Acoustic Levitation

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1. Introduction

Levitation is a phenomenon when an object stays in the air. The levitating object must be affected by a levitating force, which balances the gravitational pull. In my research I used the method of standing sound wave levitation. Sound is a longitudinal wave. In standing sound waves the nodes with lower pressure and antinodes with higher pressure are motionless. Levitating force is the result of the average pressure difference among the surface of the object. The aim of my research is to find the best method for acoustic levitation, with home-made devices.

2. Research Methods

I built three different devices which can produce standing wave levitation. Piezoelectric transducers were used to create the acoustic waves, in addition each device has different properties. As shown on *Figure 1*, two transducers were placed opposite to each other and connected to a function generator, the distance was adjustable between them. A 12-cm big, pre-designed base was 3D printed and 72 transducers were fixed in it, as shown on *Figure 2* [1]. This levitator creates several spots, half-wavelength from each other, where objects can levitate. It works with a 40-kHz square signal. The ultrasound stick, shown on *Figure 3*, also works with a 40-kHz square signal. A reflecting surface is necessary for the creation of standing waves.

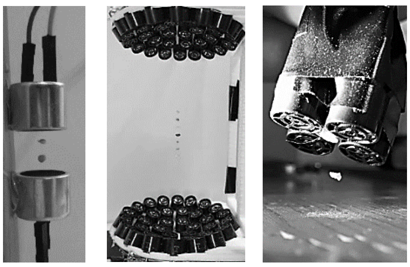

Figure 1–3 − Small levitator, big levitator, ultrasonic stick (from left to right)

The longitudinal pressure difference among the levitating object can be approximated by the following equation:

$$\Delta p = p_{\mathrm{up}} - p_{\mathrm{down}} = \frac{\varrho \cdot V \cdot g}{A}$$

where ϱ is the density, V is the volume and A is the horizontal surface area of the levitating object, and g is the gravitational acceleration. The devices were compered by their maximal Δp. The stability of different positions was examined by tilting the levitator and using external forces.

3. Results

Distance between the levitating objects were measured both in the small and big levitators, and was found to be half-wavelength, as expected. According to *Table 1* the maximal longitudinal pressure values are different in each levitator. The highest pressure differences were created in the big levitator, due to the 72 transducers fixed in it.

Table 1 – The heaviest object which could levitate

	Small levitator	Big levitator	Ultrasound stick
Material	Styrofoam	Rubber	Styrofoam
Δp (Pa)	1.26	11.77	0.25

Correlation between the tilt of the levitator and the objects levitating in it was found in the experiment carried out with big levitator. As shown in *Figure 4*, the more central the position is, the more resistant the object is. The experiment was conducted on different voltages, the tendencies were the same, and higher voltages meant greater angles. These results were also verified when external forces were applied.

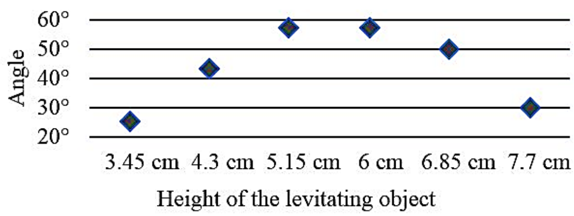

Figure 4 – The tilt of the levitator when the levitating object falls

4. Conclusion

The levitators can be compered by the pressure differences. The application of transducers on both sides has a huge advantage against the usage of a reflecting surface, because reflection cannot be perfect. When several transducers were used, focus has an essential rule [2]. Placing objects near the focus point makes them more stable. The objects are more stable when the voltage is higher, and the transducers are closer. Only tiny objects can levitate, up to the mass of 10^{-5} kg, and these are still sensitive.

5. References

[1] http://instructables.com/id/Acoustic-Levitator/
Written by Asier Marzo (Last view: 05.03.2018)

[2] Asier Marzo Adrian Barnes, and Bruce W. Drinkwater (2017): TinyLev: A multi-emitter single-axis acoustic levitator. *Review of Scientific Instruments* 88.