STUDY ON THE NOISE EMISSION OF BELT CONVEYOR IDLER ROLLS

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Abstract: The paper intends to introduce research results in area the noise of belt conveyor rollers. Measurements were carried out in laboratory by the author. At the end of the paper, used the results of measurements also gives examples to calculate noise power level of belt conveyor.

Keywords: noise; conveyor belt; roller; measurement; noise power level

1. INTRODUCTION

Noise had an insignificant impact earlier among the harmful effects of the environment affecting people. The increase of the areas settled by various industrial plants has meant at the same time that populated areas and those accommodating industrial plants have moved closer and closer to each other. This resulted in the reduction in the size of protective belts which had reduced by their effect the noise level affecting areas used for habitation and recreation to an acceptable value earlier. The situation is further augmented by a significant rise in the performance of the machines employed as caused by ever enhanced mechanization in all the fields of industry and agriculture – entailing evidently an increase in the energy of noise emitted by them. This is accompanied by an increase in the loading effect of noise originating in traffic.

2. NOISE PROBLEMS IN THE VICINITY OF CONVEYOR BELTS

Our narrower field – namely mining – is also concerned in the environmental problems associated with noise. Due to the nature of the subject the surroundings of mines operating on the surface for producing construction materials and fuels (brown coal, lignite) are affected mainly by this issue. Compared to the production machinery

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operating with considerable noise output the noise generated by conveying equipment and its effect is not negligible at all. It may appear at first approximation that the effect of the noise generated by the rubber-belted conveyors widely used for transporting bulk materials is much less than that of the machines used for production. Cautiousness is called for, however, by the increased number of complaints submitted by people because of high performance conveyor belts operated close to habituated areas. The disturbing effect is retraceable basically to two causes. One of these is the continuous mode of transportation. After all the conveyor belts positioned along the transport route of producing mines are operated generally overnight as well. However, the noise level (L_{AM} = 40 dB in small-townish & rural areas) permitted for the night period from 22:00 to 6:00 hours is low enough for an insufficiently wide protective belt or an improperly maintained conveyor belt to cause this limit value to be exceeded. The situation is further augmented by the fact that the night-time period investigated is only T = 1/2 hour. In the daytime, it is more advantageous in respect of the noise load generator that the time period of evaluation is T = 8 hours. The other cause is the nature of the source. The belt conveyor as a noise source behaves as a linear source. The noise generated by such a source is attenuated to a lesser extent as the function of distance then if it were originating from a point source.

Outside the borders of Hungary – mainly in the countries where the quantity of fuels produced in mining by open-cast method is significant (such as Australia, Canada, the United States) – the noise generated by conveyor belt approaching the living-space of people had enforced already earlier this issue to be dealt with. According to the measurements concluded a 100 m long section of a conveyor belt transporting coal of common design – running at 5 m/sec velocity and 10,000 t/h capacity – generates 113-119 dB noise output levels. [Brown et al, 2004] In the case of designs aimed explicitly at reducing the noise output even somewhat lower – around 107 dB - noise output levels can be achieved (referred also to a 100 m long section). We hasten, however, call attention to the fact that well maintained, not worn-out conveyor belts were involved in the above-mentioned cases. It is a completely different case to be faced, however, when the track contains components deteriorated during operation – such as worn rollers, strings and others as well, with their numbers being important as well, naturally. In such a case, the increase in the noise output level may reach such an extent which may mean the multiplication of the noise output level.

It is very important to decide at what level we attempt to intervene in order to reduce the noise level. Also, it may be useful in the case of operating production plants if we can estimate in advance what noise load is expectable at the inhabited object close to a conveyor belt intended to be operated along a planned route during its operation. Considerable costs could be saved for the plant if it could be determined already in the phase of designing a mine – or its revamp – whether the noise generated by the conveyor belt intended to be installed along the planned transport route would cause the limit value to be exceeded or not. Or – even if it would not in its newly installed condition - with the expected rate of attrition taken into consideration an estimate can be made of when the noise energy would rise to a level where the limit value may already be expected to be reached. The correlations describing noise propagation – usable for such an investigation – have been known for a long time. It is indispensable, however, to know the intensity of the source itself – or more technically its calculated noise output level. The noise output by conveyor belts is a complex one, in respect of its formation it is the consequence of the combined operation of several noise generating mechanisms. In summary, these mechanisms are as listed below:

- Noise originating in roller bearings and their vicinity
- Noise generated by the contact of the roller and the belt
- Noise generated by the vibration of the roller skirt
- Noise generated by air pumping due to the movement of the belt
- Noise generated by the vibrations of the conveyor frame

In the case of a track built from new components the interaction between the belt and the rollers is dominant with regard to noise generation. The observations to date have shown that the shape of the roller skirt – the skirt profile – and its defects, respectively, is the most important factor in the excitation of the vibrations the sounds generated by which are then radiated to the surroundings as noise. [Brown et al, 2004]. Thus, the important conclusion – that the skirt profile defect taken into consideration for the qualification of rollers is not only a parameter classifying a roller in mechanical aspect but is significant also with regard to the noise generated by the track – can be drawn already here. The specialists dealing with this subject propose therefore to use the maximum instantaneous slope (MIS), the parameter qualifying the quality of the skirt as the noise generation potential due to the inaccuracy of the rollers. [Brown et al, 2004] The question arises immediately, of course, whether the energy of the noise generated is influenced not only by the deviation of the roller profile from the ideal but also by the surface and condition, respectively, of the belt if the interaction between the belt and the rollers plays a primary role in the generation of vibrations and thereby of noise. Reference to this can also be found in the international literature but much less publications deal with this subject.

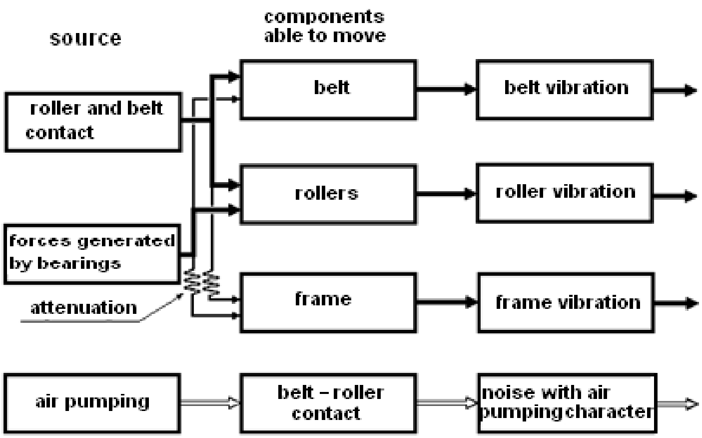

Fig. 1. Noise generating mechanisms of the conveyor belts

The experiences in Hungary show, unfortunately, that the rollers and roller strings installed in the belt tracks operated in the field of mining are replaced in general only in their severely deteriorated condition. The reason for this is to be found, naturally, in the intent to reduce operating expenses. The evaluation of whether this track maintenance concept results in the realization of actual cost saving and, if yes, whether it would entail extra cost in another area at the same time, is not a subject of this paper. It is a fact, however, that in the case of deteriorated or severely worn rollers the first element of the mechanisms shown in Figure 1 above becomes the primary factor in respect of noise generation. Thus, a large portion of energy of the noise generated originates in the roller bearings and their vicinity. At the same time, the intensity of the noise increases significantly along with the noise output level of the roller as noise source as well. A conveyor belt operating with worn-out rollers becoming noisy may subject the surroundings in comparison to its original newly installed condition to such a high noise load which may cause the limit value to be exceeded at the objects to be protected in its vicinity. Experiences indicate that in the case of high performance conveyor belts not only the track itself but also the drive system moving the belt constitutes a noise source. The motors of several hundred kilowatt power consumption, clutches and drive gears radiate a substantial acoustic energy to the surroundings. This energy is frequently higher than the noise output of the track. In spite of this the disturbing effect of the noise radiated from these components exerts itself in general to a less extent than that originating in the belt track since the drive system behaves as a point source and the noise generated by it is attenuated faster as the function of distance than that generated by the belt track. And, should the protective belt be insufficient, then the shielding of the sources – motors, drive gears – can be considered. It is reassuring that muffler enclosures can be installed also afterwards although this solution involves considerable expenses. Naturally, conveyor belts can also be enclosed. If, however, the objective of enclosing is noise attenuation, then the installation of movable noise barriers directly along the track is a less expensive solution. The limit values of noise load are checked by taking measurements at the object to be protected. (Sound pressure level measurement [L_p]=dB) Table 1 contains the limit values stipulated in joint Ministries of Environment Protection & Rural Development and Public Health Decree No. 27/2008 (XII.3.) KvVM-EüM and taken into account by the authorities in the case of inspections.

Table 1. **Noise limit values stipulated by law**

Area to be protected	**Noise Limit (LTH)**	
	Day: 6-22 h (T=8 h)	**Night: 22-6 h (T=1/2 h)**
Health Resort, health area	45	35
Living area (small town, suburb, village)	50	40
Living area (city)	55	45
Economic area	60	50

In cases where the limit value is exceeded some kind of protective measures is required. The implementation of this after the installation of the conveyor always entails higher costs as if attempts were made to intervene already in the design phase. In order to intervene in the design phase, however, the quantity characterizing the "noise generation capability" of the machine or package – in our case that of the conveyor belt, that is the [Lw]=dB noise output level must be known. If this value is known then a good estimate can be developed for the sound pressure level present at a given distance from the source by using the equations describing sound propagation. This will be only an estimate because the attenuating ability of the propagation path cannot be known accurately due to the variability of the features of the ground and the vegetation. The estimate is actually a calculation but it results only in a range of the expectable sound pressure levels according to the variation of attenuation.

3. DETERMINATION OF THE NOISE LEVEL OF ROLLERS

Few data are available in the literature about the noise output level of the rollers used in conveyors. Estimator formulas exist for some common machinery types (e.g. drive gears, transformers) which provide estimated noise output values as the function of size and performance. No such correlations are available, however, for the rollers of conveyor belts. (As yet.) For this reason, measurements were conducted at the Technical Earth Science Department, Faculty of Geotechnical Equipment of Miskolc University – in the scope of the Scientific Fraternity work of our student, Norbert Matisz, among others – with the objective of determining the noise output levels of new and used rollers. The strength of a source, the numerical value of the noise output level can be determined by measurement. This requires basically a decision regarding what measurement accuracy should be employed. In this respect, the applicable standards and the recommendations given in them classify the measurement possibilities into three groups. These are: informative, technical and accurate. The Hungarian standard used by us (MSZ EN 3744) recommends the performance of technical accuracy measurements. The test arrangement for this can be used in the case of measurements conducted in an enclosed space above a reflective surface. In the course of this the object to be measured is surrounded by an imaginary enclosed surface and the sound pressure levels are measured simultaneously at each surface portion. (See Figure 2). Then the energy and noise output level of the source can be calculated from these measured values with the use of the equations given in the standard. The measurement accuracy can be improved by increasing the number of test points at each surface portion. In this case several pick-ups are used at one (or more) boundary surface for detecting the sound energy passing through the surface. The use of several pick-ups is intended actually to track the directivity of the sound. Unfortunately, this results in increased measurement costs at the same time since the price of the pick-ups forms a significant item in the test arrangement. In our case we performed the measurements with one pick-up positioned at the centre of each boundary plane surface. The schematics arrangement is shown in Figure 3.

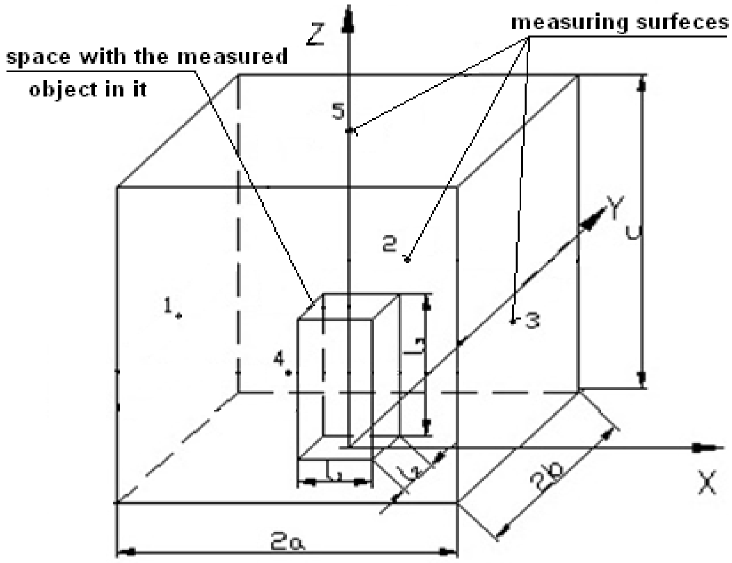

Fig. 2. Test arrangement for measurements conducted in an enclosed space

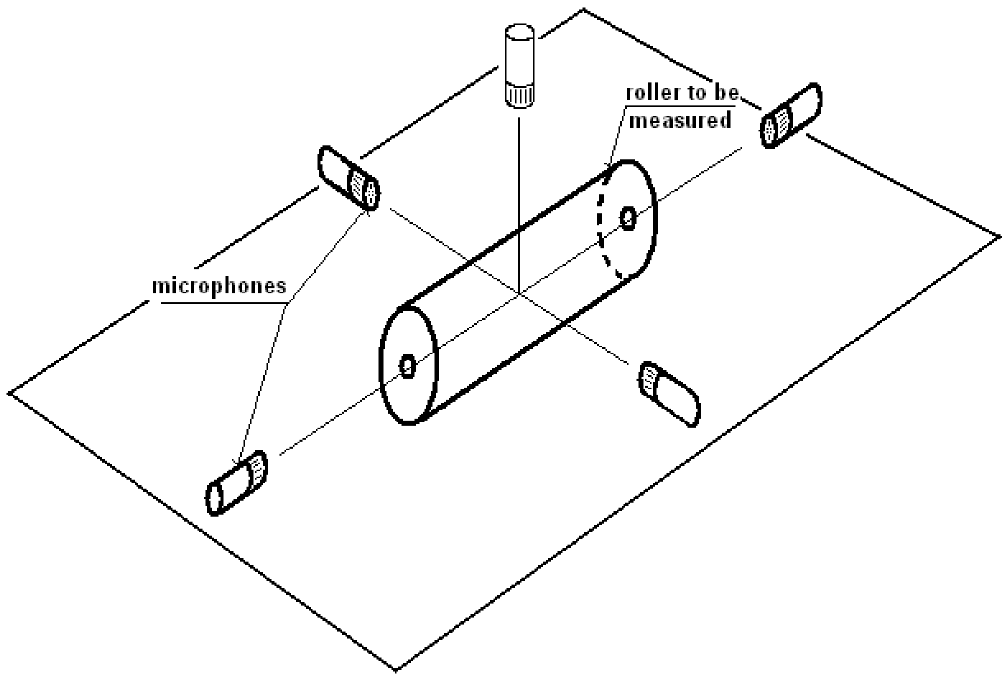

Fig. 3. Arrangement of the pick-ups during measurements

4. THE EXECUTION OF THE MEASUREMENTS

We selected 89x315 mm size rollers mainly because the rollers of this size are widely used in our country. Even so the authors are aware of the fact that conveyor belts using larger rollers are also operated at several locations. Among the twelve rollers included in the investigation two were new and ten used. Unfortunately, no information was available about the usage of the latter ones. Afterwards, subsequent to the completion of the tests we formed the opinion that there were considerable differences in respect of the usage (the number of revolutions completed until removal) of each used roller.

The tests were conducted at speeds conforming to three different belt velocities. These were: 1.56, 3.94 and 6.34 m/sec.

Based on the experiences of a few preliminary runs we found that there are major differences between the noisiness of the rollers but at constants speed (the way the test was conducted) the noise had a constant nature and thus there was no need for long observation periods in order to determine the average values of the sound pressure generated. Therefore, a test period of about 10 seconds was chosen for each roller. The devices of the company National Instruments (NI) were used as the test data collection & evaluation system for accomplishing the task. The mark NI9234 modules receiving the signals of the (Brüel & Kjaer make) pick-ups were processed by the measurement software written under the LabView application framework running on the laboratory computer.

The software was compiled for performing the following functions: initialize the elements of the measurement system prior to the tests, control the tests, collect the measurement data, produce the statistics expected as the test result along with the completion of the calculations needed for this and display the test results graphically.

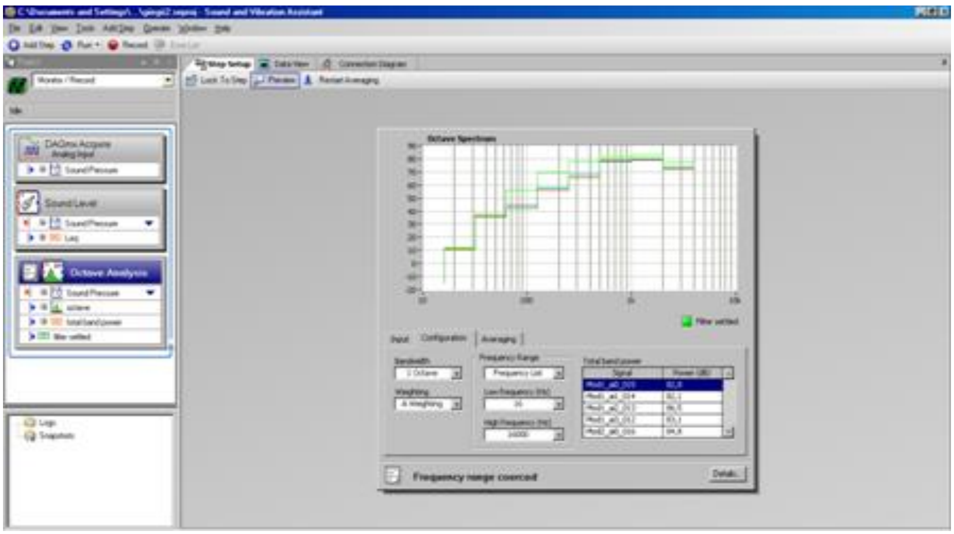

Fig. 4. Screen-shot from LabView during measurments (10 seconds)

Figure 4 shows a LabView window corresponding to the status after a 10 seconds observation cycle with the mean sound pressure values belonging to each channel (pick-up). (The display of channel 1 is seen with blue background.) The spectra of the signals from the five pick-ups resolved by octave bands are shown above this.

Table 2. **Results of measurements for different setups**

	L_W [dB]													
Idler	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	mean (worn roller)	increase
v_1=1,56m/s	49	50	-	51	56	57	55	59	72	60	79	88	79,1	3,6
v_2=3,94m/s	52	52	59	55	60	64	79	62	83	67	79	92	82,7	2,5
v_2=6,34m/s	54	54	70	59	64	69	64	63	88	71	80	94	85,2	

The results of the tests completed on the twelve rollers and the noise output level characteristic of each roller are contained in Table 2. Figures 5 & 6 show the data of Table 2 in the form of bar charts. The three charts in Figure 5 show the noise output levels measured in the case of the individual rollers with the belt velocities associated with each speed indicated alongside. Figure 6 shows the same test results combined into a single chart. Figure 5 identifies also which data apply to the new (No. 1 & 2) and to the used (No. 3 thru 12) rollers.

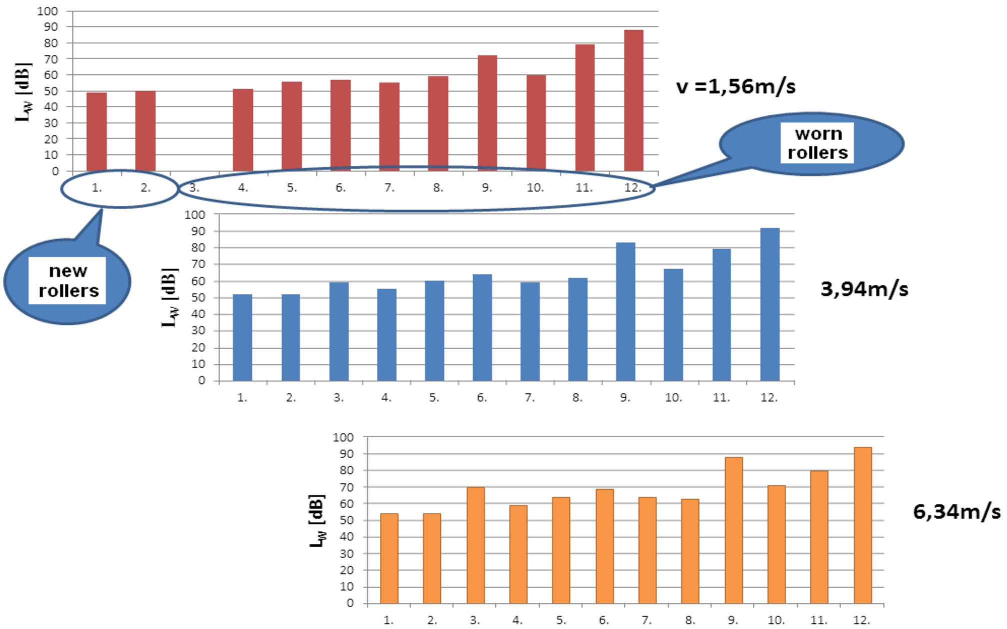

Fig. 5. Noise output levels measured in the case of the individual rollers

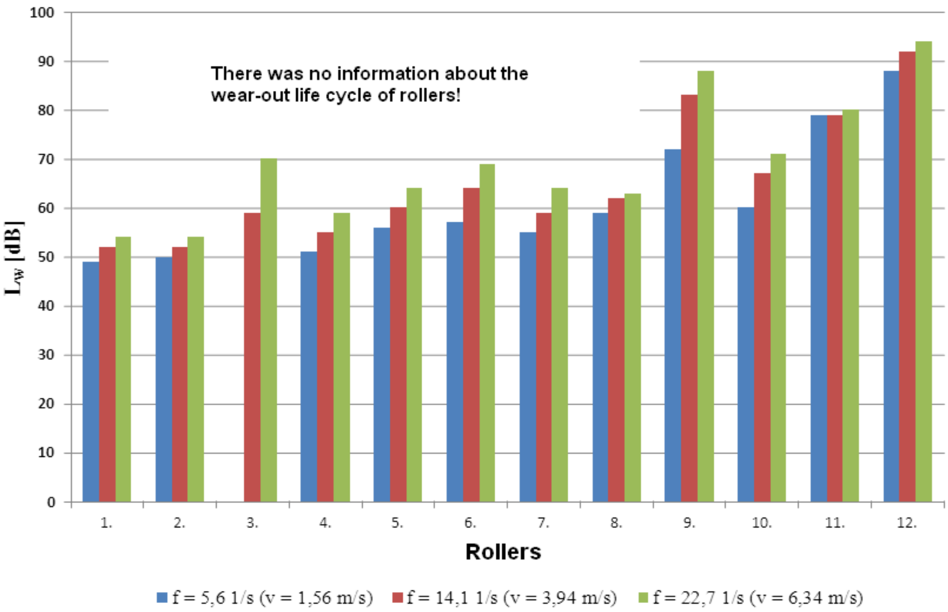

Fig. 6. Noise output levels measurements combined

4. CONCLUSIONS

As it could be expected, the noise level increases in proportion to the speed in the case of all rollers. Roller No. 11 behaved differently as an exception. Some increase could be observed also in its case but – although it was a used component – the rate of increase was smaller (1 dB) than in the case of the new rollers (2 dB). We have to emphasize also here that no information was available about “the wear-out life cycle” and the number of revolutions completed until removal for the used rollers.

All the same we wish to express our thanks to the colleagues working at the EURO GUMI Marketing Ltd and the Márkushegy Mining Plant of Vértes Power Station for putting the new and used rollers at our disposal for the purpose of our tests.

The two new rollers behaved similarly. At the speeds employed by ~2 dB rise was observed in proportion to the increase of velocity, naturally. The used rollers produced a higher increase than this. $\Delta L1$ = 3.6 dB (about 2.3 times) and $\Delta L2$ = 2.5 dB (about 1.8 times) could be observed in the mean values at the two velocities employed for both rollers. See the last row in Table 2. At the same time, the ratios of velocity increase $v2/v1$ = 2.53 and $v3/v2$ = 1.61 were not the same. (We call the attention of the esteemed reader that the averages shown in the last but one row are mean energy values generated from the values given in dB and not the averages of the numerical dB values!) On the basis of the results it can be stated that the fundamental cause of noise increase in the wear-out of the rollers and the increase of the belt velocity has a less effect on noise increase.

Maybe more warning is given if we observe the change of values taking place in the course of wear-out and characterizing the noise increase of the rollers at one given velocity. Table 3 contains these values for the rollers investigated by us. Choosing v = 3.94 m/sec velocity we can see that the difference between the average levels represented by the new rollers (52 dB) and that of the used rollers (82.7 dB) was 30.7 dB! This corresponds to a ratio of 1:1174!

Table 3. **Value changes during roll wear-out**

speed [m/s]	1,56	3,94	6,34
new [dB]	50	52	54
worn mean [dB]	79,1	82,7	85,2
increasing [dB]	29,1	30,7	31,2
multipe	813	1174	1318

The appropriate column of Table 3 also shows that the multiplication of the noise energy between new and used rollers is significant even at relatively low 1.56 m/sec belt velocity: 813 times.

The spectral distribution of noise indicates that the largest part of the energy falls into the two-octave frequency range between 500 Hz and 2 kHz. This statement applies to all used rollers. (See the spectra resolved by octave bands shown in Figure 4.) The disturbing effect on speech of noise distributed in this way is, unfortunately, considerable since the vibration components of human speech can also be found mainly in these two octave bands. It is reassuring, however, that the components falling into the higher (1-2 kHz) octave band are considerably attenuated basically due to the ground features and obstacles (trees, bushes, if any) along the propagation path.

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