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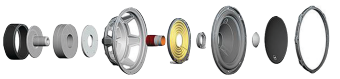
Speaker Enclosures



Selecting the right cabinet prevents unwanted resonance

Our Speakers—"Parts is Parts" series has focused on various speaker components. Now, let's take a break and look at the enclosure. Assuming you have already selected the drivers for your latest project, your attention is most likely focusing on the enclosure. No matter how much effort was spent on the drivers' design, the enclosure characteristics are still a significant factor in achieving smooth response, controlled bass, a defined stereo image, clarity, and definition.

PRACTICAL USES

Speaker enclosures are mainly used to isolate the backwave of the woofer from the front. This is needed to avoid the two equal but out-of-phase outputs from canceling each other. Wood cabinets are traditionally used for speaker enclosures. Other materials have been tried, but they have not been generally accepted. Enclosures need to provide a rigid structure to support the woofer with minimum panel resonances. Most boxes are simply medium-density fiberboard (MDF) that are vinyl covered and "groove folded" out of a larger sheet. The grove-folding process cuts a V-groove into the wood, down to, but not through, the vinyl covering. A bead of glue is dispensed into the V-groove and the enclosure is folded into a box shape (see **Photo 1**).

Conventional particle-board boxes are inexpensive, readily available, and a known commodity. But, wood boxes have intrinsic flaws. The sharp baffle edges diffract sound where it is not wanted. The flat baffle with the woofer and tweeter directly mounted means the acoustic centers are most likely not aligned, and perhaps most importantly, your box will look just like the other dozen models on the sales floor. How can you blame the customer for assuming little thought was spent on engineering if the exterior appearance gives this impression?

WOOD ALTERNATIVES

Over the years, there has been great interest in finding an alternative to wood enclosures. The material should be as strong and light as plywood, as easy to work with as particle board, and have a simplified construction (i.e., moldable materials that eliminate joint assembly and enable curved edges and shaped front baffles for time alignment, waveguides, and esthetic flexibility).

Dramatic enclosure styling that combines unique materials and forms takes courage. But, the rewards can be great. Bose launched the five-sided 901 in 1968. B&W's distinctive Nautilus 800 series was a breakthrough in the late 1990s. And, today's B&O Beolab 5 and the B&W Zeppelin Air continue to offer innovative enclosure shapes.

The usual injection-molded plastic thin-wall construction found in outdoor speakers or low-cost 5.1 systems is marginally adequate for commodity consumer speakers. Most speaker engineers are unhappy with the hollow, buzzy sound that comes from funky, plastic home-theater satellite speakers. From the most inexpensive styrene to filled acrylonitrile butadiene styrene (ABS) to talc-filled poly, plastic enclosures have high levels of breakthrough (the driver's backwave passing through the shell and excessive bass loss because of the lack of rigidity). When driven hard, these plastics contribute too much of their own noises, further degrading sound quality. None of this is news to speaker designers. And, audio engineers have been looking to glass-fiber, Kevlar, and carbon fiber composites for rigid and well-damped enclosure parts such as Klipsch's outdoor speakers (see **Photo 2**).

Some technologies give designers more flexibility to achieve aesthetic and technical goals. Enclosures should suppress vibrations that ripple through them and provide higher sound transmission loss (a measure of how good a barrier the enclosure is to prevent sound from passing through it). Higher stiffness is needed to drive resonances into higher frequencies where they are more easily controlled. At various times, Polk, JBL, and others have offered flagship products with laminated, damped baffles using two reduced-thickness layers of wood or particle board with a damping layer of adhesive in between.

Another consideration is reducing edge diffraction with curved edges. The curved corners result in reduced dents and rework during manufacturing and shipping. Response irregularities contributed from sharp front cabinet edges can result in peaks and dips of up to 4 dB. Audiophile speaker

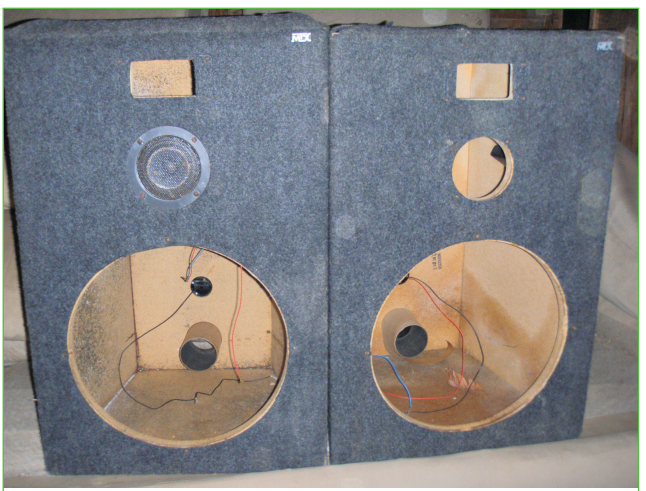


Photo 1: This loudspeaker enclosure shows a basic MDF construction. (Photo courtesy of Wikipedia)

Photo 2: This is an example of a Klipsch outdoor speaker with an ABS cabinet. (Photo courtesy of Klipsch)

systems in Japan, from Sony and others, and world-class recording studio monitors from Genelec, use rounded edges to maintain the accuracy of their precision drivers (see **Photo 3**). Sharp edges cause diffraction, which means the edge of the cabinet acts as a second sound source, destructively interfering with the original signal. Curved edges are made through direct molding, cutting of the relief on the back edge of rigid materials, or routing the edge.

To achieve an optimum engineered design for a more precise or "focused" soundstage, consider mechanically aligning the drivers' acoustic centers, which is especially beneficial in the vicinity of the crossover frequency. The molding of horn/waveguides can control directivity, increase sensitivity, and provide for the time alignment of the acoustic centers, as the woofer tends to lag the tweeter.

EXPERIMENTAL TECHNIQUES

Over the years, numerous techniques were introduced to revolutionize the speaker enclosure business, but not all of them are practical. In the mid-1990s, Cubicon used recycled paper and fabricated enclosure tubes with fancy finishes (as well as carpet cover, etc.). These tubes were square, round, D-shaped (autosound), trapezoid (disco mobile), and so forth. The multilayered paper/resin composite offered a well-damped material for enclosures and the radiused edges minimized diffraction effects. But, the tube shapes were not consistent enough for mass production. End cap fittings were problematic, although a few firms managed to devise workable production techniques. In any case, while recycled materials are "in," you won't see many speaker enclosures made from recycled cardboard tubes these days, although sound bars could benefit from this approach.

Curved panels, sculpted shapes, and all sorts of stuff that usual enclosure suppliers cannot provide, could be laser precut and shipped to the speaker factory's enclosure shop for assembly. Advantage Cutting and Gasket had big plans but closed down about 10 years ago, as speaker-enclosure assembly shifted offshore.

Another technology that did not gain acceptance, at least for speaker enclosures, was Gridcore. Thin, but light, stiff panels made of inexpensive molded honeycomb wood fiber enabled curved panels and thin-wall construction. The material originally developed for interior door panels is also used by the military for emergency shelters and other structures because it is light enough to be easily transported (see **Photo 4**).

A more sophisticated honeycomb technique was used in Celestion's SL600. Introduced in the mid-1980s, the speaker enclosure used a rigid honeycomb alloy called Aerolam instead of wood. Honeycomb had its advantages, but attaching drivers, joining panels, and sound breakthrough were problems not easily or inexpensively resolved.

Nu-Stone, a bulk-molded compound (BMC) composite (compressed of glass fiber, talc, mica, etc.) can be molded into enclosures. BMCs are typically compression-molded, so the forming time was 10 minutes or more. BMC offers great acoustic performance, in part because of the high-density material, easily molded ribs, radiused edges, and the baffle. Unfortunately, the thicker walls and denseness increased the cost per unit. Sharp edges chipped and high aspect-ratio details like internal posts had poor production yields. Polk and NHT, among others successfully used this material (see **Photo 5**). These days, cost-sensitive products (e.g., docking stations) cannot defend the higher cost of goods versus inexpensive ABS and other commodity injection-molded, thin-wall plastics. Industrial Dielectrics, which develop Nustone, still makes huge quantities of BMC materials, and production has expanded to China. Globe Plastics is a

Photo 3: The Genelec 8260a monitor utilizes a more engineered design. (Photo courtesy of Genelec)

vendor of BMC-molded speaker enclosures, horns, and other parts, and its products are established in the market. BMC has also found a home for outdoor and higher grade products (e.g., automotive body parts, electrical boxes, etc.). From these applications, it is apparent the material has extreme temperature tolerance and is weather resistant enough for speakers permanently installed outdoors.

POWDER–COATED WOOD

Powder-coated paints for wood enclosures have been under development

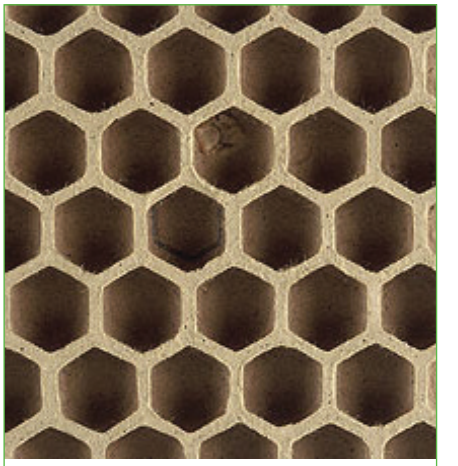


Photo 4: The Gridcore panel detail helps decrease the enclosure's weight. (Photo courtesy of Gridcore Products)

and refinement for more than a decade. Until the last decade, powder coating, which provides a strong, attractive finish, was only possible for metal parts. UV-curable powder coating or low-temperature curable powder coatings are now common for wood furniture. When used on wood, it is possible to get a "show car" or lacquer paint-like finish on a speaker enclosure. Success on wood components usually occurs when a single piece is powder coated. Complete boxes do not lend themselves to straightforward powder coating. Early processes tended to char the wood and over time, cracking resulted, particularly at the joints.

HIGH-QUALITY LAMINATE ENCLOSURES DISAPPEAR

From the 1950s through the 1960s, audiophile speaker enclosures were handcrafted wood and wood veneers. By the 1970s, the cost of conventional domestic woodworking and the popular walnut veneers were too high for mainstream consumer audio products.

Photo 5: These Polk RM6600 speakers with Nu-Stone enclosures use BMC materials. (Photo courtesy of Polk Audio)

Vinyl-wrapped particle board dominated audio stores' shelves. In the late 1990s, high-end wood grain and black lacquered speakers reappeared because of quality wood speaker enclosure factories in China. Now, most of the Chinese woodworking shops have done one of three things: expanded into other businesses (e.g., furniture for luxury hotels and retail store display furniture for high-grade products); found other endeavors; or closed. Several factors have driven these firms away from high-end speaker enclosure work (e.g., the atrophying of the global audiophile market, wage costs for such labor-intensive and time-consuming work (in some shops the multilayer lacquer finishing process took almost a week), and loss of interest in such tough and arduous jobs.

WHAT'S NEXT?

If cost of goods was not such a sensitive issue, BMC enclosures for docking stations, sound bars, and related products would be ideal. While some BMC formulations can be injection molded, this is a special process not mastered by most offshore factories. ABS plastic resins dominate, but they have mediocre acoustical characteristics. Filled ABS requires painting, and the surface finish can be an issue. Higher-grade resins like polyetherimide (PEI) are extremely costly and the injection-molding temperatures require expensive special steel tools. An interesting upgrade from the commodity ABS plastics is compounding wood flour with plastics. Wood flour is finely milled saw dust with a sizing (coating) and, when mixed with various plastics at about 30%, imparts a somewhat wood-like acoustic characteristic. Wood-flour plastic composites are injection molded. While the raw material costs about the same as ABS, the process costs a bit more. The process requires humidity control of the materials and humidity control at the injection molding area. While this is common in the U.S., humidity control is rare in China. Also, parts molded with compounded wood-flour require a primer and a finish-paint coat.

CURRENT STATUS

MDF boxes with vinyl wrap or veneered wood surfaces continue to dominate the home theater and stereo audiophile enclosures. Unfortunately, these product categories have shrunk over the last few years. Quality speaker systems, considered the realm of audiophiles in the 1960s, then became mainstream stereo in the 1970s and 1980s. Home theater was mainstream in the 1990s. Today, we are faced with sound bars often made of plastic construction, sometimes with a MDF baffle inside. Perhaps large-screen TVs provide enough distraction from sound quality. Docking stations and inwall and ceiling speakers are typically injection-molded plastic. In general, current sound reproduction enclosures leave a lot of room for improvement, with the exception of increasing obscure higher-end brands.

As some manufacturing comes back to the U.S. many factors could affect "tuning" products.

Next month, we will think "inside the box" and discuss box stuffing. *aX*