Properties of Drum Shells and Bearing Edges

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Abstract

Drum shell bearing edges dictate the boundary conditions and point of contact between drum heads and drum shells. Properties of single 45º, single 45º with slight round-over, and double 45º bearing edges have been studied. It has been found that the double 45º drum allows for the best head/shell energy transfer.

I. Background

Tom drums are typically composed of a wooden drum shell, a head that rests of top of it, and a mechanism to apply tension to the head. A good discussion on drum physics can be found in *The Physics of Musical Instruments*, by Fletcher and Rossing.[1]

One important property of a drum head is its boundary conditions. The bearing edge is where the drum head comes into contact with the drum shell. There are several bearing edge shapes which are currently used in drum production. It is expected that different bearing edges will have a significant affect on the sound of drums. One possible reason for the importance of bearing edges is that the edge is the primary outlet for energy to transfer between the drum head and the drum shell. Because the sound of a drum is produced by both of these components, it would be desirable to have a higher rate of energy transfer at the bearing edge.

Dennis Stauffer has supplied three 12 inch diameter, 6 inch deep single headed toms. Each has a different bearing edge design.

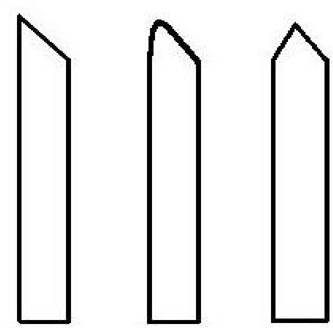

Fig. 1. Representation of cross sections of three bearing edge designs with the outside of the shell on the left side. Single 45º, Single 45º with slight round-over, and Double 45º

In figure 1, from left to right, the drums will be referred to as drum A, B, and C.

I seek to determine the characteristics of these different drum shells.

II. Method

The three drum shells are recorded with no hardware attached and also with the lugs attached. Making these recordings requires special mounting. Because the shells cannot easily be attached to a stand, they are suspended from the ceiling using three strings. For mounting the shell only, the strings are attached to the shell using nylon screw, as seen in figure 2. For mounting the shells with the lugs, the strings are attached the screws that hold the lugs in place. A soft, heavy mallet is used to excite the drum shell.

A Peavey PVM 45 microphone is positioned 5cm from the outside of the drum shell. The microphone signal goes through the line-in on a computer, and through a sound card. Cakewalk Guitar Tracks Pro is used to record the signal and to convert it to a .wav file for analysis.

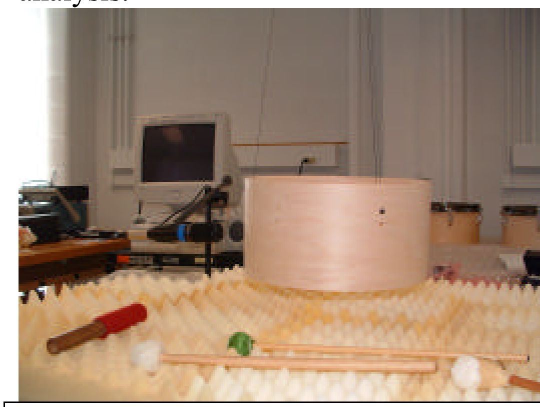

Fig.2 Setup for recording drum shell sounds. Using strings to support the shell only creates a small perturbation to the system.

For recording the drums after all of the components have been attached, they are simply mounted on a drum stand. The mount attaches to the tension rods, rather than to the shell, allowing the drum to more fully resonate. The sound from exciting the shell is also recorded with the drum is fully mounted. Placing a hand on the drum head deadens its sound.

Two PVM 22 microphones are used to record the drum sound. One is positioned over the head, and the other is very close to the shell, as shown in figure 3. The microphone windscreens are removed to get this close. A “Y” adaptor cable is used to feed the two signals into the line-in input on the computer as a stereo signal. Guitar Tracks Pro creates a stereo .wav file.

Fig. 3. Two microphone setup used to record drum sounds. One microphone will record overall drum sound, while the other will focus on the drum shell.

Remo Ambassador Clear heads are used to make the drum recordings. Before playing the drum, the head must be seated. To do this, the head is centered on the drum and the lugs are slowly tuned to a very high tension. The order that the lugs are tuned is important. It is best to go across the drum, rather than around the drum. After the head is tightened, it is stretched by pressing firmly on it.

The tension rods are lubricated to allow smooth tuning. The drum head is tuned to various tension levels using a Drum Dial. The drum is tuned so that the Drum Dial reads the same tension at every lug. The head is played several times at *mf* (mezzo-forte) about 1 cm from the center of the head, using a 5A Vic Firth stick.

The torque on the tension rods is measured with a Neary Drum Torque, seen with the Drum Dial in figure 4. Torque vs. Tension is measured on each lug of all three drums.

Fig. 4. Drum Dial and Drum Torque are used to make measurements for drum tuning.

Matlab is used to analyze the .wav files. There are several versions of a program written to do the following: time independent and dependent fast Fourier transforms, Chebyshev or Butterworth digital filtering, amplitude representative standard deviations of filtered data, and exponential curve fitting to the standard deviation vs. time data. Using these tools, a variety of information can be obtained about the recorded sounds.

III. Results

Before discussing the results from the recordings, it should first be noted that the drums shells are not identical in weight and in the organization of the seams in the wood plies.

Table 1

Drum	Shell Weight	Rim Weight
A - Single 45º	491±1g	590±1g
B - Single 45º w/round-over	461±1g	598±1g
C - Double 45º	444±1g	660±1g

Drum Torque vs. Drum Dial

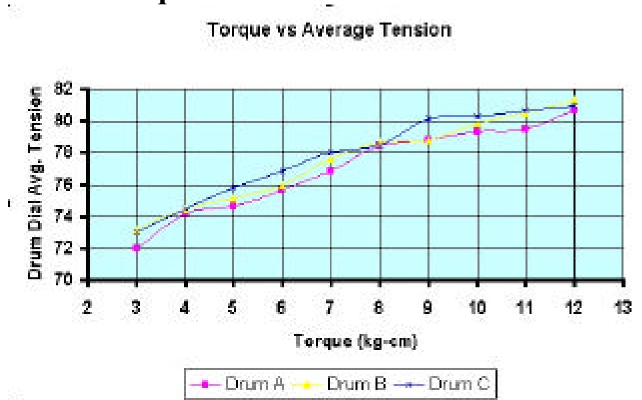

Fig. 5 Torque of all tension rods vs. average tension across drum head. All three drums show a rough linear relationship.

Because some tension rods have more friction than others, the measured relationship between torque and tension shown in figure 5 has some scatter. None of the drums seems to show a significant deviation from the others.

Drum Shell Harmonics

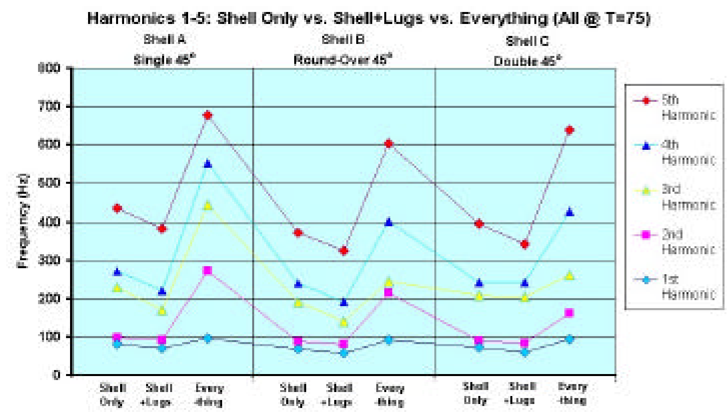

Fig. 6. Progression of frequencies of major harmonics. Drums are tuned to 75 on Drum Dial. Frequencies are shown for shell only, shell and lugs, and shell with everything attached. The three drums were recorded with the PVM 45 microphone

For each drum in figure 6, one can see that the harmonics decrease in frequency when the lugs are added. When the drum is fully assembled, the frequencies increase. It should be noted that through the progression of the drum shells, the dominant frequency bands may not remain the same. This data only represents the first five highest harmonics. Some of the harmonics, especially in the case of the fully assembled drums, are extremely weak. The first harmonic remained relatively strong compared to some of the others.

Drums

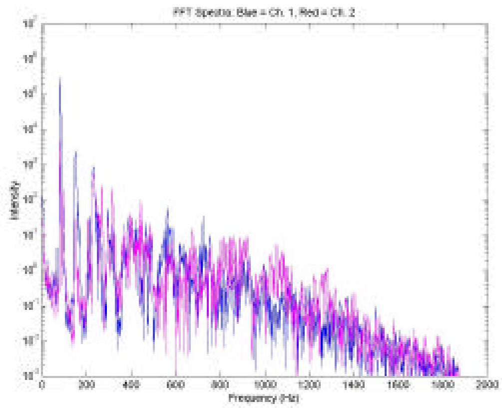

Fig. 7. Representative semi-log FFT of signal from both microphones. The head microphone is blue, the shell microphone is magenta.

As shown in figure 7, a typical recording of the drum head and drum shell sounds generates a wide range of frequencies. The two microphones will gather much of the same sounds, however there are differences in how much of each they receive due to their locations. A ratio of the FFT data from the shell microphone to the head microphone is shown in figure 8.

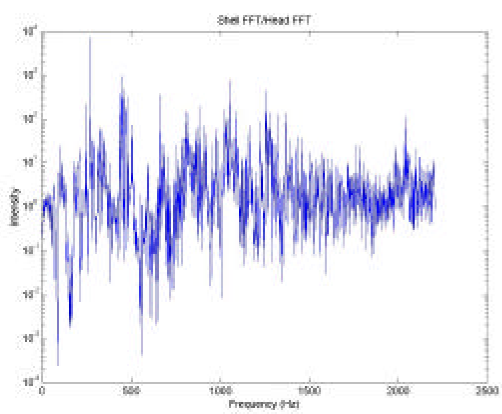

Fig 8. Semi-log plot of the ratio of shell FFT, to head FFT from figure 7. Positive peaks indicate dominate shell signal amplitudes, while negative peaks indicate dominate head signal amplitudes.

Figures 9 through 14 show these ratios with the addition of a third variable, Drum Dial tension. The tops and bottoms of these ratio surfaces are shown for each drum.

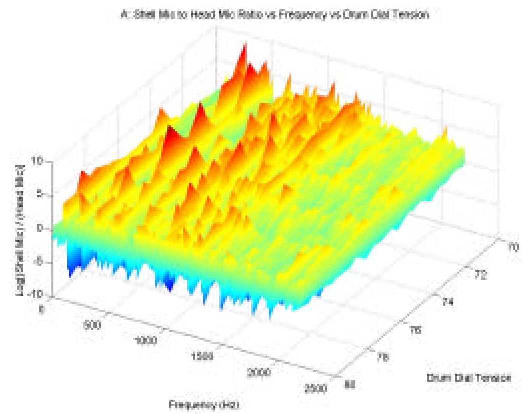

Fig. 9. Drum A. Log(Shell FFT/Head FFT) vs Drum Dial Tension

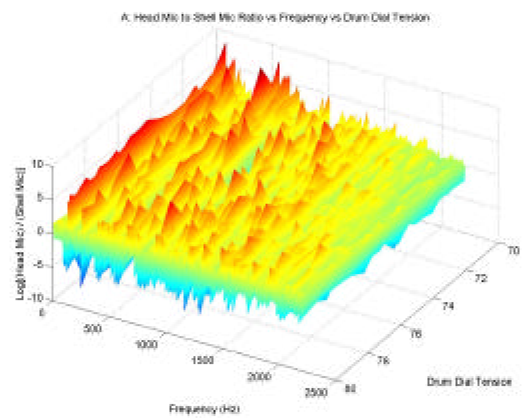

Fig. 10. Drum A. Log(Head FFT/Shell FFT) vs Drum Dial Tension

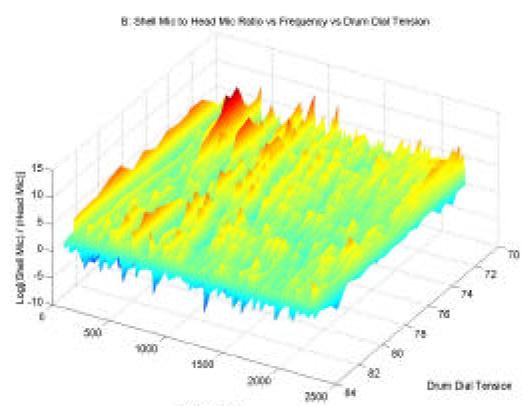

Fig. 11. Drum B. Log(Shell FFT/Head FFT) vs Drum Dial Tension

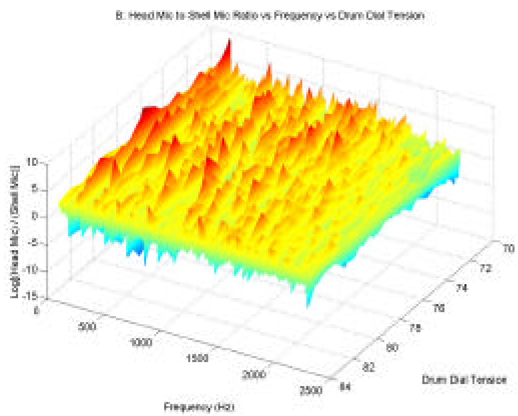

Fig. 12. Drum B. Log(Head FFT/Shell FFT) vs Drum Dial Tension

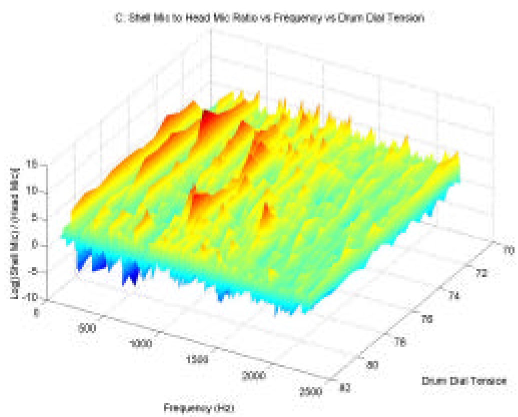

Fig. 13. Drum C. Log(Shell FFT/Head FFT) vs Drum Dial Tension

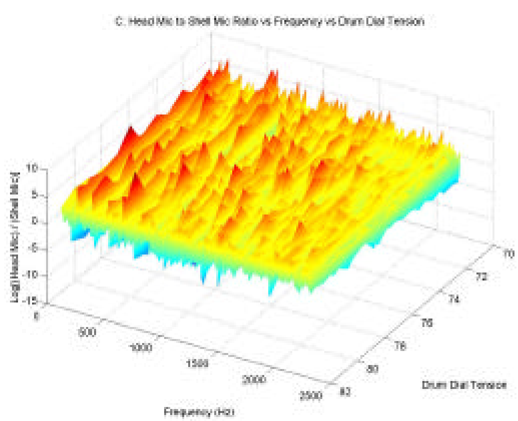

Fig. 14. Drum C. Log(Head FFT/Shell FFT) vs Drum Dial Tension

Looking at figures 9, 11, and 13, we can see that there are frequencies where the shell sound is more pronounced that the head sound. It is also apparent that there is dependence on the tension in the drum head. The other figures show where harmonics exist in the head, and how they evolve with changing head tension.

One can also look at the tension dependent evolution of exponential decay curve parameters as the first harmonic of the drum head passes through the first harmonic of the drum shell. This should give insight as to how energy is transferred from the drum head to the drum shell.

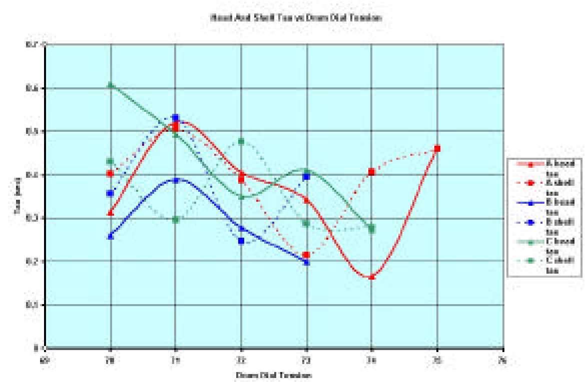

Fig. 15. The y-axis is showing the decay time constant extracted from the exponential curve fit to first harmonic data. The x-axis shows drum dial tension. Solid lines are the drum head, while dashed lines are the drum shell. Drum A: red. Drum B blue. Drum C green.

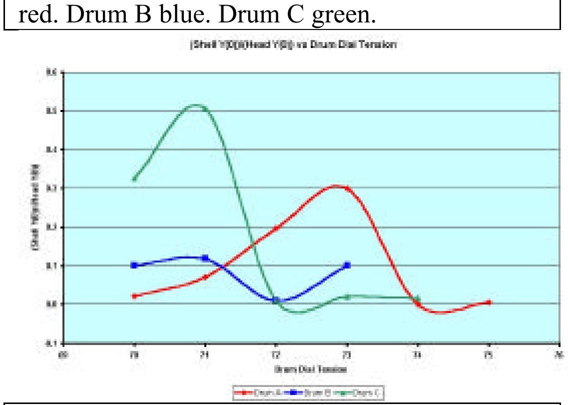

Fig. 16. The y-axis is showing the ratio of the y-intercept of the exponential fit of first harmonic shell data, to the first harmonic head data. The x-axis shows drum dial tension. Drum A: red. Drum B blue. Drum C green.

The information obtained from each drum is made more meaningful by comparison with the others. Comparing these ratios shows which type of drum shells, for specific tension values, are more responsive relative to the sound from the head.

IV. Conclusions

Looking at figure 6, the initial decrease in the harmonics of the shells as the lugs are added can be attributed to the addition of mass to the shell. As the rim, head, and stand are added, the drum shell becomes more rigid and restricted, analogous to an increasing spring constant. It is expected that this would raise the frequency of the modal vibrations and allow less harmonics to vibrate fully.

Interpreting the ratio data shown in figures 9 through 14 is difficult. The data shown in figure 9 is generally lower than that shown in figures 11, and 13, indicating that less sound is emanating from the shell.

Figure 15 is also difficult to interpret. Each data point represents an average of measured decay time constants. Each data point has relatively low uncertainty. However, there may be systematic uncertainties at each tension setting, resulting in an unpredictable behavior. One would expect that the decay time constant for each of the shells to be approximately constant, as we are not drastically changing the properties of the shell as the head tension is increased. If the fundamental of the head is in the vicinity of the shell fundamental, the behavior of this coupled system is complex, hence interference effects – constructive/destructive can/will occur as the head fundamental passes through the shell fundamental.

As the first harmonic of the drum head approaches the first harmonic of the drum shell, we would expect that the time constant decreases, as more energy is transferred into the shell. This appears to be the case with drum A, but not for the other two tom drums. This could be due to the bleeding of head/shell sounds into the two microphones.

Figure 16 shows how much the drum shell responds relative to the drum head. At the resonance, drum C, appears to be the most responsive, with drum A second. Perhaps the round-over on drum B allows for more energy dissipation than with the sharp edges of drum A and C. The difference between drum A and C arises from the contact point and contact angle the drum head makes with the bearing edge on drum A (single-45º) vs. that of drum C (double-45º) as shown in figure 17 below.

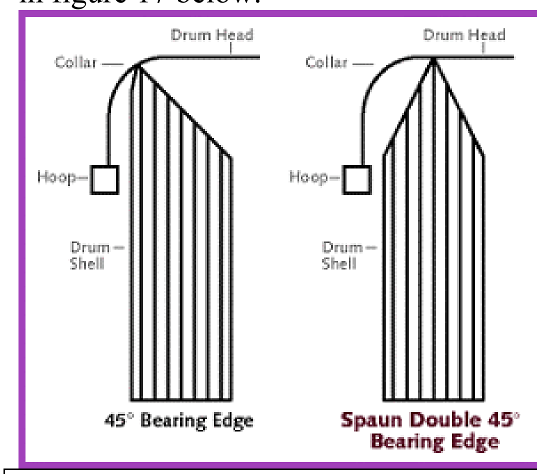

Fig. 17 Cross-sectional view of contact of drum head with drum bearing edge for single-45º vs, double-45º bearing edge.

If the point of contact of the drum head with the bearing edge is closer to the center of the drum head, this means that the point of contact is more likely to be on the flat part of the drum head rather than the stiff, curved collar of the drum head. This is likely to be an advantage.[2]

A possible advantage of the point of contact being in the middle of the drum shell, is that the energy will remain within the drum shell, rather than leaking off of the outside of the drum shell.

Personally, I preferred the sound of drum C over the other two tom drums. I do not know if this is due to the energy transfer properties of the bearing edge, or due to the intrinsic lower tone of the drum shell. Lower mass drums tend to sound more pleasing to drummers.

I do not believe that with the current results we have obtained that it can be said with absolute certainty that a double 45º bearing edge facilitates better energy transfer between the drum head and shell. In order for this to be confirmed, many more drums would need to be tested. The fact that each drum and rim is different, besides the bearing edges, complicates matters. However, I do believe that of the three drums provided, the one with the double 45º bearing edge does promote more energy transfer than the other drums.

V. Acknowledgments

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VI. References

[1] Fletcher, Neville H. and Rossing, Thomas D. *The Physics of Musical Instruments*. Springer-Verlag New Yourk, Inc. New York. 1998.

[2] Spaun Drums <http://www.spaundrum.com/edges.html>