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SOUND QUALITY SUBJECTIVE AND OBJECTIVE ASSESSMENT METHODS OF DOMESTIC APPLIANCES

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Abstract: The acoustic properties of the electronic products become important factor for the most of customers. Aim of this article is to describe term psychoacoustics as well as more closely specify used equipment for an evaluation of acoustics parameters of products. Results of the psychoacoustic analysis show characteristics similar to human hearing and offers possibilities for objective valuation of sound quality. The most effective tool for psychoacoustic measurement and analysis is binaural measurement technique – artificial head. Artificial head has two ears that are positioned at about equal height at the two sides of the head. Currently, manufacturers of electrical home appliances that emit noise trying to reduce the noise. For some product groups, manufacturers must declare the level of acoustic power according to accepted standards. This is perhaps the most important driving force for reducing noise of household appliances. However, not in every case, is the most important quantity of the emitted sound, but also the sound quality i.e. customer perception of sound. Just the sound quality is engaged in a scientific discipline psychoacoustics, which brings a new perspective and ways to optimize acoustic performance of household electric and electronic appliances.
Keywords: psychoacoustics, binaural measurement, sound quality

1. INTRODUCTION

Human have two ears that are positioned at about equal height at the two sides of the head. Physically, the two ears and the head form a perception system, mounted on a mobile base. This system receives acoustic waves emitted by the source of the sound. The two waves received and transmitted by the two ears are the physiologically adequate input to a specific sensory system, the auditory system. Specifically, it is the basic biological role of hearing to get information about the environment, particularly about the spatial positions and trajectories of sound sources and about their state of activity.

2. SOUND QUALITY AND PSYCHOACOUSTICS

Sound quality testing is an important design concept in the automobile and audio industries. Marketing studies in these areas can demonstrate a relationship between sound and non-auditory concepts e.g. luxury, power, speed, safety, expense [3] making the sound of a product an important design consideration. There are a large number of metrics, some of which are well defined and others which are not. Very few have been standardised and the usefulness of a particular metric is dependent on the nature of the sound being tested. The majority of sound quality metrics can be divided into those that quantify some physical aspect of the sound (e.g. pressure level, frequency content) and those that try to quantify some physical effect taking place in the ear (e.g. impression of loudness, tone etc.)

Some frequently used metrics are: roughness, sharpness, loudness, fluctuation strength, tonality. Hardly anybody would evaluate a sound with closed ears. However, this is still common practice for conventional acoustic and vibration measurements. Recordings with conventional measurement microphones are not suited for an aurally - accurate evaluation of an acoustic scenario, because substantial acoustic information such as the spatial array of sound sources and the selectivity of sound perception gets lost.[2,6] The aim of the artificial head measuring technique is, to get apart from the conventional possibilities of the evaluation, acoustic data with which the actual situation at the item under test is at any time callable.

The noise analysis ability of the hearing is not attainable or replaceable by any other analysis. So that the noise analysis with the hearing functions, is necessary a binaural input signal. This is made available with the help of the artificial head measuring technique.

Binaural hearing cannot be simulated by simply using two measurement microphones as "ear replacements". Only after having taken the acoustic filter characteristics of the head and ears into account, do aurally-accurate, unaltered recordings become possible [6,7,8]. Binaural technique:

- recording with an artificial head (Figure 2),
- more close to the function of the human hearing,
- makes all information e.g. for the direction hearing available.

The binaural measurement system is a stand-alone, mobile measuring device that is ready to perform aurally accurate binaural recordings immediately. The patented artificial head geometry offers [7]:

- a mathematically describable reproduction of the human head and shoulder geometry,
- an accurate reproduction of all acoustically relevant parts of the human outer ear.

3. ASSESSMENT METHODS

The sound quality assessment is realized by the two basic methods: approach of subjective testing using juries and objective assessment using metrics.

4. JURY TESTING

Asking customer's opinions of products is important part of sound quality testing. Jury testing is subjective testing done with a group of persons, rather than one person at a time. Subjective testing can be realized with a single person or many people. Subjective testing and analysis involves presentation of sounds to listeners, then requesting judgment of those sounds from the listeners and finally performing statistical analysis on the responses. However, this has to be done with care to prevent results being biased. A major technical problem centre around context - the assessment of sound quality is very dependent on the context, for instance the expectation and emotional state of the listener. It is also important that appropriate statistical analysis is carried out, otherwise you risk drawing incorrect conclusions from the data.

Figure 1. Artificial head – Head Acoustic (Binaural measurement system) [7]

The main problem of quality assessment sounds by the audience is dependent on various circumstances, such expectations and emotional state of the humans. These effects can be removed only appropriate selection and instruction of the respondents. It is very important to select the appropriate methods of statistical processing of data obtained of questionnaires in order to avoid distortions in evaluation of the data obtained. In general we can say that subjective evaluation through respondents allows the assessment and determination quality products based on their sounds e.g. designation better and worse in terms of sound perception customers, it means identifying best and worst products in terms of quality sound can design the product to be minimize annoying sounds. Manufacturers are often motivated to address the issue of sound quality when exposed customer complaints in case the product produce increased noise. Evaluation of sound quality by the respondents it can also be used in case of a required audio performance. If we want achieve product sound more powerful, more robust, stable etc. To rate sound through respondents are currently available on the market specialized software applications that all optimize the testing process [4].

5. OBJECTIVE ASSESSMENT

While jury testing evaluates the opinion of the user directly, it is time demanding to carry out if done many times. For this reasons, acoustic engineers like to draw up metrics that directly relate to the subjective response. There are a variety of metrics in use for sound quality measurement and testing. Once you have established appropriate metrics, this means that quick and easy measurements of sound quality can be made using competent instruments. However, it can sometimes be very difficult (if not impossible) to define appropriate sound quality metrics.

Figure 2. Sound quality measurement of washing machines

Objective evaluation methods of psychoacoustic sound quality based on ratings binaural recordings is made by special measuring devices. These devices are called artificial heads and subsequent software evaluation of the audio signal leads to determination various psychoacoustic parameters (sharpness, roughness, fluctuation, tonality etc.). Sound recordings and records captured by the classic microphones are not suitable for hearing accurate assessment of acoustic environment and sources of noise, as it is lost significant acoustic information such as spatial and directional distribution of noise sources, masking effects, selective hearing, and more. Man is able to locate the source of the noise three-dimensionally in horizontal

and vertical plane. Localization is performed automatically based on time delay and different level acoustic signals incident on both ears. The outer ear causes directionally dependent filtering of audio signals. Anatomy of the head and shoulders and earlobes itself has vital importance. The ability of the human hearing system to locate the noise source one is able to perceive the different sources of noise from the overall noise and background noise.

Binaural perception is not possible simulated simply by using two microphones as replacement ear. Such recordings may be used only after application of the acoustic filter, which takes account of properties and the geometry of the human head, ears and shoulders. Processing of acoustic signals by the hearing apparatus is complex and acceptor provides comprehensive and holistic perception of sound events. Sound field is affected by head arms and ears. Artificial head is simulation human head and shoulder, not only with regard to the shape of but also the surface properties which correspond to the properties of human skin. With this form of artificial head allows modify the sound field as in fact, thus able to recognize differences such as human ear [5]. The ear has placed microphones, to be used to record audio signals. Artificial head enables the recording and subsequent play sounds as though he heard them, if it was at the time of measurement at the place where it is located artificial head.

6. CORRELATION SUBJECTIVE AND OBJECTIVE ASSESSMENT

Objective measures that are used in sound quality assessment to measure human response without the effort of undertaking jury testing. Not all objectives measures are applicable for every product group. Before using objective measures, it is necessary to carry out jury testing to see which measures are useful and important for product sound characteristic. Sound quality is measured by computing metrics, which represent the objective data. In parallel, sound quality is subjectively assessed by performing jury tests where different sounds are presented to jurors who are asked to express a preference or opinion. The valuation of sound quality can be realized following different possible approaches, however if the results has to be correlated to objective sound quality metrics, it is recommended to perform a controlled experiment, where jurors and answers can be checked for consistency and repeatability [9]. Figure 3 shows basic steps of complex sound quality assessment.

It is appropriate to seek links between the two methods in order to achieve real results of psychoacoustic evaluation of sound quality individual product groups. In practice, it will be a correlation experimental measurements and determination psychoacoustic parameters results evaluation questionnaire for the same sound. On the base of this correlation will be designed mathematical model, which would be able to assess psychoacoustic sound quality only on the basis binaural measuring technology followed by determining the psychoacoustic parameters. As inputs in the mathematical model, are the values of individual psychoacoustic parameters and their correlation with the results of the questionnaire. On the base of correlation will be determined importance of individual psychoacoustic parameters. These model however, is not generally applicable to all products, but only for a given product group.

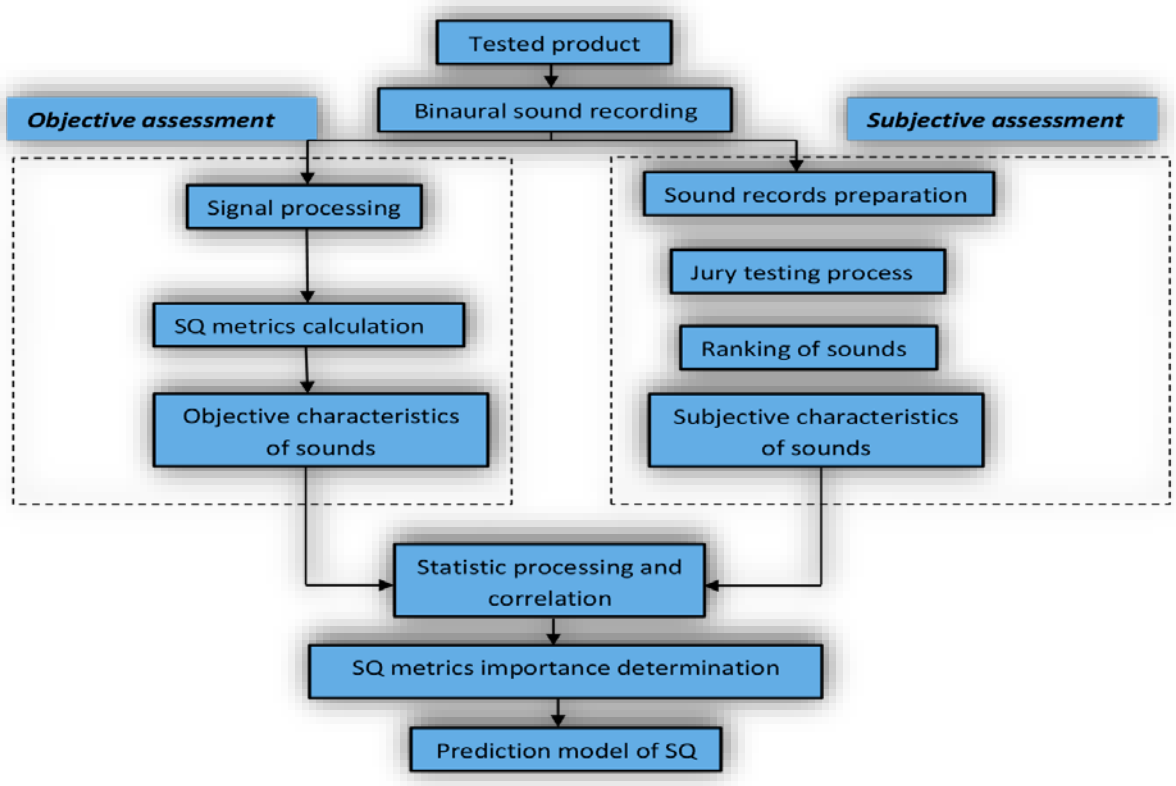

Figure 3. Sound quality assessment process

7. CONCLUSION

The sound quality of the noise emitted by the product has increasing importance when assessing the total quality of the product. For products ranging from cars to hand tools, not only the level of noise but also the quality of the noise is part that makes product more attractive for customer; the right sound can lead to better sales. Many factors come into play in the sound quality evaluation process. Traditional objective measuring and analysis methods, such as A-weighted sound pressure and FFT analysis, are not enough for complex analyse of product sound. To obtain correct results is necessary realize significant correlations jury study results with objective metrics. Customer expectations and jury testing are also important factors for determining acceptable sound quality because, in the end, only the human ear can tell the designer whether or not the product has the right sound.

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