MAIN SOURCES OF LOUDSPEAKER DISTORTION

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ABSTRACT

This paper deals with three sources of a loudspeaker distortion. It is evident that all mentioned sources are well known, but often ignored. Diaphragm Imperfections caused by Diaphragm Own Resonances, Enclosure Imperfections represented by Standing Waves and Enclosure Resonances and Diffractions are mentioned. Potential solutions and practical examples used by some producers are outlined.

1. INTRODUCTION

We are witnesses to a dynamic technology development of all conceivable brands without exception of a sound technology. We encounter with an overlooking of basic conventions and principles in commercial devices in spite of all well known and even modern knowledge and all opportunities of a quality sound device development. This paper is motivated by an effort to remind several elemental sources of a loudspeaker distortion. It is typical to say "loudspeaker coloration" in a loudspeaker branch. Probably a more clearly understandable term "distortion" is used in this paper.

2. ANALYSIS

2.1. DIAPHRAGM IMPERFECTION

The diaphragm is probably the most important part of a loudspeaker driver. The ideal diaphragm should be infinite rigid and have a zero mass (a low material density). These properties are inaccessible and driver producers should be looking for a reasonable compromise. The diaphragm is driven in its center and because of the finite rigidity and the elasticity of a cone material, a move of diaphragm is non-coherent. A deflection of diaphragm spreads from its center to the edges which arises standing waves and resonations. These standing waves interfere with a piston move of the diaphragm and produce nonlinearities at *SPL* (sound pressure level) characteristics. Own resonances of the diaphragm usually appear at higher frequencies and can be audible. Passivity to these effects can be reached by using of high rigid materials, sandwich constructions of the diaphragm or special shapes, which increase the rigidity of diaphragm. The rigidity is physically represented by the Young's modulus and the mass is represented by density. A proportion of Young's modulus to the density is known as a specific modulus and it is often used for evaluating of materials suitability.

Kevlar or Aluminum are contemporary used materials, the example of the special shape profile used by THIEL Audio [1] is diagonal rippled diaphragm shown in Figure 1.

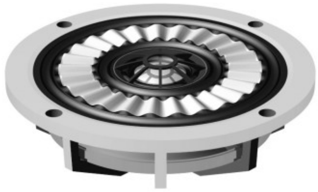

Figure 1: The rippled shape of aluminous diaphragm by THIEL Audio

There is an example of modern midrange driver of THIEL Audio company with non-cone rippled shape diaphragm made of aluminum with a tweeter mounted coaxially on the center of the midrange driver in Figure 1.

2.2. IMPERFECTIONS CAUSED BY ENCLOSURE

A main purpose of the enclosure is an isolation of front and back sound waves radiated by the diaphragm and the next is mounting of the driver on its inert position. Booth purposes are connected with problems. Required properties of the enclosure material are similar to diaphragm materials with exception of low density.

STANDING WAVES AND ENCLOSURE RESONANCES

Back radiated sound waves combine and produce inner standing waves which affect walls of enclosure. Finite rigidity of the enclosure material and low wall damping cause that walls are excited by standing waves and radiate a parasitic sound. Radiated waves frequencies and their degree are in dependency on enclosure rigidity and vibrations degree. These sounds could be significantly spurious because of quite big area of enclosure in proportion to the area of diaphragm.

Standing waves could be suppressed by using of internally damped enclosure filled by an absorbent material, which is probably the most often used method. A next way is to use special shapes of enclosures where the formation of standing waves is limited. These shapes are based on non-parallel walls, for example pyramid, triangle or rounded shapes of enclosures.

Vibrations of the enclosure could be also excited by an affect of a driver motion. The reaction between the enclosure and the driver should be eliminated by a heavy and strong front panel that could be made by laminating of different strong materials e.g. aluminum or carbon fiber. It is also very effective if the layer of the damping material is laminated between other layers [2]. Similar techniques could be used for building all enclosure walls to increase rigidity and decrease radiated parasitic sounds. A stiffness of the enclosure depends on its constructions and used materials properties. Commonly used rectangular cuboid is the less suitable shape on this point of view, because the uniform rectangular panel has high number of resonant modes. The stiffness could be improved by internal bracing and used shape. We can encounter spherical shapes using for high rigid enclosures like subwoofer speakers today. We could still found the solid plywood bonded directly into final shapes as a used material. However the most common material is MDF (medium density fiberboard). Less often there are solid injected plastics of various types, aluminum or stones e.g. a marble. Plastic materials are often used in low-cost designs which usually have nothing to do with quality loudspeakers, but it is not a rule.

DIFFRACTIONS

Diffractions are the second important source of the distortion caused by enclosures. Mechanism of the diffraction is a parasitic radiation of sharp edges and other non-smooth objects close to the driver. It produces significant polar response anomalies on wavelengths comparable to front panel sizes. Diffractions produce stereo imagination problems. Most common way for diffractions reducing is the beveling or rounding edges, but the most suitable shape of the enclosure is a sphere [3]. Measured spherical enclosure provided a uniform frequency response without considerable peaks or dips.

Example for explanation of diffraction effect is given in Figure 2 [1]:

a) b)

Figure 2: Explanation of diffraction effect

Figure 2: a) diffraction of a sound wave radiated by the tweeter and diffracted by enclosure edges and a driver cavity, b) rounded enclosure edges and using of a flat, non-cone driver diaphragm. In this case the sound wave is radiated without diffractions.

3. CONCLUSION

Three of main sources of the loudspeaker distortion were mentioned above. The effect of an individual distortion source to a final sound quality depends on relations between all attended sources.

ACKNOWLEDGEMENT

This work was supported within the framework of the research plan no. MSM 0021630513 entitled “Research of Advanced Electronic Communication Systems and Technologies (ELKOM)”.

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