Resonance. Fenomenon of a cup above the surface

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1. The purpose of the investigation

My purpose was to verify if, and how changes in frequency of a sound, depends on the position of the cup in a space. In particular on the distance from the cup to the surface of the water.

2. Method of the investigation

For my research, I used a plastic cup, of an approximate shape of a conical frustum 9,8 cm long, The cup was placed upside down above the water surface. Two support stands were used to keep it stable, while I was tapping the bottom of the cup. Microphone was placed next to the cup, about 4 cm above the water. The distance from the cup to the microphone was also 4 cm. I made a sound records for different distances from the cup to the water.

In order to make these records useful for my investigation, I used an application “audacity”. The program was using a Fourier transform (spectrum analysis) in order to generate graphs. Every wave, even most complex, is built of simple, sinusoidal waves in diverse frequencies [2]. Thanks to the Fourier transform, it is possible find frequencies of this simplified waves and moreover compare, which frequencies are louder than others.

In second part of my research I placed the cup 1m above the floor, away from any obstacles. In a second part, I was about to check if the sound spectrum varies with the changes of an amplitude of a vibrating cup. It means, I was varying the strength with which the vibrations of the cup were forced. Again, I made records and graphs.

3. Results of the experiment

Results clearly show, that the sound spectrum changes, when we place the resonator next to the water. First, we observe differences in the location of the further harmonic tones. Changes in first aliquot start if we place the cup within 5 cm of the surface.

According to my research, when the angle between opposite sites of cone is small, that is less than 20 degrees, and the difference in diameters is within 3 cm, the resonator will have resonant frequencies approximately equal to those of a tube with one end closed, with same length. The equation has got a form showed below.

$$f = \frac{nv}{4l} \qquad (1)$$

Where, f is the frequency of a resonator, n an odd number, l the length of a cup. v denotes a phase velocity [3]. Research was conducted in temperature of 19 degrees. The result of the calculations (Eq. 1) was about 868 Hz. The resonant frequency of the cup I measured, equaled to 866 Hz. Research shows, that the frequency of a first harmonic tone lowers as we shorten the distance between the surface and the cup. I wanted to make sure, if the same happens for all aliquots. I chose one, that would probably be considered as the loudest by human ear. The frequency of this harmonic tone rises. In this case, the difference is three times larger. It is about 600 Hz, while previously it was almost 200 Hz. In the second part of my investigation, I intended to prove, that different forces causes changes in sound spectrum.

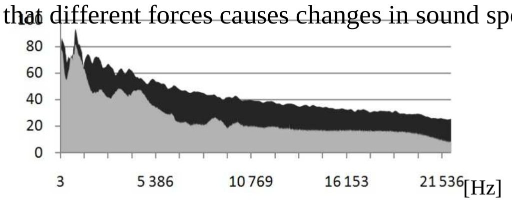

Fig. 1 Cup’s sound spectrum

On a graph showed above, lighter series denotes a sound spectrum of a cup, that was forced into vibrations with a strength I normally used in a first part of my research. The darker series shows sound spectrum of the same cup, but this time, the force used was four times greater.

4. Conclusion

We can easily imagine, that the surface of the water is somehow a boundary for the wave. In summary wave should shorten. Well, if it occurs exactly as we expect the frequency should rise (Eq. 1). In fact, for a first aliquot we observe the opposite situation. Also, I checked what is happening to further harmonic tones. It occurred, that the second one is getting higher as we shorten the distance from cup to water. This changes occur, because the boundary conditions are different. Propagation of waves changes. On the Fig. 1, we can see the results of my second research. The harder we tap the cup, the amplitude of vibrations is greater. In this case, plastic is no longer a linear-elastic material - strain is not directly proportional to stress [1,4]. The more non-linear system is, the more harmonic tones we can distinguish [4]. Only the value of the first aliquot remains constant.

References

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