DIAGNOSTICS THE NATURAL FREQUENCIES OF THE AUTOMOBILE DISC AND THEIR ANALYSIS

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Summary

The article deals with the analysis of the natural discs frequencies realized by the means of mathematic simulation by the finite elements method, by which the programs AutoCAD and Cosmos M were used. First fifty natural frequencies are presented for the listed type of the steel disc.

The experimental measurement for the listed disc type was made by the Doppler vibrometer. The results of the measurement are presented in a graphic form and the measurement was performed in radial and axial direction.

Key words: Diagnostic, frequency, experimental measurement, shape of disc.

1. INTRODUCTION

The discs of tyre casings belong to the main parts of transport vehicles. During the operation they are exposed to a big dynamic load. From their correct function in many cases depends the safety of their operation. While exposed to outside forces, they may be forced to oscillate that may cause the natural frequencies (in surroundings of resonance frequency) a dangerously high level of amplitudes. Premature tear and wear may appear and eventually it can damage the disc. Because of these facts, it is very important to know the frequencies of the natural vibration of the disc. During the construction of these discs, it is possible, by suitable geometric forms, (profile, shell thickness, beam) and also by the suitable selection of material to influence the value of natural vibration frequencies. The theoretically calculated shapes of vibration and values of their frequencies are not 100% reliable, because the mathematic model is not able to explain all characteristics of the product. Because of these facts, it is necessary to make experimental verifications. Fig. 1 represents the detailed discs parts. The basic static load bearing capacity is 400 kg. The rim thickness is 2,4 mm, and the disc thickness is 3,95 mm. The output temperatures of the semi-products extruded by extruders are 110^o –120^o C. For further technological operations it is necessary to decrease their temperature to 40^{o}C.This is realised usually in coolers where water is applied as a coolant medium. The cooling can be realised by spraying or by dipping.

Fig. 1. Detailed discs parts

2. THE NATURAL FREQUENCY AND NATURAL FORM CALCULATION

The mathematic model of the disc (Fig. 2) was designed in COSMOS M program like a four-nodal thin shell element. Only half of the model was created, as it is symmetrical around the centre line.

Under the true vibrations we understand the ability of the system to perform vibrations without the effect of excitated oscillation. The natural frequencies and the natural vectors are dependent on the static parameters of the mechanical system (weight, stiffness, damping, respectively on the grip point coordinates), it means on structure of the **M, K** matrix. The number of natural shapes of vibrations is equal to the number of degrees of freedom of mechanical system. The basic natural shape of vibration is represented by the free vibrations of the system with the lowest natural frequency Ω_1. The analysis was executed without the system damping.

The problem represents the solution of differential equation:

$$[\mathbf{M}]\ddot{q}(t)+[\mathbf{K}]q(t)=0 \qquad (1)$$

where

M - is the symmetric weight matrix

K - is the symmetric stiffness matrix

$q, \ddot{q}$ - are column matrixes of generalized coordinates and accelerations

The solution of the equation (1) is searched in form:

$$q(t)=\mathbf{A}\sin(\Omega t+\varphi) \qquad (2)$$

With the solution of the equation (2) we get:

$$\ddot{q}(t)=\mathbf{A}\Omega^2\sin(\Omega t+\varphi) \qquad (3)$$

where **A** - is a column n-dimensional matrix of amplitude displacement.

After the solution of equations (2),(3) into (1) and execution we get:

$$([\mathbf{K}]-\Omega^2[\mathbf{M}])\{\mathbf{A}\}=\mathbf{0} \qquad (4)$$

This equation represents the generalized problem of natural values whose solution was made by the iteration method of under space. This method is based on the idea of working inverse iteration with same natural vectors simultaneously. The initial vibration of the disc is displayed on Fig. 3, Fig.4, Fig.5, and in the table you will find the first fifty natural frequencies of the disc.

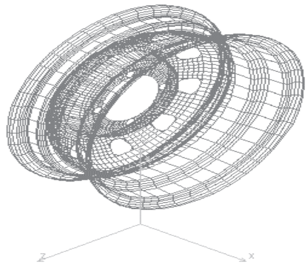


Fig.2 Calculated model disc
F_Mode = 1 16.7366 Hz

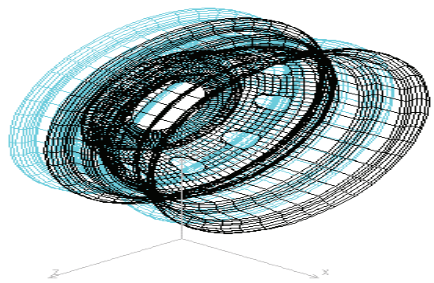


Fig.3. The first shape of disc vibration
F_Mode = 2 20.8501Hz

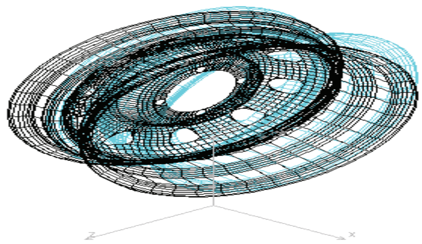


Fig.4. The second shape of disc vibration
F_Mode = 8, 36.3898 Hz

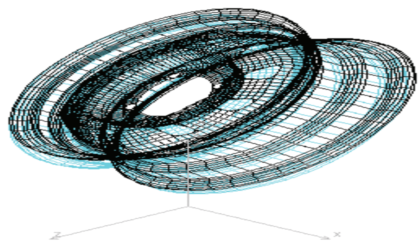


Fig.5. The eighth shape of disc vibration

3. THE EXPERIMENTAL MEASUREMENT OF THE NATURAL DISC FREQUENCIES BY THE DOPPLER VIBROMETER

By the measurement was the disc driven by the impact of the rubber hammer. The ray direction of the vibrometer laser head was changed so we could denote axial and radial oscillation amplitudes.

In the radial and axial direction we measured identical frequencies, it means that the disc, which deforms in axial direction deforms also in radial direction. The scheme of the apparatus by the measurement with the Doppler vibrometer is on the Fig. 6.

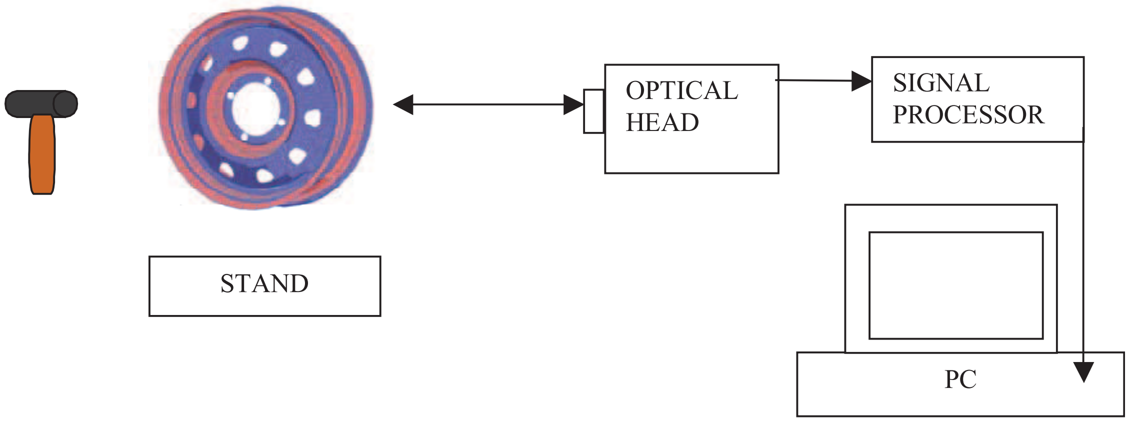
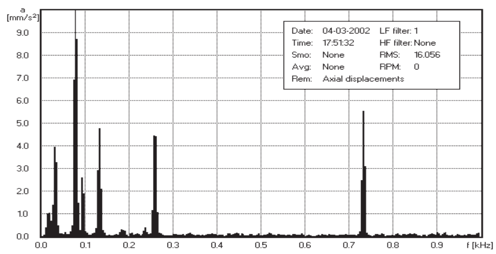
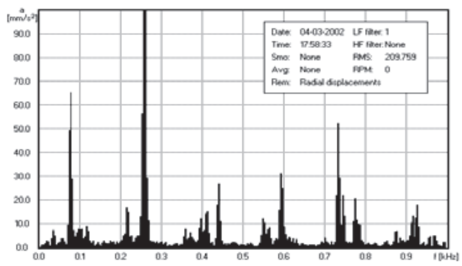


Fig. 6 The scheme of the apparatus by the measurement

On the graphs number 1 and 2 we can see measured frequencies of the iron disc in radial and axila direction



Graph 1. Natural disc frequencies
in the axial direction



Graph 2. Natural disc frequencies
in the radial direction

For the identification of the mainly axial modes we can´ t use ESPI (Electronic Speckle Pattern Interferometers), because radial modes form great amplitudes of the radial oscillation, which uncorrelated interference pattern ESPI, it means that on the sensitive area of the CCD camera will individual spots wobble in cross direction into amplitudes, in which is disturbed bilateral correlation between speckle structures of the duo exposure record. It means, that the interference pattern contrast will decrease virtually on zero and the pattern is not observable.

4. CONCLUSION

By the disc production we try that their natural frequencies should be out of the car operating frequencies. This fact guarantees greater car stability by the arbitrary operating mode, reduced vehicle noisiness and greater drive comfort.

If we compare the numerical calculation with the experimental measurement for the specified iron disc, we can see, that natural frequencies from the experimental measurement and computer simulation are almost identical

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