Ultra-Light Speaker

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1 Introduction

These days there are rapidly growing needs for automobiles mainly in emerging countries, and yet at the same time problems of global warming and air pollution brought by exhaust gas are expected to become more serious than ever. In the automobile industry, competitions of technology development for EV or HV and better fuel efficiency of a gasoline vehicle are heating up. And each car manufacturer is engaged in thorough reduction of vehicle mass by changing materials of vehicle bodies and other parts.

The adoption of a magnetic circuit using neodymium magnet to an in-vehicle speaker from around 1995 has drastically reduced the mass of an in-vehicle speaker from approx. 600 grams down to approx. 200 grams, but the mass saving by each car manufacturer has been subsequently hovering around. Under these circumstances we proposed the "ultra-light speaker" which was under development to differentiate us from competitors, to a car manufacturer in 2012. Accordingly, we could receive an order at an early stage because our target model car was planned to be changed to HV. Our mass-saving activity to reduce the mass of the current speaker by 30% was started and the mass production of the mass-saving speaker was started in January 2014. This paper describes the product outline of the newly developed ultra-light speaker.

2 Mass-saving Technology

The newly developed mass-saving technology is described below.

Target: To reduce the mass of our base model speaker by 30% without deteriorating sound quality.

The investigation of each component mass of our previous 16cm speaker as the base model

Table 1 shows that a speaker frame and a magnetic circuit account for 81% of the total mass. Therefore our mass-saving review was mainly focused on these two components.

2.1 Development of Ultra-light Speaker Frame

Simple change to thin frame lowers the frame strength, which produces unwanted resonance and results in deterioration in sound quality.

Then we have developed "vibration distributing frame" that achieves both thickness reduction and distribution of frame vibrations, in order to reduce the mass **(Fig.1)**.

<Major measures> Optimization of the frame shape by using a strength analysis simulation technology

①**Measure to ensure strength and improve sound quality:** Changing to the sectional shape having double struts arranged one above the other.
(Vibrational dispersion type frame - - - **Patent pending**)

②**Measure to reduce mass:** Thickness reduction of the frame

Table 1 Composition in Mass

Component	Previous product	Mass percentage		Developed product	Reduction rate	
Frame	75g	37%	81%	58g	23%	Approx. 30% of the total mass was reduced
Magnetic circuit	83g	44%		52g	37%	
Others	32g	19%		25g	21%	

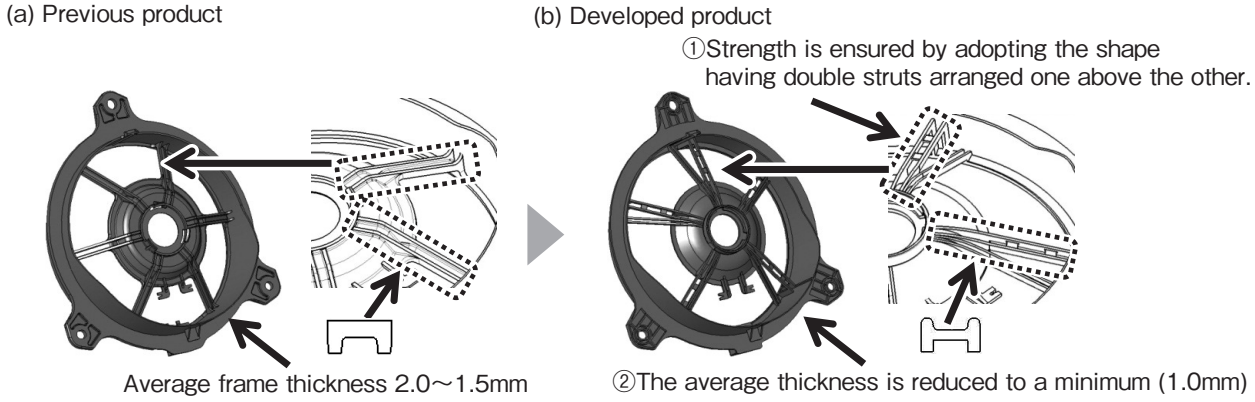

Fig.1 Thickness Reduction of Speaker Frame

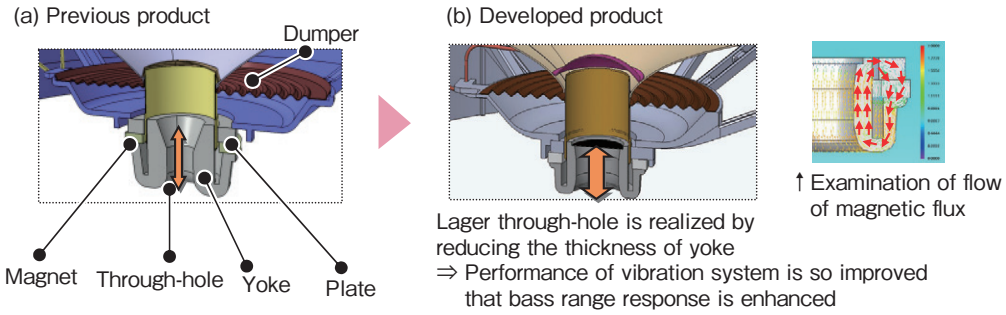

Fig.2 Improvement of Magnetic-Circuit Structure

2.2 Development of Ultra-light Magnetic Circuit

Reducing the thickness of a yoke decreases the magnetic flux density to drive a diaphragm, which causes a decrease in the acoustic pressure and deteriorates the sound quality. Then we have optimized the shape of the magnetic circuit, using a magnetic circuit simulation technology, and reduced the mass by finding the shape which enables the volume to be minimized while retaining the magnetic flux density. Also we have reduced the thickness of the yoke and made the through-hole larger in it. As a result, the performance of the vibration system is so improved that bass range response is enhanced.

<Major measures> Optimization of magnetic circuit by a magnetic circuit simulation technology **(Fig.2)**

①**Measure to reduce mass:** Reducing the thickness of plate and yoke and optimizing their shapes

②**Measure to reduce mass and improve sound quality (bass range response) :** Enlarging the through-hole of a yoke

2.3 Result of Sound Quality Evaluation

①**Vibration distribution frame:** Distributing the vibrations generated by a speaker frame for clear and spacious sound on the whole.

②**New magnetic circuit:** Enhancing the powerfulness in bass range

Since simply making the through-hole larger disrupts the balance between powerfulness in the bass range and the transient response, we took much time to determine the size of the through-hole and hardness of the support system (dumper and speaker edge). In a joint-evaluation meeting with the car manufacturer, we received a good evaluation for "the speaker producing the same or even higher quality sound although its mass was reduced." **(Fig.3)**

By reflecting the result of the study described in Sections 2.1 and 2.2 on the design, a significant reduction in the mass and improvement in the sound quality of the speaker were both realized. We achieved the 30% mass saving set as our target and could start to provide the speakers to the car manufacturer as "Ultra-light speaker" in January 2014. **(Fig. 4)**

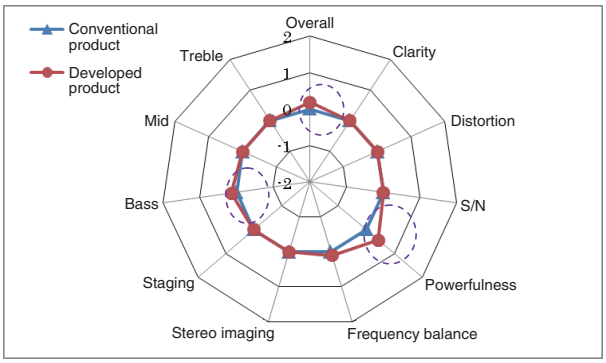

Fig.3 Result of Sound Quality Evaluation

Fig.4 Ultra-Light Speaker (Production Model)

We will apply the mass-saving technology developed this time to other speakers, and contribute to advancement of automotive society and to the solutions for the problems of global warming and air pollution by mass-saving of speakers.

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