TRANSPORT PROBLEMS 2010
PROBLEMY TRANSPORTU Volume 5 Issue 1

Gear transmission, vibroactivity, FEM

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A STUDY OF THE INFLUENCE OF RIBS SHAPE ON THE GEAR TRANSMISSION HOUSING VIBROACTIVITY

Summary. The paper presents the results of model studies aimed at reducing the vibroactivity of the toothed gear housing. The effect was analyzed of the shape of additional ribs on changes of the forms of vibration of the upper housing plate and on its vibroactivity. Simulations were conducted using the Finite Element Method (FEM). Based on the studies performed, the shape of ribs with dimensions ensuring a reduction of vibroactivity by several dB was determined, with a minor increase of the housing weight.

BADANIA WPŁYWU KSZTAŁTU UŻEBROWANIA KORPUSU NA WIBROAKTYWNOŚĆ PRZEKŁADNI

Streszczenie. Praca przedstawia wyniki badań modelowych nad obniżaniem wibroaktywności korpusu przekładni zębatej. Analizowano wpływ kształtu dodatkowego użebrowania na zmiany postaci drgań górnej płyty korpusu oraz na jej wibroaktywność. Symulacje prowadzono z wykorzystaniem MES. Na podstawie przeprowadzonych badań wyznaczono kształt żeber o wymiarach zapewniających obniżenie wibroaktywności o kilka dB, przy niewielkim wzroście masy korpusu.

1. INTRODUCTION

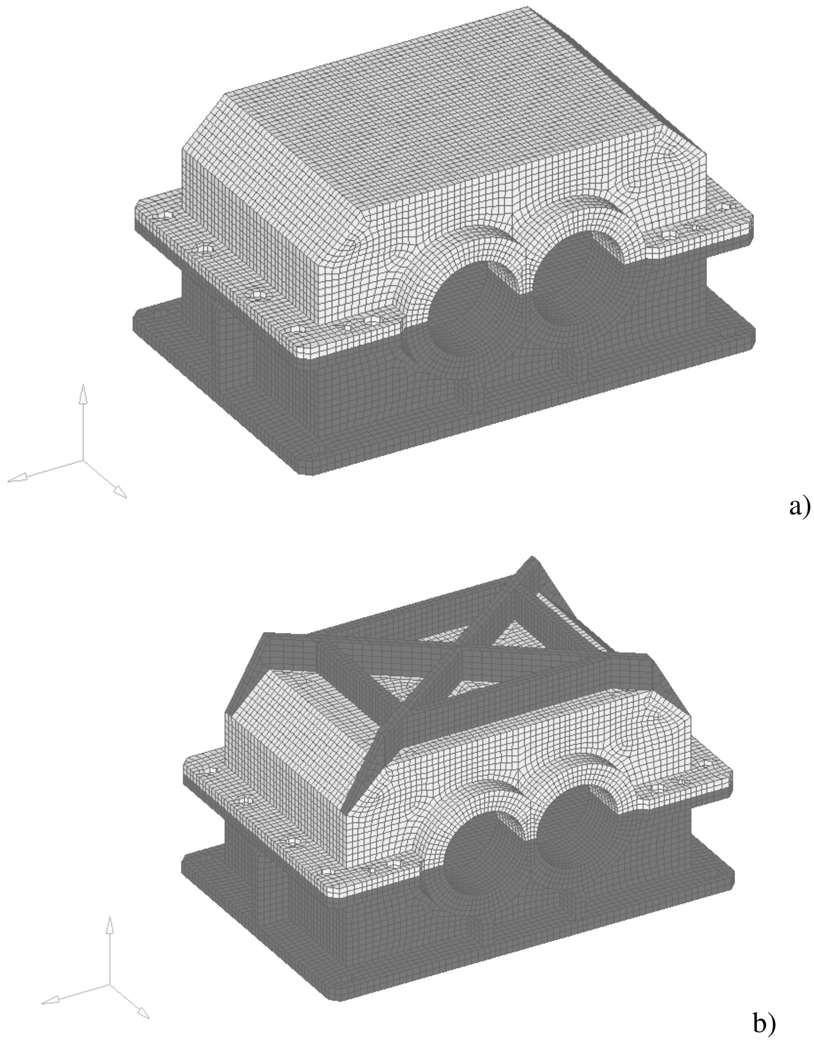
The common application of power transmission systems results in growing expectations regarding the emission of vibration and noise. The research currently conducted enables decreasing the noise of the gear transmission at its source. As results from the examples quoted in the literature, one of the factors influencing the emission of vibration is the design of the gear transmission housing. The tests conducted so far on simple models (inter alia [1]) indicate that the level of emission energy falls by as much as a dozen or so dB as the thickness of the gear housing walls increases. At the same time, the maximum emission energy shifts to higher ranges of frequency. This however, is accompanied by a significant increase of the gear transmission weight.

When selecting the engineering parameters of the housing, a useful range of rotational velocity of the toothed gear is taken into account. It appears from former research that the first 3 harmonic meshing frequencies transmit the main energy of vibration induced by the cooperation of toothed wheels (inter alia [2, 3]). This causes additional difficulties selecting those design features of the gear housing which effect the values of characteristic modal frequencies of the housing and selecting properties of toothed gears which influence the values of excitation frequency, i.e. the frequency of meshing and their harmonics. This problem was investigated, inter alia in papers [4, 5] which analyzed the phenomenon of transmission of the toothed wheel vibration through bearings onto the gear transmission housing and in papers [6-13], where research was undertaken on forecasting structural vibration of the housing, based on examples of simple plates. An issue unresolved so far is the selection of the position and dimensions of additional ribbing of the gear transmission housing and, in particular, its upper plate, the latter being the main emitter of vibration, as results from the studies [1,2,4-13].

The paper quotes the results of research on the gear transmission housing, aimed at determining the effect of the shape of additional ribs on changes of the frequencies of resonance vibration of the housing upper plate and on vibroactivity of the housing.

2. OBJECT OF RESEARCH

A model of a gear transmission without ribs was adopted for the research. The model was braced with ribs situated in the regions where the maximum amplitude of normal vibration velocity occurs. The location selected for the additional ribs is presented in [14]. The view of the housings is presented in Fig. 1.



a)

b)

Fig. 1. The FEM model of the gear transmission housing: the housing before modification (a) and the housing with additional ribs (b)

Rys. 1. Model MES górnego korpusu przekładni zębatej: korpus przed modyfikacją (a) oraz korpus z dodatkowym użebrowaniem (b)

The adopted thickness of the upper cover sheet of the housing was 6 mm (thickness = 6 mm). The study assumed that the shape of ribs of various heights within the range of the height/thickness ratio = 1÷5 would be investigated, with a simultaneous modification of the width of the ribs within the width/thickness range = 1÷5/3. The calculations were conducted using MSC software in a frequency band of 20÷5000 Hz, assuming single forces (1 N) in all bearing assemblies of the housing.

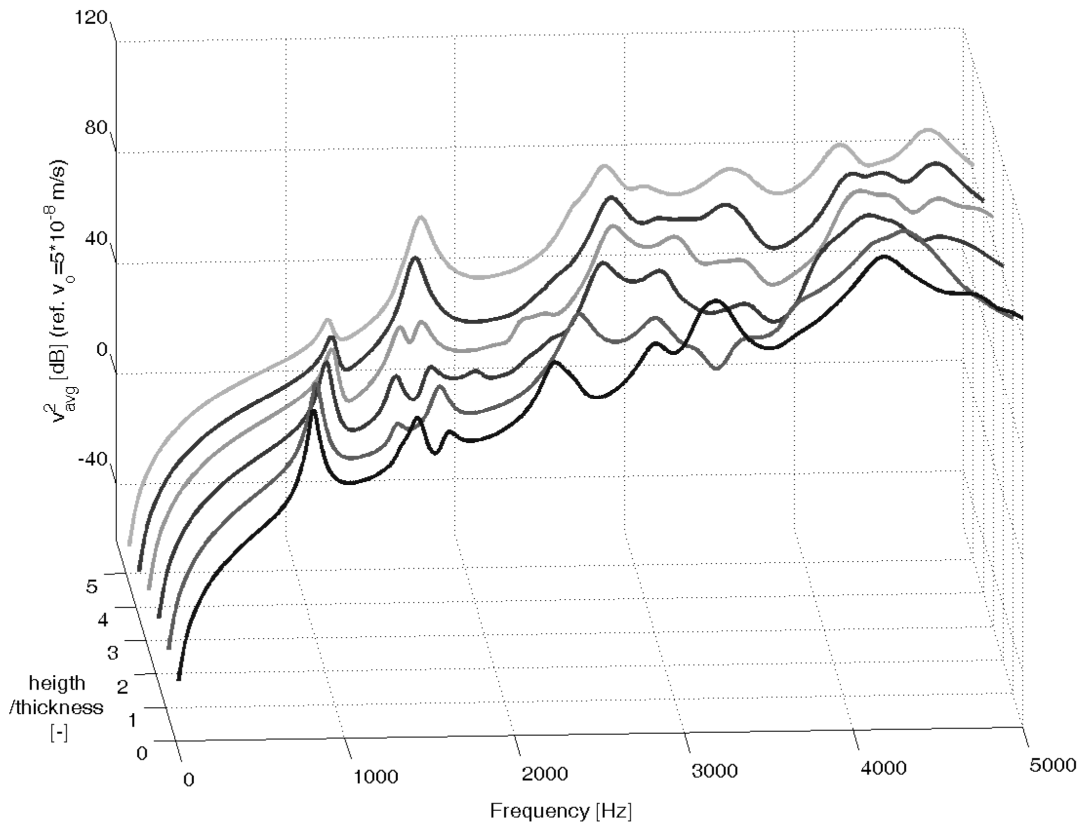
Based on the calculated values of normal vibration velocity vi of the assembly points of the upper housing plate in the FEM model, the measure of vibroactivity v^2_{avg} [2, 13-16], was determined according to the dependence:

$$v_{avg}^2 = \frac{1}{n} \sum_{i=1}^{n} \sum_{j=k}^{l} (v_i\ (f_j))^2 \tag{1}$$

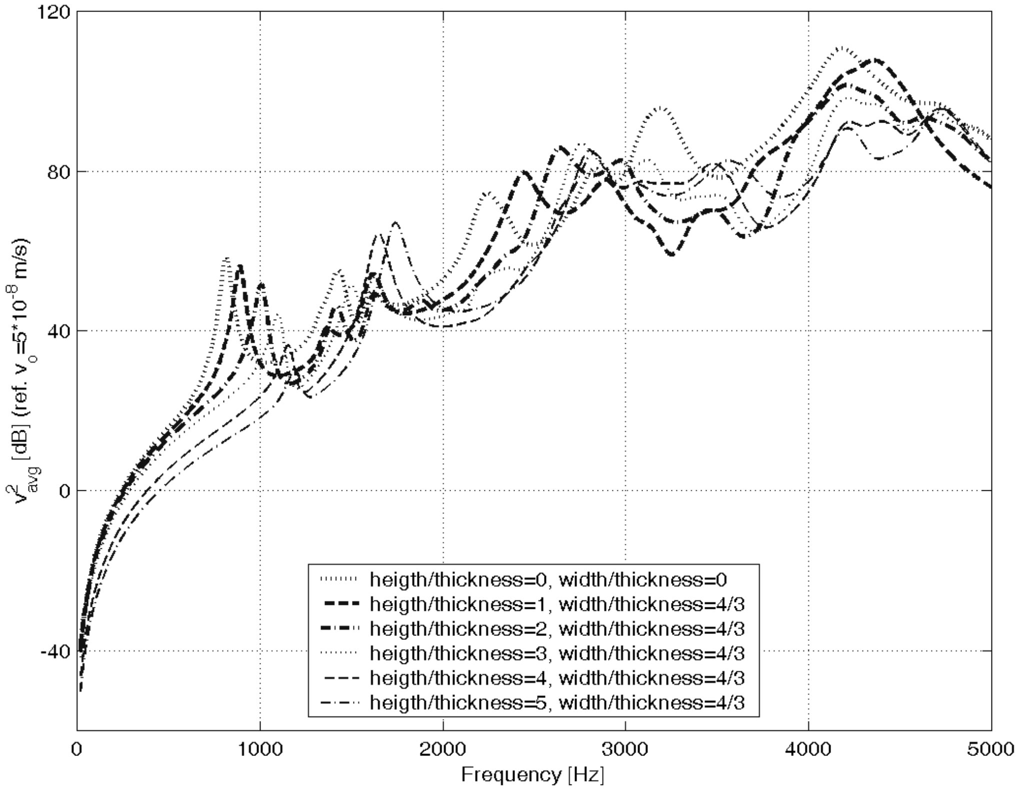
where: n - number of measurement points, k - lower range of the frequency analyzed, l - upper range of the frequency analyzed, f – vibration frequency.

3. RESEARCH RESULTS

Fig. 2 presents some examples of the calculation results for the analysed vibroactivity measure obtained for the assumed ratios of the ribbing cross-section: height/thickness = 1÷5 and width/thickness = 4/3.



a)



b)

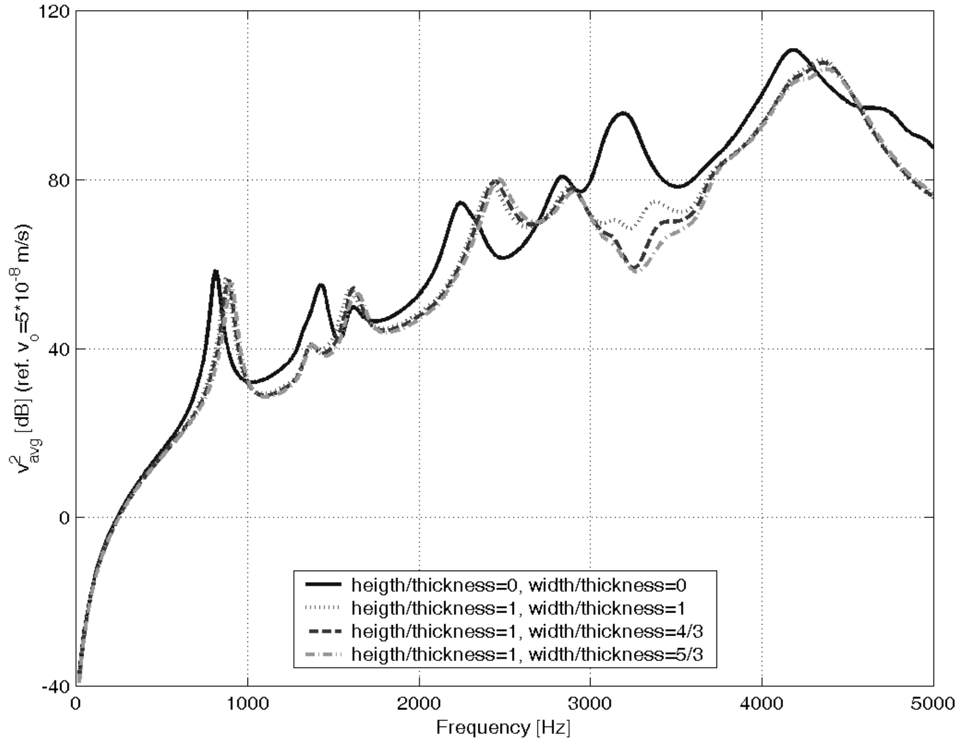
Fig. 2. A change of the value of vibroactivity measure, v^2_{avg}, depending on the shape factor of the housing ribbing, assuming that: height/thickness = 1÷5 and width/thickness = 4/3

Rys. 2. Zmiana wartości miary wibroaktywności $v^2_{śr}$ w zależności od wartości wskaźników kształtu użebrowania korpusu, przy założeniu wys/gr=1÷5 oraz szer/gr=4/3

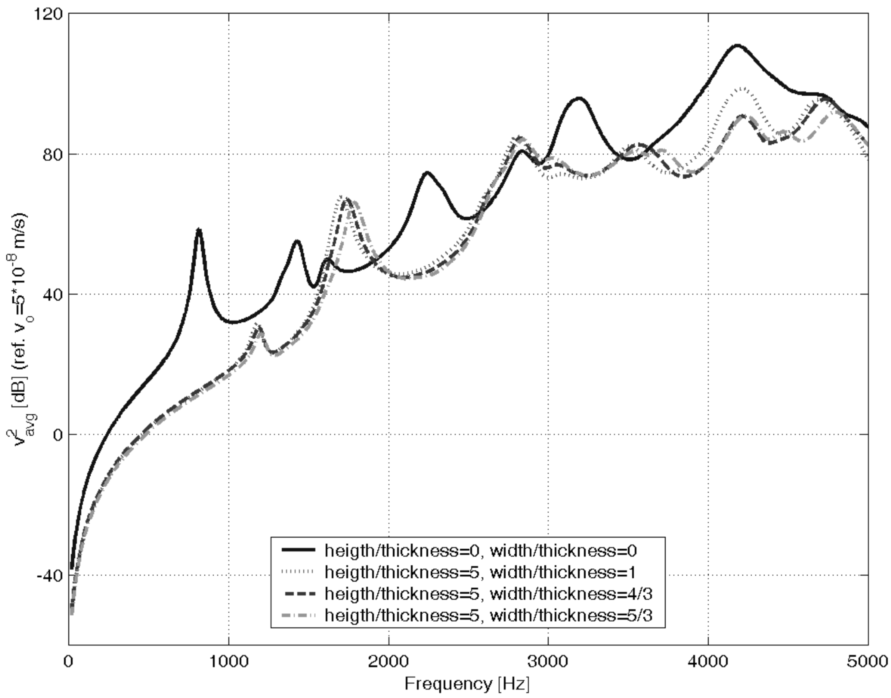
The changes of the measure v^2_{avg} presented in Fig. 2 and 3 prove a significant influence of the ratios of the ribbing cross-section on the resonance structure of the upper plate of the gear transmission housing. As the height of the ribbing grows, a shift of selected resonance frequencies is observed to higher ranges of frequency by 400 to 600 Hz, whereas a change in the width of the ribbing (Fig. 3) does not cause any significant changes in the frequency characteristics of the housing.

Continuing the calculations for the assumed indicators of the shape of ribbing, an average value of the v^2_{avg} measure was determined in the analyzed range of frequency. The results of the calculations are presented in Fig. 4a, while Fig. 4b illustrates the influence of the shape factors of ribs on the change of the gear transmission housing weight.

By analyzing the results of calculations of the adopted measure of vibroactivity of the housing depending on the ratios of cross-section of the ribbing, it can be observed that an advantageous solution will be, e.g., to adopt a cross-section of the ribbing in the following proportions: height/thickness = 4 and width/thickness = 1. In this particular case, the reduction of the adopted measure of vibroactivity amounted to ca. 4.5 dB, with an increase of the weight of the housing by less than 5%.



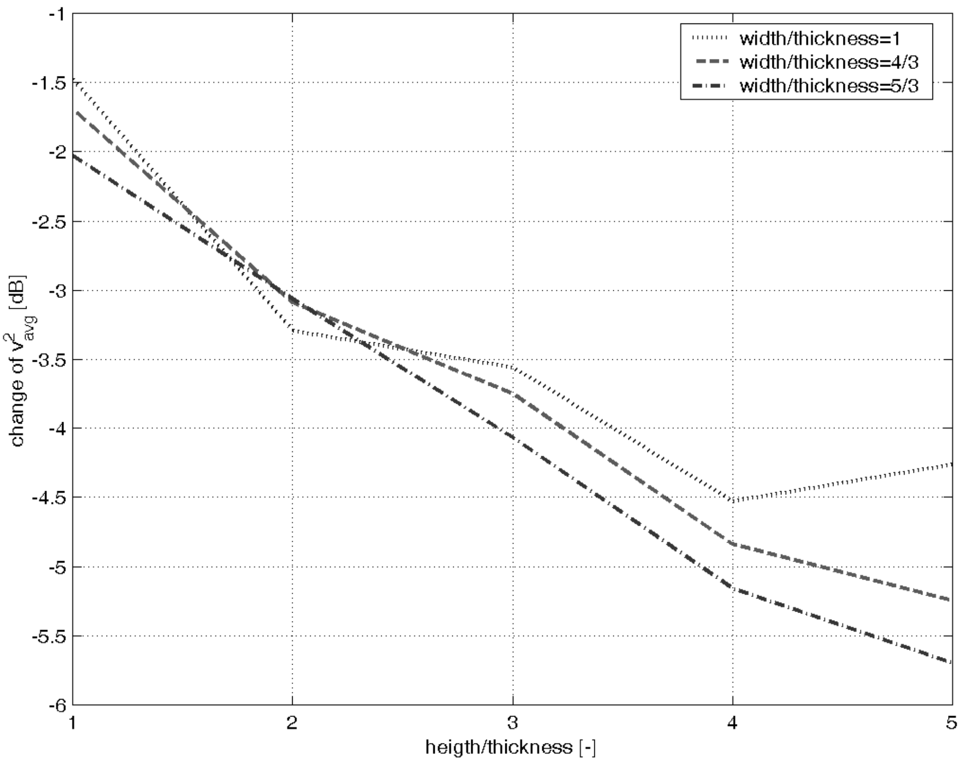
a)



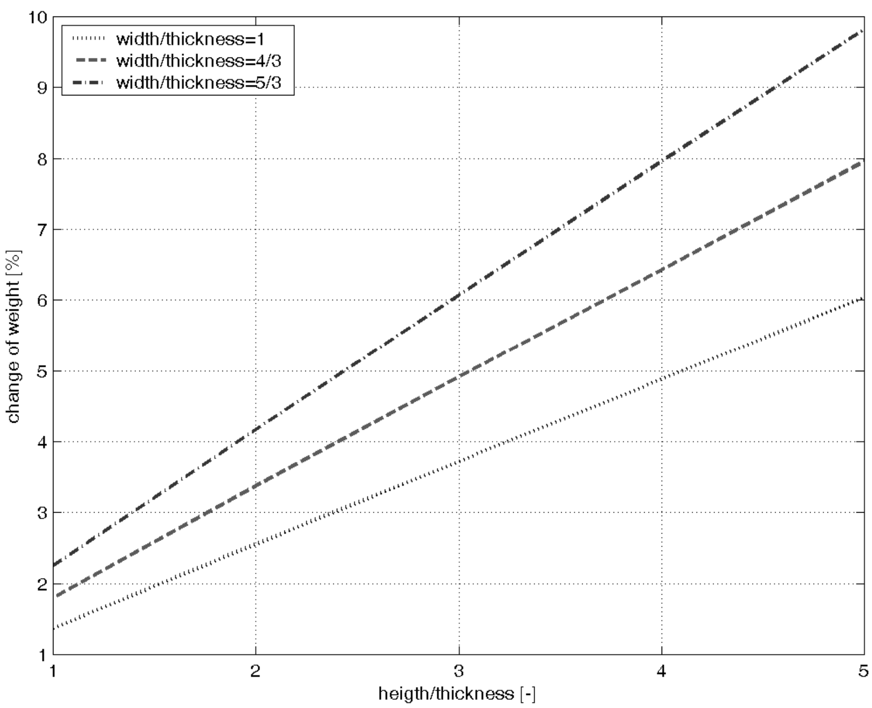
b)

Fig. 3. A change of the value of vibroactivity measure, v^2_{avg}, depending on the shape factor of the ribbing, assuming that: height/thickness= 1 and 5, and width/thickness = 0÷5/3

Rys. 3. Zmiana wartości miary wibroaktywności $v^2_{śr}$ w zależności od wartości wskaźników kształtu użebrowania, przy założeniu wys/gr=1 i 5 oraz szer/gr=0÷5/3



a)



b)

Fig. 4. The effect of the shape of the housing ribbing on the changes of the value of measure v^2_{avg} (a), and on the weight of the housing (b)
Rys. 4. Wpływ kształtu użebrowania korpusu na zmianę wartości miary $v^2_{śr}$ (a) oraz masę korpusu (b)

4. CONCLUSION

The research on reducing the vibroactivity of power transmission systems may be nowadays conducted using FEM numerical models of housings.

It has been demonstrated in the paper that the shape of ribbing has a significant effect on the level of vibroactivity of the gear transmission housing. It results from the calculations that using ribs of a reduced height is a reasonable solution. In such case, a considerable decrease of vibroactivity of the gear transmission is obtained, with a minor increase of the weight.

Also, by increasing the height of the ribbing, a shift of resonance frequencies of the housing to upper ranges is obtained, the width of the ribs being of minor importance.

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Received 01.08.2009; accepted in revised form 21.03.2010