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CONSTRUCTIVE MEASURES ON REDUCTION OF GEARBOX NOISE LEVEL

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Abstract: *Reducing noise from cars, imposed by the CE rules or the ECE-ONU regulations, is an objective for the designers and builders of cars. The noise reduction provides an increased comfort for vehicle driver and a reduction of harmful effects of noise on the human factor. Noise level of cylindrical gears from gearboxes and distributing boxes is influenced by factors such as design, technological and operational. Changing the geometry of the mating gears leads to reduction of external noise of the transmission components and thus vehicle as a whole.*
Keywords: *noise, gearbox*

1. INTRODUCTION

In this paper we present some results of exterior noise measurements performed on a gearbox considered standard and two gearboxes, one with geometric changed parameters of gears and one with unchanged parameters. For this purpose, we present:
- Some results of the gear geometry calculation;
- Results of level noise measurements on a considered standard gearbox;
- Results of level noise measurements on a 10C-100 gearbox with geometric unchanged parameters and a 10C-120 gearbox with geometric parameters of changed cylindrical gears;
- Analysis and comparison of measurements noise results;
- Conclusions.

2. CALCULATION OF CYLINDRICAL GEARS

Using a computer program of cylindrical gears according DIN-ISO method were made, on computer, gears geometry calculations. Basically, start to redesign the cylindrical gears of 10C-100 gearbox. Every gear has preserved the transmission ratio but they changed the module, the angle of gear and specific movements. The module was reduced at each gear as appropriate, and the angle of gear was reduced from the value $\alpha = 200$ to the value $\alpha = 150$.
In the current practice of achieving the gearwheels tend to use low gear angles where friction force is directed toward the center of the wheel, thereby producing less noisy and higher degrees of coverage gears, combined with the angle of the teeth.
The results of the gears calculation have set up documentation for implementing the new version 10C-120 gearbox. Will present calculations results of cylindrical gears made for 1st and 4th gears from 10C-120 gearbox.

GEARS PARAMETERS

Specification gear – 1st gear , CV 10C-120
Design data
- external gear;
- Number of teeth: $Z_1 = 23$; $Z_2 = 79$;
- Normal module: m = 3 mm;
- Distance between axles: AW = 160 mm;
- Angles: $\alpha = 15^0$; $\beta = 15^0$

Geometrical elements calculated
- Wheel width: b_1 = 33,000 mm; b_2 = 33,000 mm;
- Division diameters: d_1 = 71,434 mm; d_2 = 245,360 mm;
- External diameter: da_1 = 82,034 mm; da_2 = 250,966 mm;
- Internal diameter: df_1 = 66,634 mm; df_2 = 235,566 mm;
- Base diameter: db_1 = 68,835 mm; db_2 = 236,432 mm;
- Rolling diameters: dw_1 = 72,157 mm; dw_2 = 247,843 mm;
- Displacement profile: x_1 = 0,700000; x_2 = - 0,132356;
- Displacement sum: x_s = 0,568;
- Thicknesses teeth in the frontal plane of the circle division: sdf_1 = 6,004 mm; sdf_2 = 4,666 mm;
- Coverage degree: ea = 1,745, additional eb = 0,906, total eg = 2,651;

Reference of the geometrical elements of the rack
- Angle: $\alpha = 15^0$; ha = 1,1; co = 0,4;
- Quota over 4 teeth: 33 403 mm to 1st wheel;
- Quota over 7 teeth: 60,526 mm to 2nd wheel.

GEARS PARAMETERS

Specification gear – 4th gear , CV 10C-120
Design data
- external gear;
- Number of teeth: Z_1 = 41; Z_2 = 56;
- Normal module: m = 3 mm;
- Distance between axles: AW = 160 mm;
- Angles: $\alpha = 15^0$; $\beta = 23^0$

Geometrical elements calculated
- Wheel width: b_1 = 33,000 mm; b_2 = 33,000 mm;
- Division diameters: d_1 = 133,622 mm; d_2 = 182,509 mm;
- External diameter: da_1 = 142,358 mm; da_2 = 190,578 mm;
- Internal diameter: df_1 = 127,022 mm; df_2 = 175,242 mm;
- Base diameter: db_1 = 128,297 mm; db_2 = 175,235mm;
- Rolling diameters: dw_1 = 135,258 mm; dw_2 = 184,742 mm;
- Displacement profile: x_1 = 0,400000; x_2 = 0,288880;
- Displacement sum: x_s = 0,689;
- Thicknesses teeth in the frontal plane of the circle division: sdf_1 = 5,762 mm; sdf_2 = 5,584 mm;
- Coverage degree: ea = 1,794, additional eb = 1,368 total eg = 3,162;

Reference of the geometrical elements of the rack
- Angle: $\alpha = 15^0$; ha = 1,1; co = 0,4;
- Quota over 6 teeth: 51,621 mm to 1st wheel;
- Quota over 7 teeth: 60,892 mm to 2nd wheel;

Analyzing the obtained results it is found that reducing the module and angle gear, will obtain high coverage gear. This leads to a smooth gearing of gearwheels because always are gearing more than two teeth. It obtains a better distribution load and a lower demand of tooth flanks.

3. NOISE MEASUREMENT NOISE

3.1. Measurement noise for standard gearboxes, modified and unmodified

Have made measurements at following gearbox noise:
- EATON type RT-11609A, considered standard;
- 10C-100, box with geometric parameters of cylindrical gears unchanged ;
- 10C-120, symilar box with 10C-100 of cylindrical gears changed .

Was measured sound power level L_{WA} for gears V, VI, VII and VIII from three input speeds: 600, 1650 and 2200 r / min. Method of measurement was in accordance with SR EN ISO 3744:1997.

The result of noise measurement for standard box EATON tip RT-11609A are summarized in table 1.

Table 1

RPM [rot/min]	Sound power level L_{WA} [dB(A)]			
	Vth Gear	VIth Gear	VIIth Gear	VIIIth Gear
600	81,5	81,8	82,6	82,7
1650	91	91,5	93	92
2200	96	94,6	95,6	94,5

The result of noise measurement for gear box 10C-100 with geometric parameters of cylindrical gears unmodified are summarized in table 2.

Table 2

RPM [rot/min]	Sound power level L_{WA} [dB(A)]			
	Vth Gear	VIth Gear	VIIth Gear	VIIIth Gear
600	85,7	86,5	87	89,3
1650	96,6	98,4	98,8	100,9
2200	100.2	102,2	102,5	103,7

The result of noise measurement for gear box 10C-120 with geometric parameters of cylindrical gears modified are summarized in table 3.

Table 3

RPM [rot/min]	Sound power level L_{WA} [dB(A)]			
	Vth Gear	VIth Gear	VIIth Gear	VIIIth Gear
600	82,3	83,3	82,6	84,5
1650	93,6	94,4	95,3	95,7
2200	97,8	95,4	99,3	97,3

3.2. Analysis and comparison of measurement noise box

Results of noise measurements on a standard gearbox and on 10C-100 gearbox with geometric unchanged parameters are compared and presented in the Figure 1.

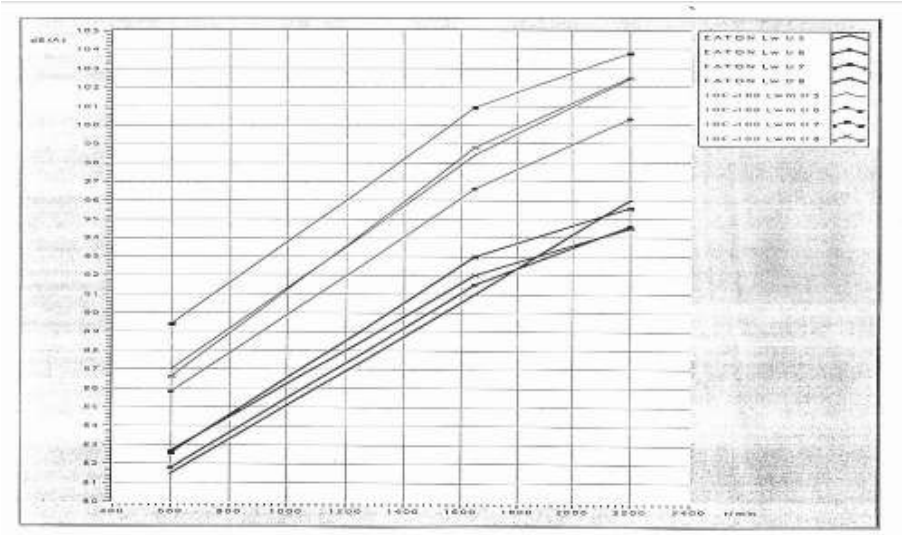

Figure 1

From the result and compared diagrams from picture 1 result that the noise level of gear box EATON is with 3 – 6 dB (A) small than gearbox 10C-100.

More conclusive results support the influences of geometrical parameters on gear noise were obtained from the analysis and comparison of measurements made on the gear box 100 and 10C-10C-120 gearbox with geometric parameters change.

In pictures no. 2 and 3 are compared, diagrams drawn for the two gearboxes sound power values from two-speed V gear and VIII gear.

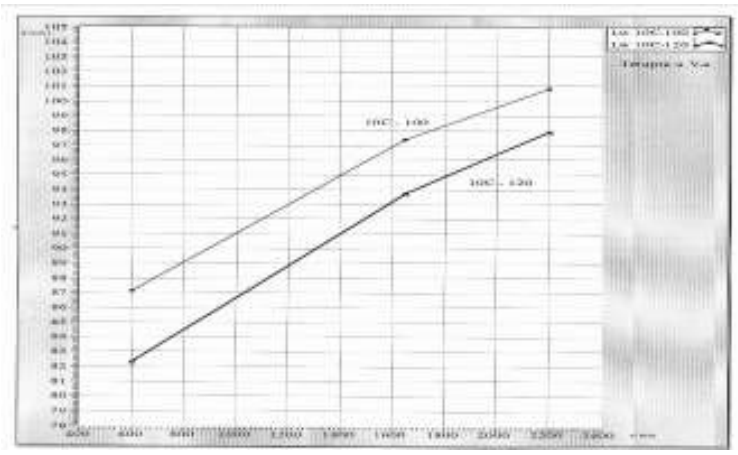

Figure 2

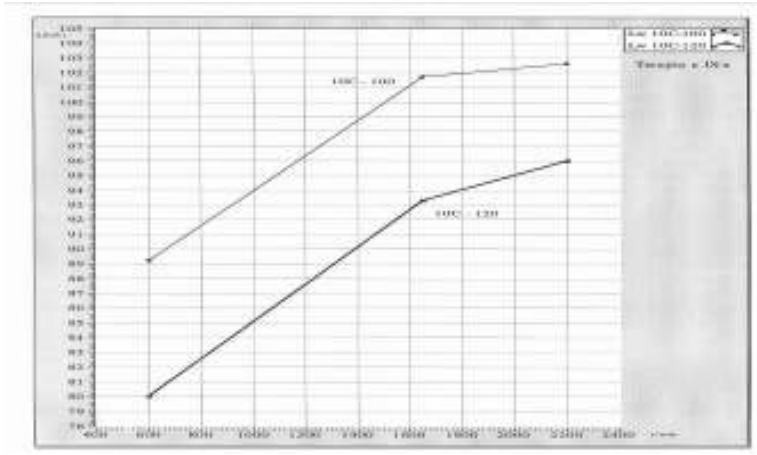

Figure 3

From diagrams drawn from measurements made on the two cases is observed that in all gears at three speeds, sound power level values are 3-6 dB (A) lower at 10C-120 gearbox to the 10C-100 box.

Also, the diagrams drawn, one can see that values obtained for gearbox noise 10C-120 are comparable to those obtained from standard box type RT EATON-11609A.

4 Conclusions

To reduce noise transmission gears of vehicles to be driven cylindrical, generally, the constructive and technological parameters.

Use gears with reduced modules, reduced gearing angle coverage and high noise reduction results in 3-6 dB (A). This increases their competitiveness and employment aggregates in the transmission of international standards on noise pollution.

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