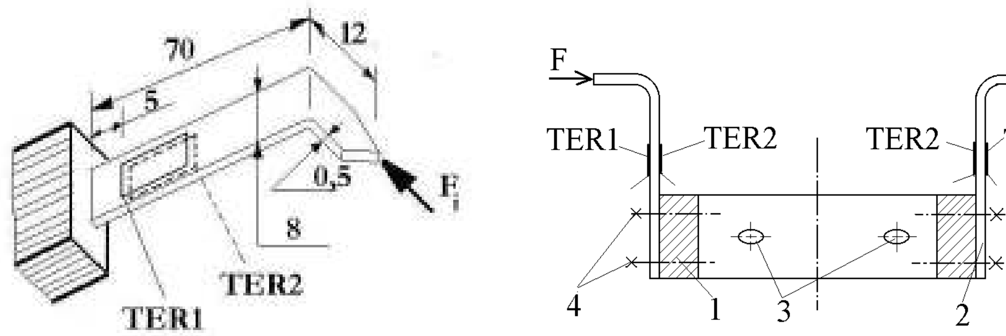

Figure 1: The displacement transducer and its positioning in cylinder

Due to the fact, that these lamellas are very flexible (their acting force has very low values), their influence on the real phenomenon of the cylinder-head gasket flanged hole's displacement is negligible.

2. THE CYLINDER-HEAD GASKET EXPERIMENTAL INVESTIGATION

Cylinder-head gasket qualities made of a certain material depends on some factors decisively:

- engine thermal regime;

- gasket strain-tension state both after assemblage and during engine function;
- combustion process character and cylinder pressure law variation p(α);
- cylinder shirt type;
- un-uniformity of cylinder-head gasket elements height-ness.

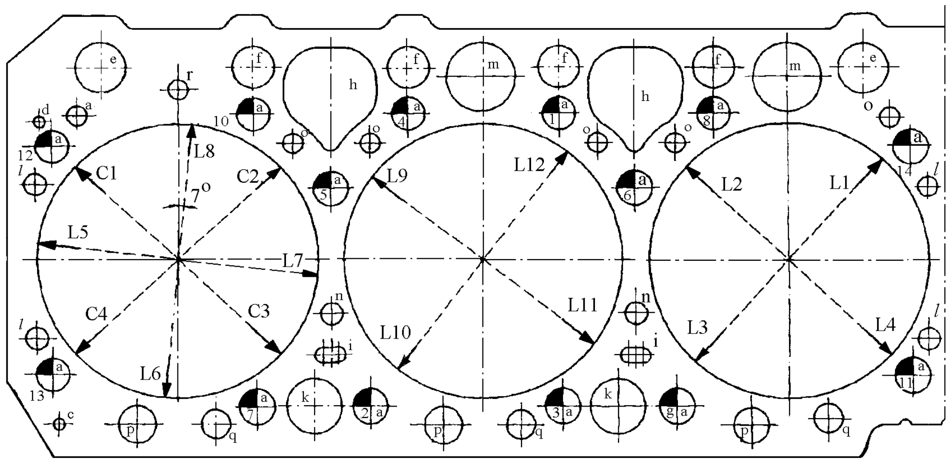

Figure 2: Cylinder-head gasket for half engine

The investigated engines have had two half-cylinder-heads and a single gasket and the cylinders were "SLIP-FIT" type (fig. 2), where ***a ,b, ..., q*** represent its characteristic elements (flanged holes) and ***1, ..., 14*** are the cylinder-head dowel pins (the number corresponds to the clamping order number). L_j represent the lamellas measuring points.

Two different cylinder-head gasket were used (***MARSIT*** and ***DIROLASTIC***), each one being used on Romanian trucks with 6 in-line cylinders.

From stiffness point of view in each gasket materials, were identified 8 characteristic zones (elements).

For these zones, using measured data from the reference [4], the authors established/draw up both the force-displacement and stress-strain curves.

3. SOME PRELIMINARY RESULTS OF THE NUMERICAL ANALYSIS

For numerical calculi were accepted the following hypothesis:

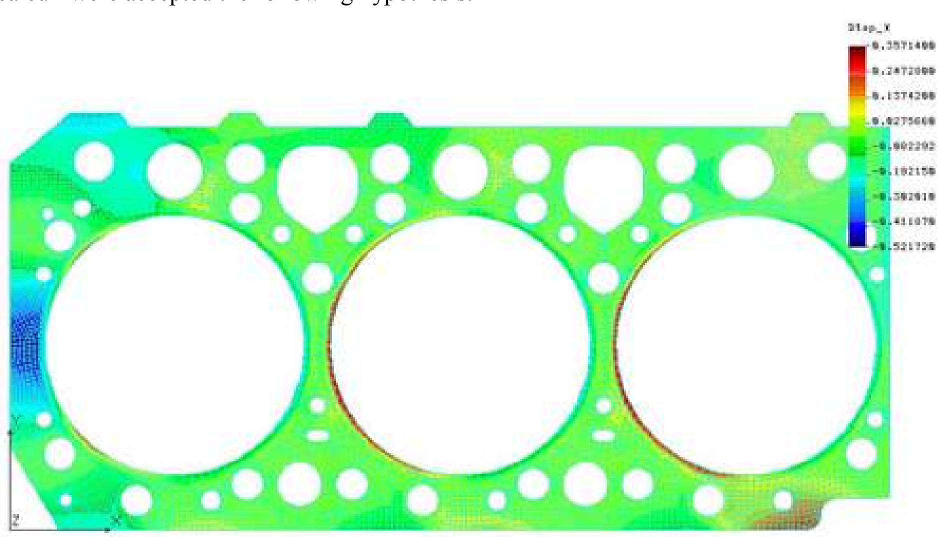

Figure 3.: DIROLASTIC displacement field for force $\mathbf{F_1}$ on OX direction

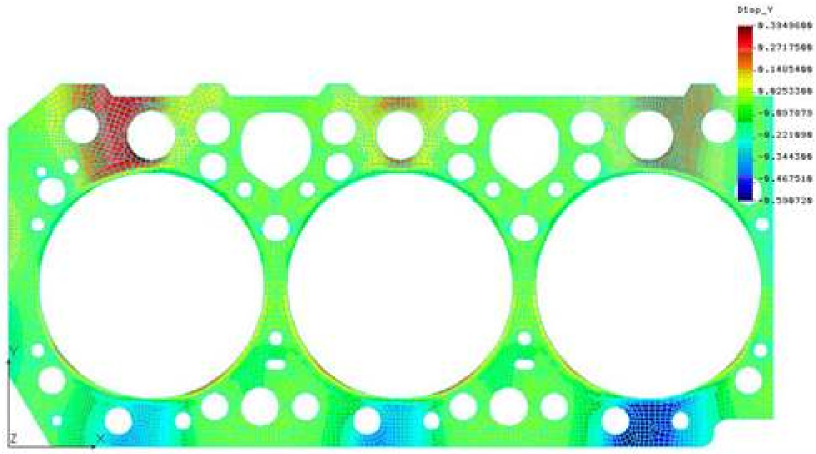

Figure 4.: DIROLASTIC displacement field for force $\mathbf{F_1}$ on OY direction

- the gasket is composed of a series of parallel connected elastic elements which present different initial heighten;
- all the cylinder-head dowel pins are uniformly and simultaneously clamped, so that the cylinder-head to get to the cylinder block by a plane-parallel movement and gasket component elements to take over the total pre-stressing one by one;
- the measured displacements with lamellas represent initial data (constrains) for FEM analysis.
- in the ideal case, the final loading value have to assure not only the shortening of the all of these elastic elements, but also to be greater as the cylinder-head dowel pins' elongations over the burning process action.

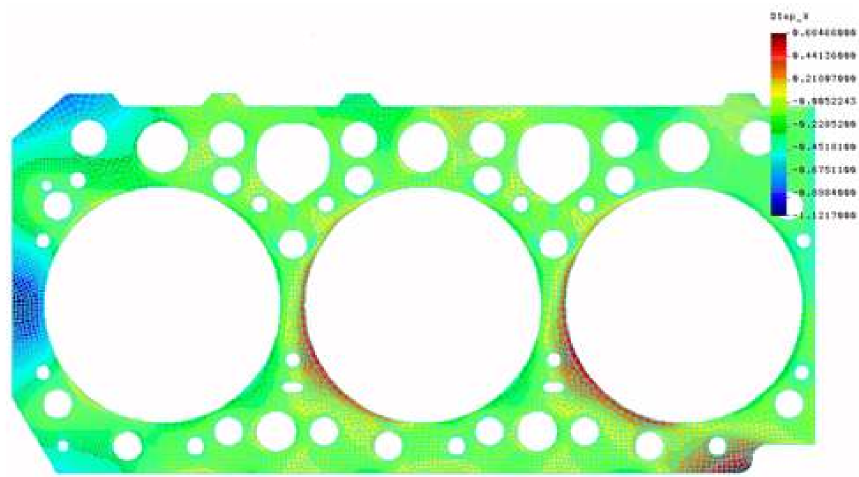

Figure 5.: MARSIT displacement field for force $\mathbf{F_1}$ on OX direction

Based on these initial conditions, step by step were analyzed by FEM the elastic displacements fields of these cylinder-head gaskets, manufactured from MARSIT and DIROLASTIC materials.

The figures 3, 4, 5, respectively 6 represent, for these two materials, for the tightening force F_1, and directions of displacements (*X*, respectively *Y*), the results for MARTENSIT ("MAR") and DIROLASTIC ("DIR").

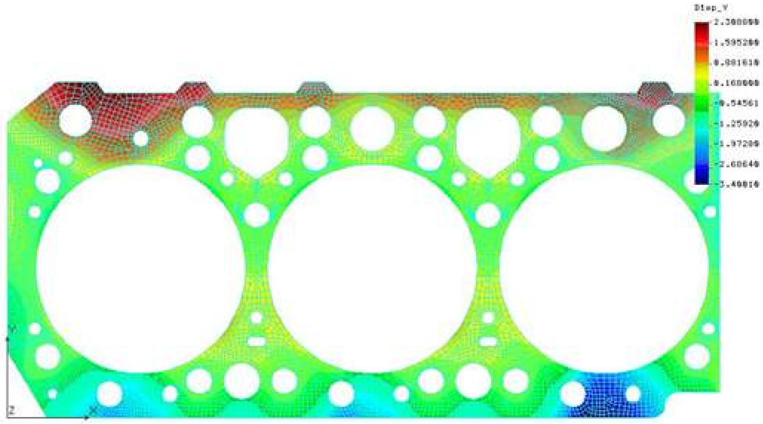

Figure 6.: MARSIT displacement field for force $\mathbf{F_1}$ on OY direction

4. CONCLUSION

As result of the detailed analytical and numerical investigations, described in [3], on can conclude that the MARSIT presents still one uncompressed element at the maximal (nominal tightening force).

In conclusion, this material is inadequate for this engine.

At the nominal tightening force, the DIROLASTIC assures the compression of all of the characteristic elements, but the last elements pre-stressing (I mean its shortening) is insufficient to compensate (counter-balance) the cylinder-head dowel pins' elongations over the burning process action.

As a general conclusion, the authors recommend selecting other kind of materials (and manufacturing companies) for obtaining a better and more competitive engines.

Also, the presented analytical and numerical procedure can prevent, from the earlier conceiving stage, the eliminating of some, low quality cylinder-head gasket material.

REFERENCES

[1] Sperchez, L.Fl., Száva, I.: *Tensometric device for cylinder head seal displacements analysis*; Proc. the VI[th] National Symposium on Tensometry, p.120-129, 1992, Craiova, Romania,

[2] Száva, I. *et al.*: *Influence of the elastic properties of cylinder head Seal Materials of Engine Operations*, Proceedings of 14[th] Danubia Adria Symposium on Experimental Methods in Solid Mechanics; p.26-27, 1-4 oct. 1997, Porec, Croatia.

[3] Száva, I., Ph.D. Thesis, Univ. Trans. din Braşov,1994.

[4] Enache, V., Dogaru, Fl., Száva, I.: *Some Results Concerning on The Mechanical Properties Evaluation of the Cylinder-Head Gasket Materials*, CONAT 2010, Transilvania University of Brasov, Romania, Oct. 27-29, 2010, Proceed. Conf. Under printed.