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ASSESSMENT AND EVALUATION OF THE SOUND QUALITY OF HOME APPLIANCES

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Abstract: Currently, manufacturers of electrical household appliances that emit noise are trying to reduce the noise of these appliances for several reasons. For some product groups, manufacturers must declare acoustic performance levels according to accepted standards. This fact is perhaps the most important driving force for performing anti-noise modifications on household appliances. However, the quantity of the emitted sound is not important in every case, but also the quality of the sound, i.e. customer perception of sound. The scientific discipline of psychoacoustics deals with sound quality, which brings a new perspective to the evaluation of the acoustic quality of household appliances.
Keywords: psychoacoustics, binaural measurement, valuation

INTRODUCTION

Psychoacoustics, or psychological acoustics is an interdisciplinary scientific discipline dealing with human perception of sound, i.e. how the brain processes sound. Sound perception is a very detailed and complex process. The task of psychoacoustics is to observe and investigate the impact of various sounds on a person and his psyche [1].

Psychoacoustics has found its application primarily in the automotive and aviation industries in the design of cabin and cockpit interiors, but also in the development of household appliances and their optimization, with the goal being that the sound of the given appliance is not unpleasant for the consumer. Another application is in binaural measurements, sound diagnostics and quality control.

PSYCHOACOUSTICS AND SOUND QUALITY

The term psychoacoustics has been better known for the last 25 years. Sound has many objectively measurable properties, but these may not give a good picture of what a person perceives by hearing. Air is a continuous medium, so its molecules can theoretically transmit any mixture of frequencies, each with a unique amplitude and phase. However, the fact is that not everything is important to the human ear and therefore does not need to be recorded. The perception of sounds is, for a non-negligible part, also judged by people according to immediate facts and sound-induced associations (emotions).

In recent years, much effort has been devoted to describing the quality of individual sound stimuli or phenomena, such as warning signals in cars.

Today, especially in the automotive industry, the trend of increasing the "sound quality of products" is strongly preferred, the goal of which, based on the wishes and evaluations of customers, is to assign sounds to individual products that would connect them with important sales criteria such as luxury, robustness, performance, etc. A similar trend is currently being enforced in the household appliance industry [2].

OBJECTIVE ASSESSMENT METHODS

Objective methods of evaluating the psychoacoustic quality of sounds are based on the evaluation of binaural recordings made with special measuring devices called artificial heads and subsequent software evaluation of the sound signal with subsequent determination of individual psychoacoustic parameters (sharpness, roughness, fluctuation, tonality, etc.) [3].

Sound recordings and recordings captured by classical microphones are not suitable for aurally accurate assessment of the acoustic environment and noise sources, because essential acoustic information such as spatial and directional distribution of noise sources, masking effects, selective hearing and others are lost. A person can locate noise sources three-dimensionally, in the horizontal and vertical planes.

Localization is performed automatically based on time delays and different levels of acoustic signals reaching both ears. The outer ear causes direction-dependent filtering of sound signals. The result of this filtering is dispersion and thus modification of sound waves - reflection, bending, and attenuation. The geometry, anatomy of the head and shoulders and the auricle itself are important. Based on the ability of the human hearing apparatus to localize noise sources, a person can perceive individual

noise sources selectively from the overall noise and background noise [4].

Binaural perception cannot be simulated by simply using two microphones as substitutes for ears. Such recordings can only be used after applying an acoustic filter that takes into account the characteristics and geometry of the human head, ears and shoulders. The processing of acoustic signals by hearing and apparatus is complex and provides the receiver with a complete and holistic impression of the sound event.

The sound field is influenced by the head, shoulders and ears. The artificial head is a simulation of the human head and shoulders, not only concerning the shape but also the surface, the properties of which correspond to the properties of human skin. Also, the shape of the ears of the artificial head corresponds to the anatomy of the real human ear. Thanks to this form, the artificial head is allowed to modify the sound field just like in reality, so it can recognize differences just like the human ear [5, 6].

He has microphones in his ears, through which sound is recorded. The artificial head enables the recording of sounds as a person would hear them if he were in the place where the artificial head is located at the time of measurement.

Currently, several devices from different manufacturers are available on the market, which are intended for the measurement of acoustic and psychoacoustic sound parameters. These devices are generally called artificial heads. They have the shape of a human head with a partial torso and have a pair of microphones placed in their ears. The material of these devices has similar acoustic properties to human skin. Since these devices have a pair of microphones placed in the ears, they are also called binaural measuring devices. Binaural measuring devices from different producers are shown in Figure 1 – Figure 4.

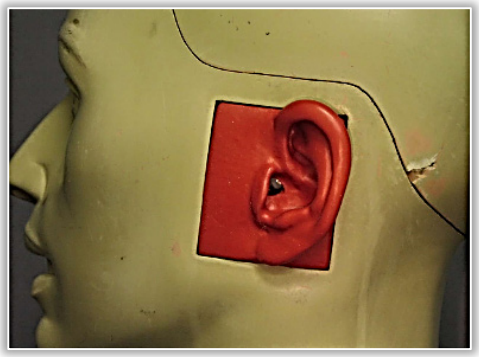

Figure 1. Artificial head – KEMAR [9]

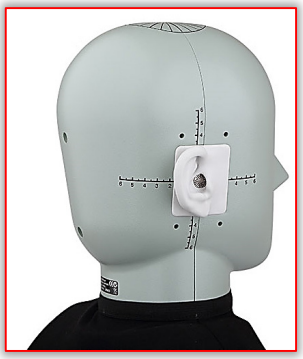

Figure 2. Artificial head - Brüel & Kjær [11]

Figure 3. Artificial head – Head Acoustics [8]

Figure 4. Artificial head – Neumann KU 100 [12]

SUBJECTIVE ASSESSMENT METHODS

Subjective assessment methods are based on getting people's reactions or customers to individual sounds. Such evaluation is carried out with a selected group of people, to whom the evaluated sounds are played. Respondents then fill out a questionnaire with their opinion on these sounds. The questionnaire can take different forms, where people evaluate these sounds on a numerical scale, assign certain properties to the sounds, or semantic differential methods are often used. By subsequent processing of the results from these questionnaires, we can assess the quality of individual sounds from the point of view of perception by ordinary people. However, the entire process of such testing is very demanding and lengthy and requires rigorous preparation.

The main problem of evaluation of sound quality by listeners is the dependence on various

circumstances, for example, expectations and the emotional state of the listeners. These influences can only be eliminated by appropriate selection and training of respondents. It is very important to choose an appropriate method of statistical processing of the data obtained from the questionnaires to avoid distortion in the evaluation of the obtained data.

In general, we can say that subjective evaluation by respondents allows assessment and determination of the quality of products based on their sounds, i.e. determination of better and worse sounds from the point of view of customer perception. By identifying the best and worst products in terms of sound quality, it is then possible to design the product to minimize unpleasant sounds.

Manufacturers are often motivated to address the issue of sound quality if they are exposed to customer complaints if the product emits disturbing sounds.

The evaluation of sound quality by respondents can also be used in cases of achieving the desired sound characteristics. If we want to make the sound of the product more powerful, more powerful, stable, etc [6].

Specialized software applications are currently available on the market for sound evaluation by respondents, which optimizes the entire testing process.

COMPARISON OF OBJECTIVE AND SUBJECTIVE ASSESSMENT METHODS

As we mentioned above, both objective and subjective methods of assessing sound quality have their advantages and disadvantages.

Subjective methods are time-consuming and lengthy to prepare and implement, and the main problem is the pitfalls associated with respondents. However, some knowledge about the quality of sounds cannot be obtained other than through questionnaire methods. These methods cannot be used for the evaluation of sounds with a longer duration, e.g. the washing cycle in the washing machine takes more than 2 hours. It is necessary to prepare representative samples of sounds with a duration of only a few seconds, but the entire evaluation process is partially distorted since it does not evaluate the entire cycle [9].

Objective methods are less time-consuming and do not require lengthy preparation. Based on the results of determining the values of individual psychoacoustic variables, we cannot unequivocally claim that sound with lower values of sharpness, roughness, tonality, etc. is better for the customer. And for several reasons. There are also several issues to be resolved. One of them is the correct selection of psychoacoustic parameters for the given product groups, based on which the sound quality assessment will be carried out. Determining the weight and importance of selected psychoacoustic parameters is also crucial. These factors will vary for each product group based on the differences in their sounds.

Objective assessment methods are implemented through binaural measuring devices - artificial heads. However, these measuring devices are also suitable for subjective methods. It is advisable to capture the sounds that will be played to the respondents using an artificial head and then reproduce the recordings obtained in this way through the dynamic headphones of the respondents. Respondents thus get a real feeling from the recorded sound.

Both methods require complex preparation and it is necessary to focus on individual partial tasks:

- place of measurement and recording,
- preparation of the measurement and recording process,
- editing audio recordings,
- creating test sounds,
- activities related to creating questionnaires,
- implementation of tests with respondents
- evaluation of questionnaires using appropriate statistical methods.

CONCLUSIONS

Basic subjective and objective methods of sound quality evaluation are described in the article. It must be emphasized that even objective methods are ultimately burdened with a certain degree of subjectivity since the selection of individual psychoacoustic quantities and determination of their weights is necessary for the evaluation. Determining the values of individual psychoacoustic values of different sounds is an objective process, but this does not guarantee that the given sound will be more pleasant for the customer or less annoying, as customer expectations and demands for the sounds emitted by individual products are different. For these stated reasons, it is advisable to look for a connection between these two methods to achieve real results in evaluating the psychoacoustic quality of the sounds emitted by individual product groups. In practice, it will be about the correlation of experimental measurements and the determination of psychoacoustic parameters with the results of

questionnaire assessments for the same sounds. Based on this correlation, a mathematical model will be proposed that would be able to evaluate the psychoacoustic quality of sounds only based on measurements with a binaural measuring technique followed by the determination of psychoacoustic parameters. The input variables of this model would be the values of individual psychoacoustic variables and the results of correlation with the questionnaire method, based on which the selection and importance of individual psychoacoustic parameters would be determined, respectively, other parameters. However, such a model would not be generally applicable for all products, but for a given product group.

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