inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 1.4

NOISE EMITTERS IDENTIFICATION OF THE PASSENGER CAR MECHANICAL GEARBOX

V. Misun

Technical University of Brno, Technicka 2, 61669, Brno, Czech Republic

Tel.: 00 420 5 41142860 / Fax: 00 420 5 41142876 / Email: misun@umtn.fme.vutbr.cz

Keywords:
GEARBOX, NOISE, EXPERIMENTAL ANALYSIS, SPECTRAL PROPERTIES

ABSTRACT
The gears in mechanical transmissions generate vibrations during running. The Campbell diagram and tracking one of the acoustic pressure levels were used for identification of the most significant causes of the higher operational vibrations and noise to be emitted. It was found out that the vibrating outer surfaces of the gearbox housing and engine block were very expressive noise emitters under running conditions, especially at individual resonant frequencies of the structure. So that the spectral and modal properties of the gearbox housing structure were being taken into account. This paper presents an experimental study of these spectral and modal properties of the passenger car gearbox housing and their influence to the total noise level.

1 - INTRODUCTION
The acoustic pressure field in the acoustic space is unambiguously determined by vibrations of the gearbox housing and engine block structure. Each mode shape of this structure, according to the intensity of its excitation during running, contributes then by its noise in different measure to the total noise which is emitted from the whole system.
Experimental and computer analyses were used for identification of the most significant causes of the higher noise level. We will pay attention to the experimental analyses in this written paper only.

2 - OPERATIONAL NOISE OF THE GEARBOX
The scheme of the mechanical passenger car gearbox is presented in Fig. 1. Higher operational vibrations of individual parts of the gearbox structure increase the total noise level.
Fig. 2 shows Campbell diagram of the acoustic pressure levels of noise spectrum emitted from the back wall of the gearbox within a 1m from this wall when the $4^{\text{th}}(\text{P} = 4)$ gearbox ratio was engaged. The noise spectra were measured at individual admission shaft revolution in the range of $(1000 - 5000)$ rpm with step of 50 rpm. The dynamic range of the acoustic pressure level is from 44 dB (white points) up to 84 dB (black points).
There are obvious the dominant contributions of the frequency components at the mesh frequencies of both engaged and constant gears from this diagram − see the inclined black lines.
From these characteristics it is also obvious that more noise sources contribute to the total noise level at various frequencies. These sources however contribute at individual constant frequencies − see vertical blur lines in the diagram. These frequency components are not changed with the admission shaft rotation change. These frequency components are the natural frequencies of the whole structure of the gearbox housing and the engine block.
In Fig. 3 is presented the tracking diagram of the gearbox noise level within driving moment of 40 Nm, total noise level of 99.4 dB. There are main contributors presented to the vibrations and the gearbox noise − the mesh frequencies of the engaged and constant gears. The engaged gear contributes to the total noise level more up to approximately 3500 rpm to the opposite of the constant gear. Individual noise levels courses have local maxima and minima. So that this characteristics also confirm the influence of the resonant phenomena of the gearbox and engine block structure.

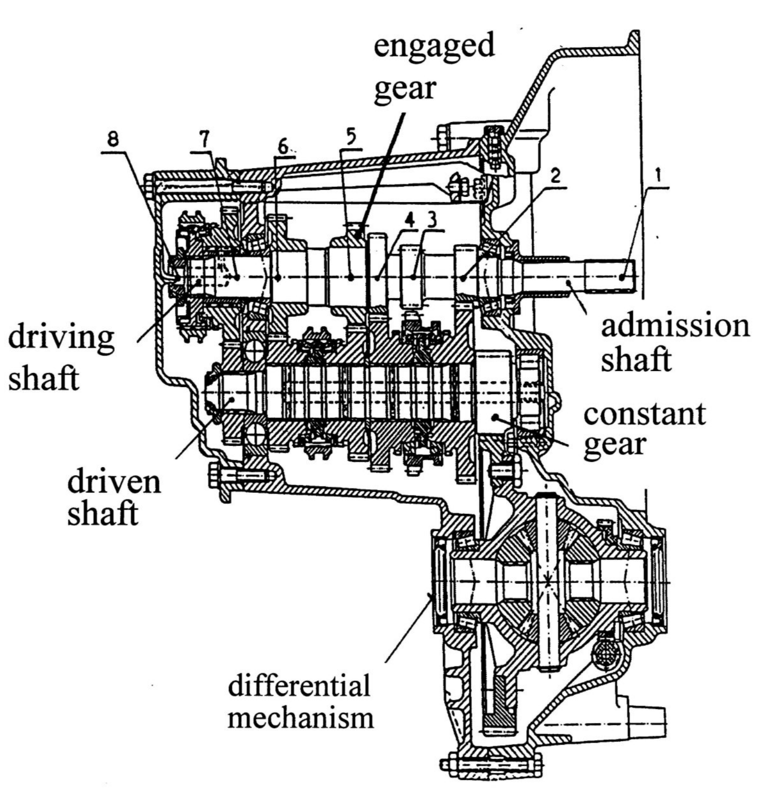

Figure 1: Scheme of mechanical gearbox.

3 - NOISE SOURCES IDENTIFICATION

The noise sources are vibrating outer surfaces of the structure. The maps of acoustic intensity distribution under different operation conditions (gearbox speed engaged, the shaft revolution, the torsional load of the shafts, direction of the shaft revolution change) were measured. The total acoustic intensity levels were measured in the frequency range $(200 - 4000)$ rpm and also in individual 1/3 octave bands for the purpose to identify the most significant noise emitters on the outer housing surface.

4 - SPECTRAL PROPERTIES OF THE STRUCTURE

The spectral and modal properties were evaluated by means of harmonic excitation of the housing structure and both driving and driven shafts. There were identified the structure modes that the most contribute to the total noise level.

In Fig. 4 measured mode of vibration of the gearbox and engine block housings is presented at the natural frequency 445 Hz. There are figured nodal lines and isolines of the constant amplitude vibrations of the corresponding mode. From this mode it is possible to identify the areas that vibrate the most expressively $-$ noise emitters.

The vibrations both of the driving and driven shafts are the causes of the gear mesh condition changes of individual gears. These vibrations cause the impacts in the system with the spectrum in a very wide frequency band.

5 - CONCLUSION

On the basis of the measured results presented above we can state that the two main dynamic problems are the causes of higher noise energy emitted from the outer gearbox housing and engine block. The basic problem is given by the bad gear mesh conditions of the gears (bad teeth geometry and their technology). The second important problem is occurrence of the resonant phenomena of the gearbox housing during operational regimes. In order to suppress acoustic resonant peaks it is convenient to introduce higher damping in the structure.

ACKNOWLEDGEMENTS

The paper has been written within the framework of solution of the grant project GACR No. 101/00/0069

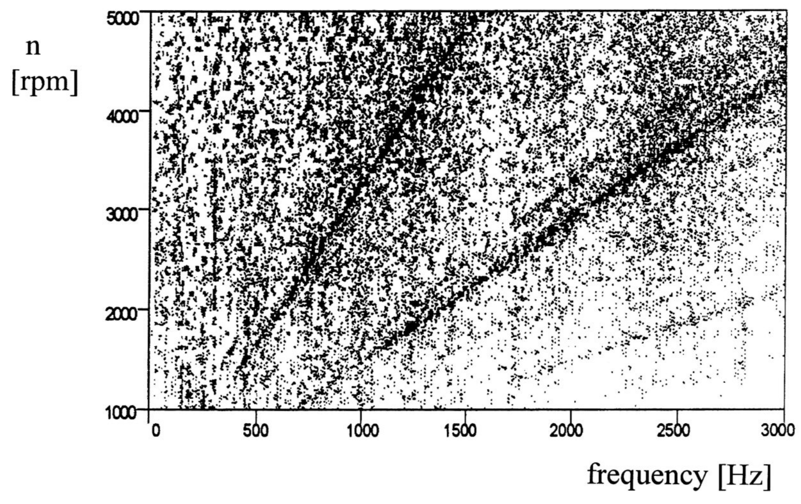

Figure 2: Campbell diagram.

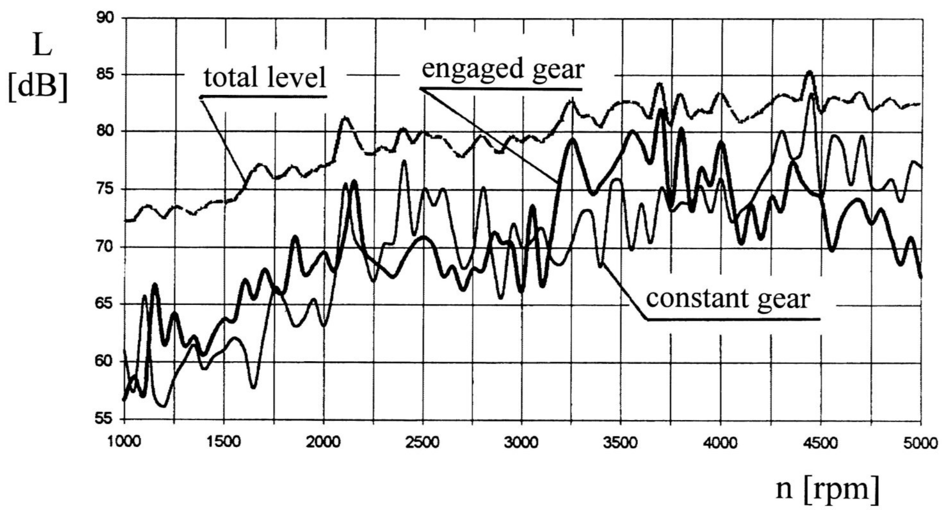

Figure 3: Tracking diagram of the gearbox noise.

and name "High Frequency Noise Analysis of Vibroacoustic Systems" and further of research project No. CEZ J22/98: 262100001 and No. CZ 390001.

REFERENCES

1. **V.Misun**, Analysis and modeling of the vehicle gearbox noise, In *Congress INTER-NOISE 96*, pp. 171-174, 1996

2. **V.Misun**, Noise analysis of the SKODA-FELICIA gearbox, In *Conf. INTERACTION AND FEEDBACK*, pp. 65-72, 1996

3. **I.Mazurek**, *Analysis of noise emission of gearbox S 791*, Research Report TU Brno, pp. 1-48, 1995

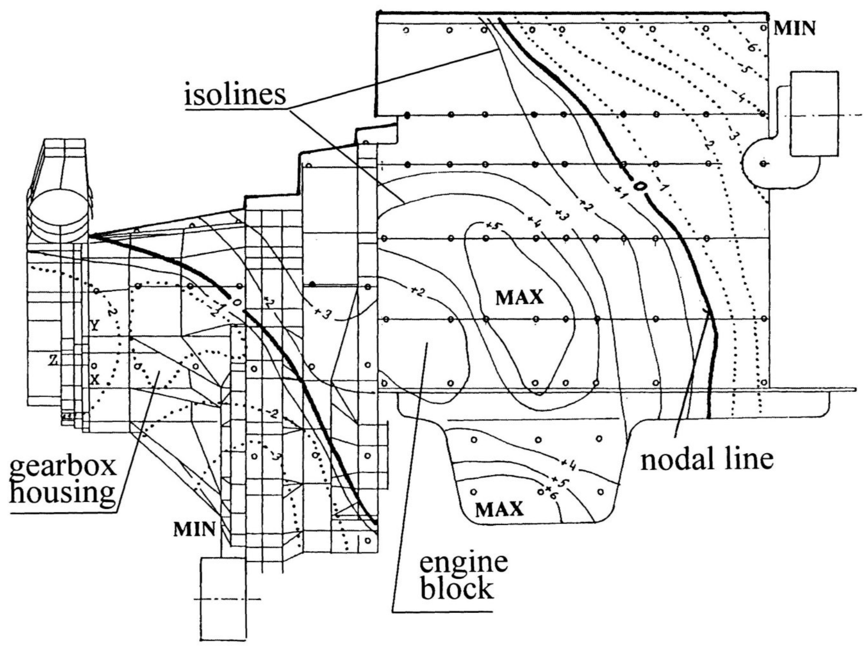

Figure 4: Mode of vibration of the structure at natural frequency 445 Hz.