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APPLICATION OF THE PSYCHOACOUSTICS AND BINAURAL MEASUREMENT FOR THE VALUATION OF THE SOUND QUALITY

The acoustic properties of the products or characteristic sounds become important factor for 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 have two ears that are positioned at about equal height at the two sides of the head.

Key words: *Psychoacoustic, binaural measurement, sound, noise.*

1. INTRODUCTION

Humans, like most vertebrates, 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 an antenna system, mounted on a mobile base. This antenna system receives elastomechanical (acoustic) waves of the medium in which it is immersed, usually air. 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 biological role of hearing to gather information about the environment, particularly about the spatial positions and trajectories of sound sources and about their state of activity. Further, it should be recalled in this context that interindividual communication is predominantly performed acoustically, with brains deciphering meanings as encoded into acoustic signals by other brains.

2. BINAURAL MEASUREMENT TECHNOLOGY

The aim of the artificial head measuring technique is, to get apart from the conventional possibilities of the evaluation, acoustic documents 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, respectively replaceable by any analysis. So that the noise analysis with the hearing functions, it needs a binaural input signal. This is made available with the help of the artificial head measuring technique.

In air with 20°C, the speed of sound amounts to 334 m/s. The human hearing is available to recognize very small time differences. If a sound event arrives somewhat earlier at the left as at the right ear, the event is noticed left.

The localization of an acoustic source is made possible particularly by binaural hearing. The human brain evaluates the differences between the signals at the left and at the right ear and determines the direction of the acoustic source. Relevant parameters for detecting the direction are run time differences and level differences between the ears [8].

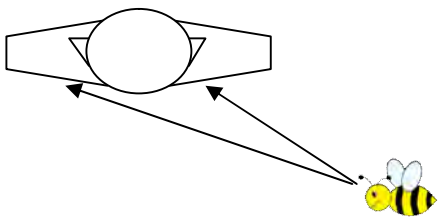

Fig. 1 Human ear as analyzer (run time differences and level differences between the ears)

3. COMPARABILITY BETWEEN CONVENTIONAL AND BINAURAL MEASURING TECHNIQUE

The four important characteristics of the human hearing:

1. The external ear is an direction filter. The sound pressure will be influenced in the range +15 to 30 dB.
2. The human hearing has two entrances:
- binaural signal processing,
- sound localization, selectivity, squelch.
3. The psycho-acoustics of the hearing determines the noise impression: loudness, sharpness, roughness and tonality.
4. High resolution of the hearing in the amplitude, frequency and time interval.

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]

Monaural technique (measuring with microphone fig. 2):

- recording with a precision microphone,
- not all information are included,
- recording of the sound pressure on just one point.

Fig. 2 Sound analyser with microphone [10]

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. [2]

Binaural technique:

- recording with an artificial head (fig. 3),
- 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 after powering up. The patented artificial head geometry offers [8]:

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

Fig. 3 Binaural measurement system – artificial head [8]

Meaning of the binaural signal recording:

- binaural hearing makes it possible to detect directions,

- reducing of disturbance noise and of reverberate,
- disturbance noise and utilizable sound can be separated more easily,
- selective hearing,
- binaurale loudness depends on the position of the acoustic sources,
- the human head changes the sound field; a sound source on the left or right side is louder than if it comes from the front.

4. PSYCHOACOUSTICAL AND SOUND QUALITY METRICS

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 dependant on the nature of the sound being tested. Manufacturers who undertake sound quality testing involving the use of sound quality metrics often develop their own metrics (the definitions of which are often not generally available), as well as making use of more well known ones. Sound quality metrics can be divides to strength and qualitative metrics (fig. 4).

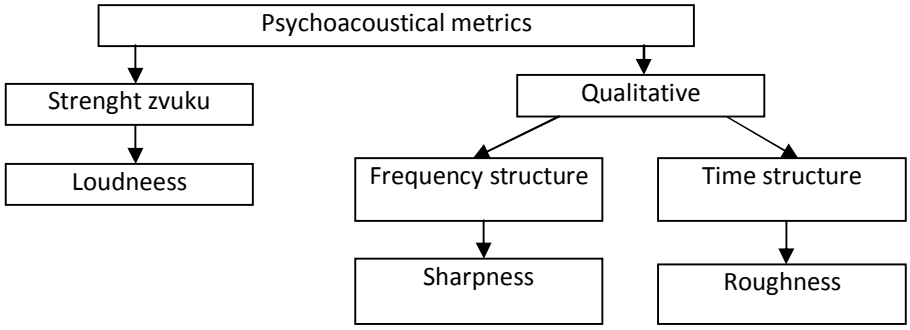

Fig. 4 Psychoacoustical metrics

5. APPLICATION OF BINAURAL MEASUREMENT SYSTEMS

Aurally accurate listening and simultaneous watching the analysis results, leads to detecting of certain noise components.

Characteristics of aurally-accurate measurement:

- recording of noise in the same way as the human hearing,
- analysis comparable to the human signal processing,
- subjective and comparative evaluation is possible,
- reproduction of the selectivity of the hearing,
- manipulation and synthesis from sound events can be used for forecast of modifications,
- documentation of original acoustic events,

Binaural measurement system is very good applicable in these sectors:

- Examination and optimization of the sound quality of technical products: motor vehicles and car components, domestic appliances, office machines and power tools,
- binaural measurements in product development and quality control,
- sound design and product optimization.

With the help of the binaural measurement and analysis the parameters of the noise can be detected (frequency, range, strength, etc.). With this information, with these data then e.g. activities can be seized to reduce unpleasant noise parts and all of these could be used for development of new products.

Fig. 5 Application of artificial head in the car interior [8]

Fig. 6 Measurement of psychoacoustic product properties in anechoic chamber

Next figures present the results of measurement of psychoacoustic properties of the washing machine by the binaural measurement systems.

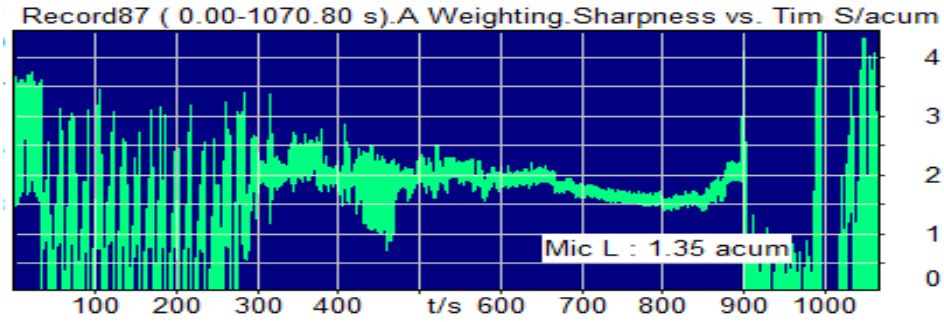

Fig. 7 Sharpness during the spin process

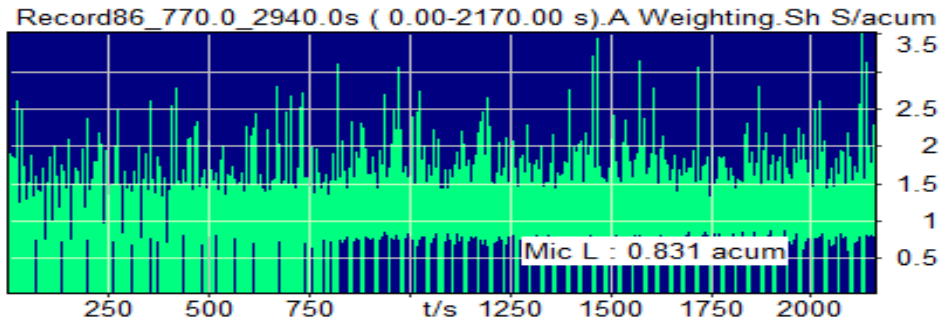

Fig. 8 Sharpness during the wash process

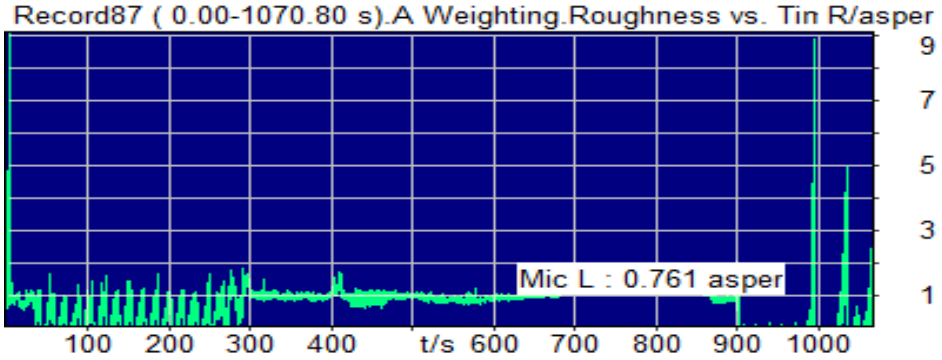

Fig. 9 Roughness during the spin process

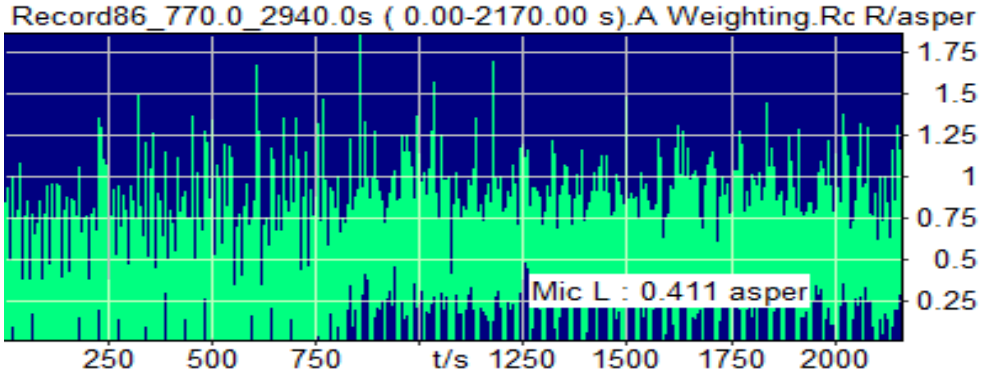

Fig. 10 Roughness during the wash process

6. ASSESSMENT METHODS

The project implemented certain aspects of sound quality assessment based on the stakeholder requirements. It became clear that simple to use methods were needed, as was an emphasis on knowledge transfer. For those well educated in acoustics, there are several commercial systems available for sound quality testing, and so replicating that was wasteful. What was needed was to produce simple-to-use methodologies and to address those with less acoustic knowledge. The sound quality assessment was a mixed approach of subjective testing using juries and objective assessment using metrics. The aim was to draw up good practice guides for both these types of assessments.

Jury testing

Asking customer's opinions of products is a cornerstone of sound quality testing. However, this has to be done with extreme 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. As it is impossible to remove contextual influences, the aim in drawing up a jury testing regime is to reduce and define the uncertainties introduced by the assessment regimes. It is also imperative that appropriate statistical analysis is carried out, otherwise you risk drawing incorrect conclusions from the data.

Objective assessment

While Jury testing evaluates the opinion of the user directly, it is time consuming to carry out if done many times. For this reasons, acoustic engineers like to draw up metrics that directly relate to the subjective response. The most common example is the decibel, which is used to evaluate the loudness of sounds (in fact there is a better objective measure for loudness which is called loudness). There are a wide variety of metrics in use for sound quality testing and you can read about them in the linked pages. Once you have established appropriate metrics, this means that quick an easy measurements of sound quality can be made using

dedicated instruments. However, it can sometimes be difficult (if not impossible) to define appropriate metrics [9].

SUMMARY

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 is used for measurement and assessment of psychoacoustic properties and sound quality. Classic measurement technique can valuate mostly quantitative parameters of the sound. Binaural measurement technology can valuate also qualitative parameters of the sound such as sharpness, roughness, tonality, fluctuations etc., that are very specific to human perception.

The head measurement system is a stand-alone, mobile measuring device that is ready to perform aurally accurate binaural recordings immediately after powering up.

Artificial head measurement systems like the HMS IV are compatible with conventional measurement technology and are necessary for an authentic hearing impression during playback.

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Acknowledgements

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