Sound Success

JVC KENWOOD Corporation employs robust design practices to develop innovative automotive speaker technology.

By Akira Shigeta, Loudspeaker Engineer, JVC KENWOOD Corporation, Tokyo, Japan

Today's consumers demand smaller audio speakers with increasingly better fidelity. As a result, companies that supply these products must innovate to develop speakers that reliably deliver the best sound in a wide range of environments. Simulation can be valuable in meeting such robust design goals, in this case by employing parametric analysis of the voice coil.

JVC KENWOOD Corporation (JVCKENWOOD) serves a number of sectors: car electronics, professional systems, home and mobile electronics, and entertainment markets. The company's automobile speaker system design once was driven by expensive physical prototype building and testing, a time-consuming and costly process that limited the number of alternative designs that the R&D team could evaluate. JVCKENWOOD now uses ANSYS electromagnetic software to determine magnetic flux density distribution and other key parameters for proposed designs prior to prototyping. Engineers work with parameters and design points within ANSYS Workbench to quickly evaluate a large number of potential designs and iterate to the optimal design. The end result: The company has substantially reduced prototyping cost, decreased time to market, improved product performance, and trimmed material costs.

The company has been able to substantially reduce prototyping cost, decrease time to market, improve product performance, and trim material costs.

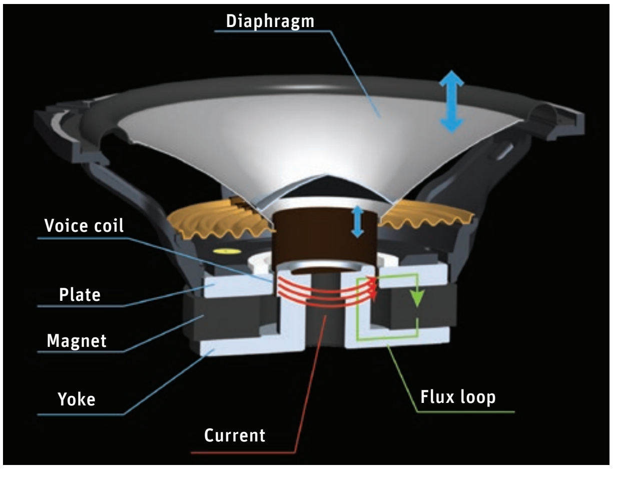
CAR SPEAKER DESIGN CHALLENGE

Audio speakers produce sound when the oscillating motion of a diaphragm causes corresponding oscillations in air pressure. The diaphragm motion is produced by a voice coil motor (VCM) device. This comprises a permanent magnet assembly containing an annular air gap, across which magnetic flux flows, and a wound coil that resides in the air gap. Electric current flowing in the coil produces Lorentz forces, causing the coil and the diaphragm to which it is connected to move.

Increasing magnetic flux in the gap of the magnetic circuit increases the loudspeaker's drive force. Although higher magnetic flux doesn't automatically mean better sound quality, higher magnetic flux and larger drive force provide a significant design advantage that enables engineers to deliver improved audio performance, greater sound volume, wider frequency response, and smaller and lighter designs.

In the past, JVCKENWOOD engineers used hand calculations to determine magnetic flux density in the magnetic circuit's gap. However, these one-dimensional calculations were limited in accuracy because they did not take into account the system geometry. As a result, the company typically needed to make approximately 10 prototypes of each design to get insight into magnetic flux density distribution and other performance parameters. If the performance of the prototypes was not good enough, then it was necessary to spend extra time and money to rework the design and produce new prototypes.

▲ JVCKENWOOD's car electronics group is well known for developing exceptional speakers. According to a review on autos.com, "KENWOOD eXcelon technology … offers better sound quality based on the sound range as well as better quality parts and superb workmanship. A KENWOOD car speaker offers a great sound experience, but once you add in the speakers with the eXcelon technology, you will be amazed by the difference in range offered, and at what you hear in a song that did not seem to be there before."



▲ Parts of the speaker

DESIGN ENGINEERS PERFORM SIMULATION

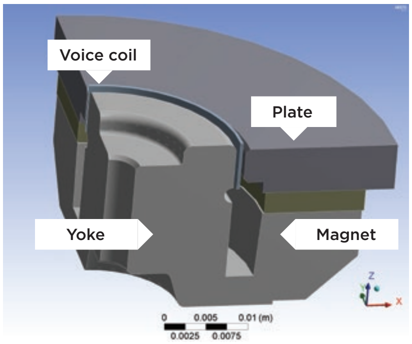
The ANSYS Workbench environment makes it easy to work with CAD geometry for electromagnetic (EM) simulation. ANSYS EM software is easy to use and provides results that can be simply viewed and understood. Design engineers can simulate speaker performance without having to involve analytical experts in the design process. ANSYS EM tools simulate low-frequency electric currents and electric fields in conductive and capacitive systems as well as magnetic fields resulting from current sources and permanent magnets. It features a complete range of automatic calculations for force, torque, inductance, Joule losses, field leakage, saturation and magnetic field strengths.

JVCKENWOOD engineers begin the process by importing their CAD geometry into ANSYS DesignModeler. The parameters can be adjusted and the design updated, and any feature removal or simplification is maintained. They then perform low-frequency magnetic simulation with ANSYS Emag. Simulation helps to visualize performance of the magnetic circuit, particularly magnetic flux density distribution. Design of an automobile speaker is still more art than science — but simulation helps engineers to gain a much better understanding of how the concept design performs; it also helps guide the R&D team toward further improvements. Simulation often assists in finding breakthrough designs, concepts that even an expert designer might not imagine without it.

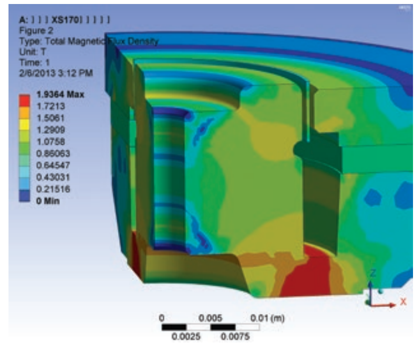
Engineers typically start by creating a few designs based on their experiences and then run simulations to determine performance. This type of study helps the engineer to move the design into the general area of what he or she is looking to achieve, but typically it does not approach optimal design. For example, with these early simulations, engineers might consider an inner magnet design with the magnet placed inside the voice coil versus an outer magnet design with the magnet outside the voice coil. They might consider using different magnet materials such as ferrite, aluminum–nickel–cobalt (alnico) or neodymium. Ferrite cannot be placed inside a voice coil, so it is suitable for only the outer magnet design. Alnico and neodymium typically work best inside the voice coil with a higher and narrower geometry.

ITERATING TO AN OPTIMAL DESIGN

The next step is to optimize the magnet design, particularly by improving magnetic flux in the gap in the loudspeaker circuit. Engineers select design parameters that are most important, such as magnet thickness, internal diameter and external diameter. They set up these design parameters as design points in ANSYS Workbench and then run parametric analysis to study what-if scenarios. They define a series of values to explore in the table of design points. When the user clicks the Update All Design Points button, the first design point (with the first set of parameter values) is sent to the Workbench parameter manager. This drives changes to the model from CAD system to post-processing.



Geometry of the magnetic circuit



Simulation results show magnetic flux plotted on the magnetic circuit.

The new design point is simulated, and output results are passed to the design-point table where the data is stored. The process continues until all design points are solved, defining the design space that may later be optimized.

The next step is to optimize the magnetic circuit, which consists of the magnet, yoke and plate. Here the design parameters of interest are width, thickness and external parameters of the yoke and plate. The results provided by what-if analysis help engineers to quickly find the best design that satisfies all requirements.

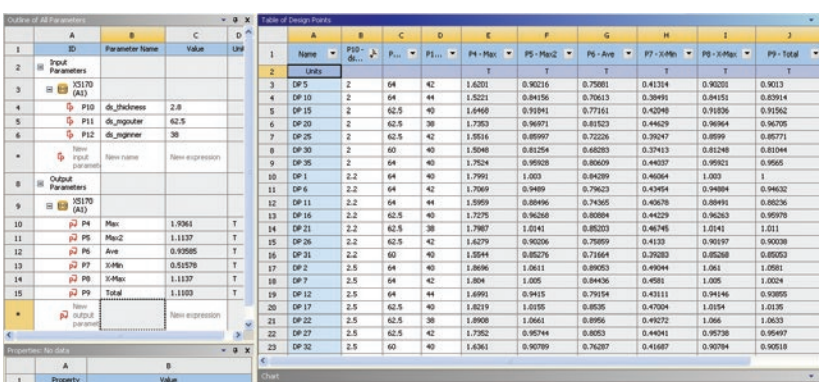
Electromagnetic simulation and design optimization have made it possible for JVCKENWOOD to substantially improve automobile speaker system performance. From a technical viewpoint, engineers can easily study new ideas, such as a completely new shape for a magnetic circuit, without the time and cost involved in building prototypes. From a business perspective, engineering simulation helps to reduce prototypes, production costs and time to market. JVCKENWOOD has significantly trimmed the number of prototypes produced for a typical project — from 10 in the past to today's two or three. Time to market is now shorter by about a month, which is 10 percent of the total product development process. Magnetic flux density in the typical speaker has been increased by 5 percent without any additional costs. And finally, the amount of materials in the typical speaker has been reduced by up to 40 percent, which translates into lower material costs.

JVCKENWOOD was supported in this work by ANSYS channel partner Cybernet Systems.

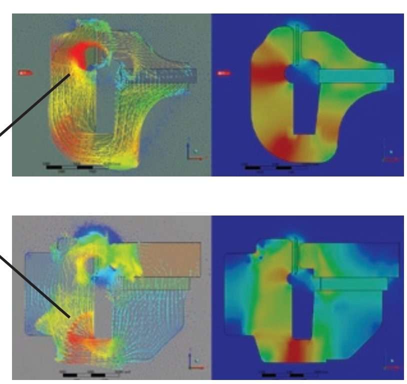
New Solution for Parametric Studies

With the most recent ANSYS release, a new licensing product is the ANSYS HPC Parametric Pack. This product amplifies the available licenses for individual applications (pre-processing, meshing, solve, HPC, post-processing), enabling simultaneous execution of multiple design points while consuming just one set of application licenses. *See page 54 for more information.*

— Wim Slagter, Lead Product Manager, ANSYS, Inc.



Engineers defined design parameters as design points to set up design optimization.



Simulation is performed for each row of parameters on the optimization chart.