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MODELS AND ALGORITHMS FOR THE CRANKSHAFT DESIGN

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Abstract: *In the paper a programming system is presented which gives the possibility to do the calculi for the checking and designing of the combustion engine crankshafts.*
Complex models are used which enable the study of the dynamic stresses, longitudinal and torsional vibrations by using the hypothesis of the deformed and unfixed bearings.
The elasticity of the crankshafts is taken into account when calculating the strength in the bearing, enabling the removement of the undetermined that appeared
The method of the finite element is used to establish the concentration of the stresses used for the safety calculus.
The programming system is accessible, it offers efficient pieces of information in designing of crankshafts and it is able to give best solutions in a certain context.
Key words: *crankshafts, models, design, algorithms*

1. INTRODUCTION

The calculi regarding crankshafts sizing and testing in general are toilsome, using different models for the study of various aspects regarding assembly behaviour in operation. The completeness of from and loads, leads to the fact, that one looks with caution to the obtained results by classical version of calculus, as the experiment has to decide their validity.

The paper, as a necessity of working out some fast and efficient calculus methods of crankshafts, suggests a system of computation programs. Some of them are based on genuine models, which are practical covering the whole range of aspects appearing at calculus of sizing and testing. The system was objectified by application to calculus if some. Romanian truck and applied at calculus of some new engine types design and test in tractor plant and truck plant of Brasov.

2. MODELS

One part of the used models is known and should be only mentioned. The other part represents a genuine contribution of the authors and should be presented in detail.

a) The calculus of forces, witch apply a stress onto the system consisting of connecting rod and crank, should be carried out taking into account the rigid movement of the connecting rod, that means the moment of its inertia (Ripeanu, A., 1999) , (Manfred, H., 2001), (Mase,T., Mase,G.,1999).
The forces acting upon the pins should take consequently into the chosen firing order. The forces resulting from gases pressure, connecting rod and piston inertia are this way diminished at crankshaft crankpins loading. At crankshaft calculus, these should be considered as loading from outside (fig. 1, 2)

b) The reaction appearing in main bearings should be established considering the crankshaft as a statically indeterminate system (Kuhn, O., Hofling,B., 1994), (Tellez,H.A., Rovira,N.L., 2006). The shaft is considered to flexible, the same the main bearings. The flexibility of main bearing is different, according to different directions. The calculus of reactions should be carried out establishing their components in two perpendicular planes.
In plane xOy (fig.2) the canonical equation of the method of forces are written:

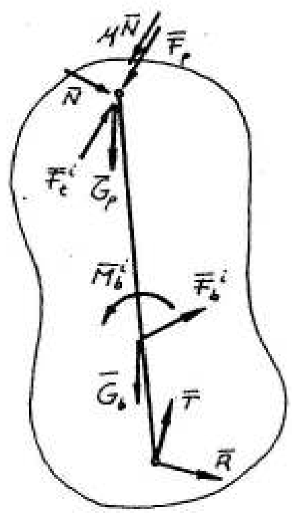

Fig.1

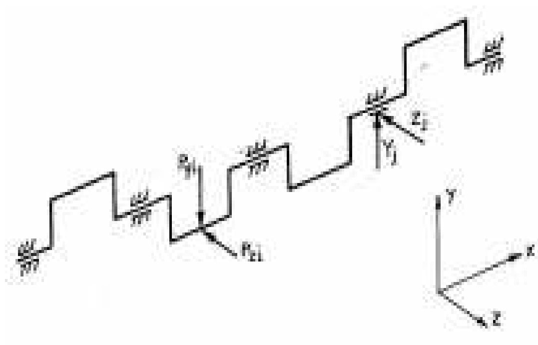

Fig.2

$$[\alpha]\{Y\}+[r]\{P_y\}=\{0\} \qquad (1)$$

$[\alpha]$, $[r]$- matrices of influence coefficients;
$\{Y\}$- components of reactions according to axis Oy in main bearings;
$\{P_y\}$- components of forces applying their load into the crankshaft according to axis Oy.

The main bearings were considered as to be rigid. As for plane yOz, there are obtained similar relationships:

$$[\beta]\{z\}+[s]\{P_z\}=\{0\} \qquad (1')$$

It should be obtained:

$$\{Y\}=-[\alpha]^{-1}[r]\{P_y\}$$
$$\{Z\}=-[\beta]^{-1}[s]\{P_z\} \qquad (2)$$

For the calculus of matrices $[\alpha]$, $[\beta]$, $[r]$, $[s]$ it is convenient to apply the method of joint transmission the witch enables fast computation even taking into consideration are taken into consideration the geometrical properties of the crankshaft , see model shown in fig. 1, consisting of cylindrical or parallelipipedical bodies. Because these are different as to the real properties , which have a complicated fluctuation law, it is necessary to take into calculus some conventional geometrical properties, which will offer the same displacement as in case of the real shaft. Their choice may be carried out measuring the deflection in different points at a certain load or on the base of previous experience in case of design calculus.

If we take into consideration also the stiffness of main bearings, the canonical equations of the method of forces will have the following from:

$$[\alpha][Y]+[r]\{P_y\}=[\mu]\{Y\}=\{\Delta_{py}\}$$
$$[\beta][Z]+[s]\{P_z\}=[\nu]\{Z\}=\{\Delta_{pz}\} \qquad (3)$$

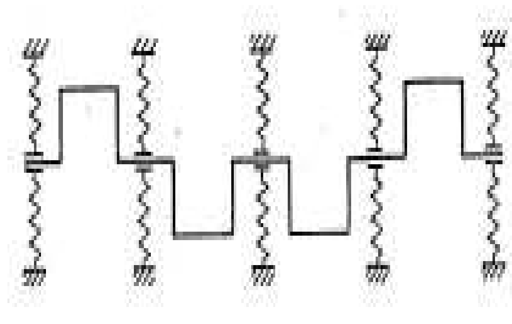

Fig.3

c) The calculus of torsional vibrations at shaft should be carried out on a model with concentrated masses (Warrior,N.A., Sime,A.P., Hyde,T.H., Fessler,H., 2003), (Argentum Group Company , 1991), (Argentum Group Company , 1992).

. The inertia moments of connecting rod and piston are diminished at crankshaft axis. The set of differential equations:

$$[J]\{\ddot{\varphi}\}+[c]\{\dot{\varphi}\}+[k]\{\varphi\}=\{Q\} \qquad (4)$$

describes crankshaft behaviour at torsional vibrations. The method of modal superposition should be used in order to obtain resolution $\{\varphi\}$, while the disturbance is factored in Fourier's series. The resolution $\{\varphi\}$ enables the calculus, in different areas, of stresses caused by torsional vibrations.

d) In order to investigate the effect of torsional vibration, the crankshaft should be considered as a rod with distributed mass, placed on flexible supports. The effect of into consideration by concentrated mass M_C placed between tow main bearings (fig. 4)

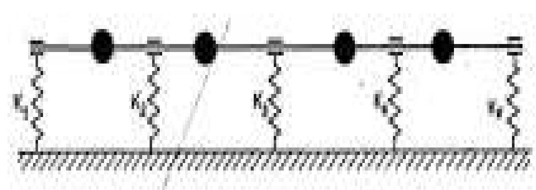

Fig. 4

d) In order to establish concentrates, which appear at crank pin elbows joining radii, due to flections and torsion, there was used the method of finite elements.

This way, a series of elbows with various dimensional properties were divided into the range of those used at manufacturing, establishing the values of safety factors.

These values were entered into memory, enabling in each investigated particular case to adopt the safety factors.

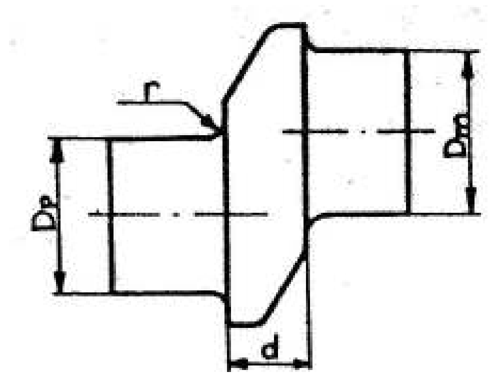

Fig. 5

3. CONCLUSIONS

The programming system enables the fast calculus of a crankshaft and the choose of the best version. It is also possible to investigate only one single from, using only the stage with useful programs. We think that the used models are efficient, taking into consideration that they were objectified by the calculus of a great number of crankshafts used in operating with known reliability and strength properties.

More sophisticated methods, as division of the entire shaft into finite elements, are not efficient from the economical point of view, if there are not also other reasons.

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