Proof

by Mark McKenzie, PhD.

What counts as proof of a claim? In the post Newton era of science, independent verification is the gold standard. I believe that is also good enough here.

This is an experiment in controlling diaphragm material vibration modes through targeted diaphragm dimpling that requires only simple tools to implement and minimal analysis equipment to verify the before and after performance.

MATERIALS NEEDED:

- Tang Band W4-1320SJ Transducer
- Embossing Tool
- Microphone
- Quasi Anechoic analysis software
- Computer with sound card

It is likely that the only materials needed to conduct the experiment are the transducer and the embossing tool. I list the other three only because I have spoken with representatives of companies in the business who have no in-house analysis capabilities.

The transducer for this experiment is a four-inch paper extended range Chinese made Tang Band transducer. It is available from Parts Express and they ship everywhere. This model may be available from other sources, but with Tang Band you never know. My reason for using the W4-1320SJ transducer for this experiment is the ease of dimpling the diaphragm material. Not all paper diaphragms are as easily dimpled. Indeed, for most “advanced” designed papers the dimpling process can become quite involved, almost arcane.

For this advanced design diaphragm material, however, the only tool needed for dimpling is a standard craft embossing tool. The tool should be available at most hobby or scrap book supply stores. Most of these tools have two tips, one being larger (or smaller) than the other. For the tool I used, the larger tip is 1.8 mm in diameter and the smaller tip is 1.5 mm. The embossing tool is shown in Illustration 1.


Illustration 1: Two tip embossing tool

If you don't have in-house analysis capabilities, you will need a microphone. For this experiment it does not have to be a high quality instrumentation microphone. Any microphone with response extending beyond 10 kHz should work. You will be looking at a peak in the response and how that peak changes after dimpling. The graphs I supply can be used as a reference of transducer performance.

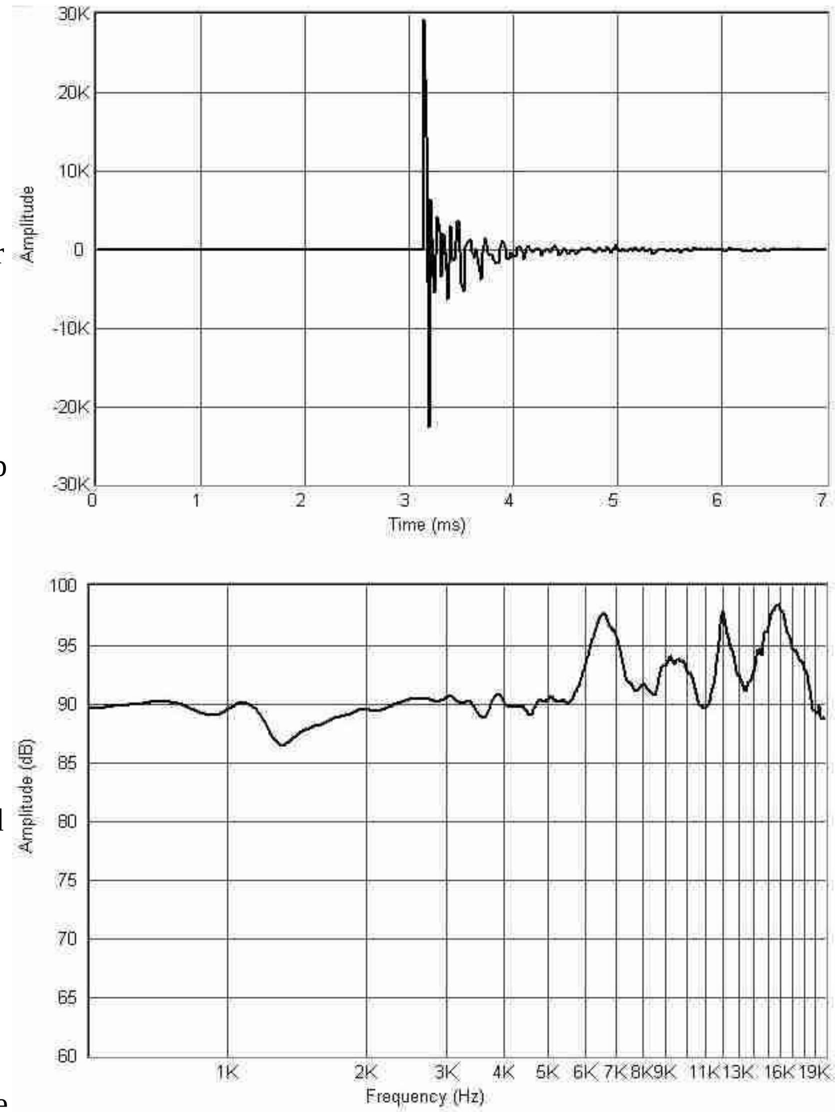

Illustration 2: TB W4-1320SJ stock one meter on axis impulse and frequency response.

The experiment can be duplicated using inexpensive computer based quasi-anechoic acoustical software. The tests shown here were made with the now open source Speaker Workshop software package. Speaker Workshop has been available since at least 2001 and Audua never got around to asking users to pay for the software. If you know how to do impulse based, gated acoustical measurement, then Speaker Workshop is all you will need. Expensive analysis software has never been needed to document diaphragm material vibration modes in transducers.

Obviously, if you are going to use computer based software, then you will need a computer and a sound card. In most cases, the built in sound card will handle all the amplification needs for this experiment.

STOCK TRANSDUCER

The stock impulse and frequency responses are shown in Illustration 2. As stock, the transducer's performance is worse than a very few, yet better than most comparable extended range four-inch transducers. There are three major material vibration modes evident in this kraft paper doped with pieces of bamboo diaphragm. The fourth peak evident between six and 19 kHz is caused by interference between two of the vibration modes. The vibration modes are lightly coupled. This means that changing one mode will also produce some change in the others. The vibration mode targeted for the test is the lowest center frequency mode, with its peak between six and seven kHz.

DIMPLING THE DIAPHRAGM

The lowest vibration mode's critical regions are in the outer half of the diaphragm's surface. Two pairs of dimples are needed to control this one vibration mode. The dimples are long but extremely narrow, covering only a small percentage of the diaphragm's total surface area.

The diaphragm is easy to dimple. Use the 1.8 mm ball end of the embossing tool. Support the back side of the diaphragm with a compressible material. I suggest using the pad on the palm side of a fingertip for this purpose. Place the embossing tool tip against the diaphragm's surface, apply pressure to dimple the material to a depth of between 0.45 and 0.6 mm. This will produce a dimple just under 1.0 mm in width.

For the 6600 Hz frequency vibration mode, two pairs of long narrow dimples are required. To explain the arrangement of the dimples, imagine two diagonals across the diaphragm forming an X with the center of the X being the center of the transducer. On each leg of the X (a diagonal), two dimples are made, mirror imaged to the other. While each pair of dimples on the same diagonal are the same length, the length of the dimples on the remaining diagonal are different.

The respective size of one dimple of each pair is shown in Illustration 3. The top image shows the placement of one of the mirror image pair of long dimples. The bottom image shows the placement of one of the mirror image pair of short dimples.

The longer dimple is eight mm long. The shorter dimple is five mm long.

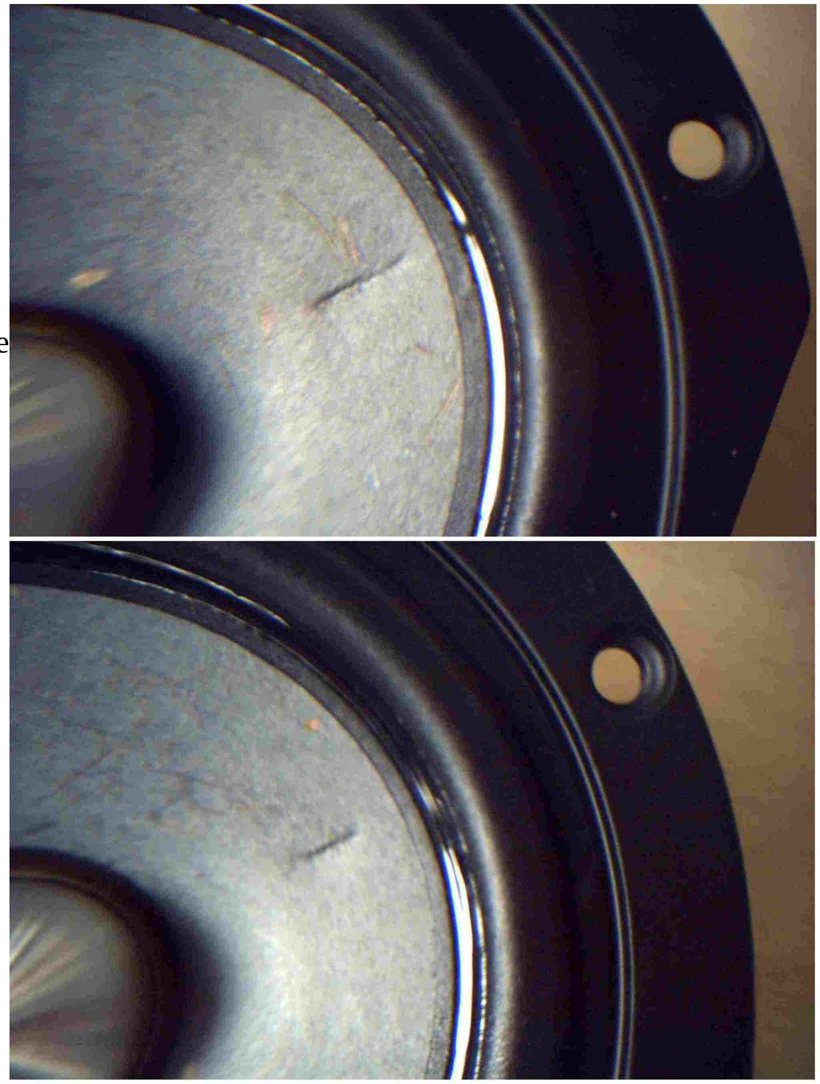

Illustration 3: One each of the two opposing pair of dimples. Longer dimple in top image, shorter dimple in the lower image.

Illustration 3: One each of pair of long and short dimples embossed on diaphragm

The most convenient way to reference the location of the dimples is to place them in relation to the inside surround trim ID. The outside end of the longer dimple is 2.5 mm in from the inside surround trim ID. The shorter dimple is four mm in from the inside surround trim ID.

You can also see in Illustration 3 some lighter colored flecks on the diaphragm. These are pieces of bamboo. The bamboo is harder than the kraft paper stock. The harder pieces of bamboo make it difficult to emboss a perfectly straight dimple. If your dimple deviates a little from straight as the top dimple does in Illustration 3, do not worry about it. Slightly imperfect lines seem to have no impact on the resulting performance.

RESULTS

Illustration 4 shows the impulse and frequency response after dimpling. The targeted 6600 Hz vibration mode is well controlled, perhaps even gone. As is often the case, the various vibration modes are somewhat coupled. Eliminating one vibration mode will "quiet" the cone and thus reduce the magnitude of the remaining vibration modes.

There is some skill to embossing the dimples by hand. You may not achieve the same level of results shown here with just four narrow dimples. Still, you will target the 6600 Hz vibration mode and you will achieve significant reduction of vibration mode's magnitude.

Even with one vibration mode controlled, the improvement in reproduction quality is easily audible. It is possible to “Whisper” this diaphragm. It does take additional dimples and those dimples are different in dimension and different in location.

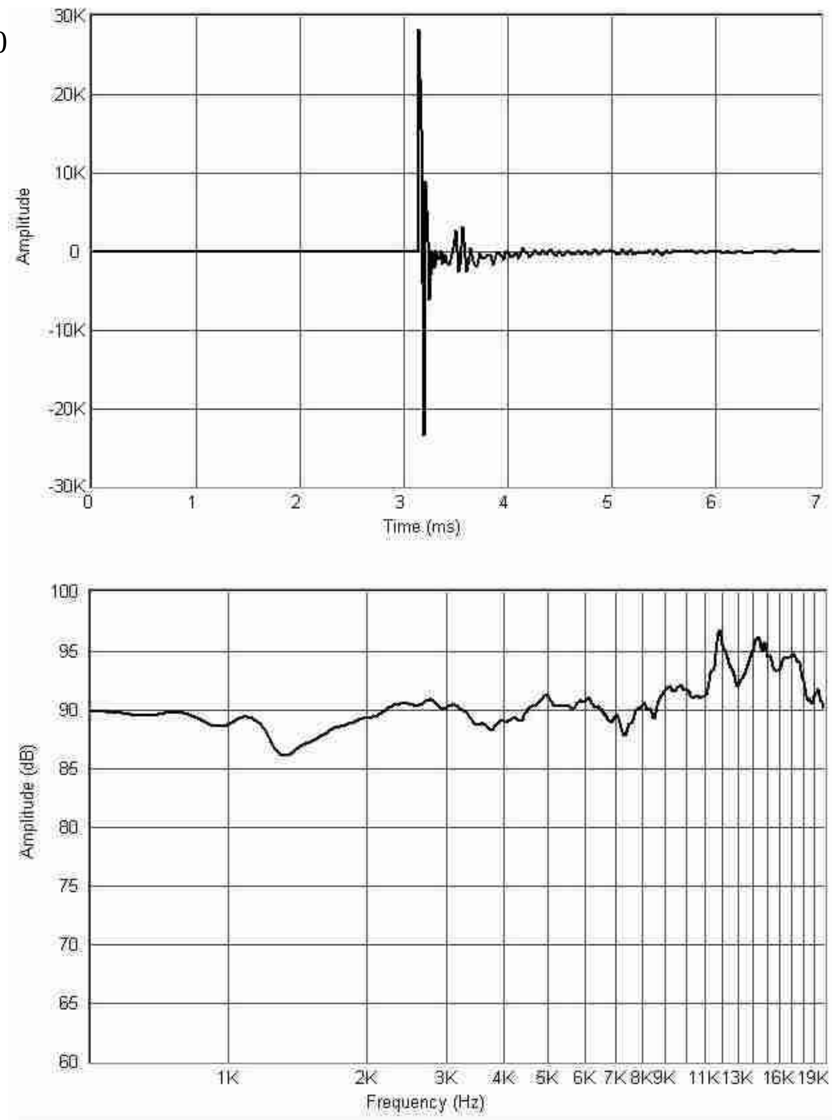

Illustration 4: The dimpled impulse and frequency response.