BUILDING A RESONATOR

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1.Abstract:

The main purpose of the project was to create a model which highlights the principle of resonance. Knowledge of resonance, natural frequency, mechanical vibrations and second order differential equations were implemented. A material has more than one natural frequency; in this project the first order of natural frequency of the steel rod was used. The natural frequency of a cantilever beam is dependent on the length, radius, density and elastic modulus of the object. In the model the word PURE is written on the wooden surface using steel rods which are then made to vibrate.

2.Introduction:

The purpose of this project was to come up with an idea to show the principle of resonance, which is a phenomenon in which a vibrating system excited with periodic waves or external force drives another system to oscillate with greater amplitude at specific frequencies. In some scenarios, resonance becomes uncontrollable and even devastating. Oscillations might exceed the elasticity of objects so thus the system gets damaged. For instance, resonance can be seen in the case of earthquakes.

Initially we studied about natural frequency which is the frequency at which a system tends to oscillate in the absence of any driving or damping force. Other then this, research on mechanical vibrations and second order differential was done.

Using the knowledge of resonance, we came up with an idea to write PURE on a wooden surface using steel rods and covering the rest of surface using steel rods of different length. This way when the system is made to vibrate using electric motor, the steel rods used in writing PURE will only vibrate while the rest of rods will not move.

The natural frequency of the cantilever beam is dependent on the length, radius, density and elastic modulus of the material (Zia et al.2011). The restriction while designing the resonator was to have the frequency of steel rods less than 150Hz so that it is easier to excite the steel rods and make them vibrate. Keeping this restriction in our mind, the length and diameter of the steel rods needed to write PURE was calculated.

3.Project Details:

In this project, the main objective was to build an interesting system which implements the principle of resonance. After coming up with different ideas in which resonance can be shown, we decided to build a system using wooden block, cantilever beams (made of transmission steel), simple electric motor and a mass attached to it and a power source. Initially research was done regarding what properties of a material affect its natural frequency and result showed that the natural frequency of the cantilever beam is dependent on the length, radius, density and elastic modulus of the material (Table 2). In this system, wooden block is used as the base, steel rods as the resonating objects and electric motor and mass on it as a source to vibrate the system. Using the formula in Table 2, a simple C++ code was written to calculate different length and diameter ratios needed to have natural frequency between 0-150 Hz. Based on our calculations, we used two types of steel rods. First one with 4mm diameter and length 20cm and the second one with diameter 4mm and 15 cm length. We get 94 pieces of 20cm steel rods and 159 pieces of 15cm steel rods. Longer ones have 72 Hz natural frequency and shorter ones have 128 Hz natural frequency. After getting all the material needed, holes were drilled in the wooden block (dimensions: 48cm * 32cm * 1.8cm), to insert the metal rods. The design of the base of our model (Table 3) was made on the computer using KeyCreator software and then the technicians in the machine shop drilled holes of 13mm depth on the surface. Longer steel rods were used to write PURE on the wooden block and the rest of the wooden block was covered with shorter ones (Table 4). When electrical motor's speed reaches 4320 rpm (corresponds to 72 Hz in sinusoidal oscillation), longer ones will resonate while shorter ones will not move. Vibrating the system will show the word PURE written on it when looked from aerial view. Similarly, when motor's speed reaches 7680 Hz (corresponds to 128 Hz in sinusoidal oscillation), shorter ones will resonate while longer ones will not vibrate.

3.1. Electrical motor:

In this system it is desired to get a sinusoidal oscillation with the help of the electric motor and mass attached to it. While electrical motor is working, mass on it rotates and creates a centrifugal force on the system. This centrifugal force creates sinusoidal oscillations in two axis of the system (Table 1). After getting a simple electric motor from mechatronics laboratory, calculation regarding how much frequency the motor can generate was done. The restriction in the project was to have a simple electric motor which creates sinusoidal oscillations of less than 150 Hz frequency.

4. Conclusion:

A material resonates when it is excited at its natural frequency and has more than one natural frequency. In the light of our research, natural frequency of cantilever beam used on our resonator is dependent on length, elastic modulus, radius and density of the material. While researching on resonance, we came across that resonance can cause harmful effects on human life such as earthquakes and landslides. However, if people can achieve to send reverse mechanical waves having different frequency than the system's proceeding oscillation frequency we may overcome possible negative effects of resonance.

5.Appendix:

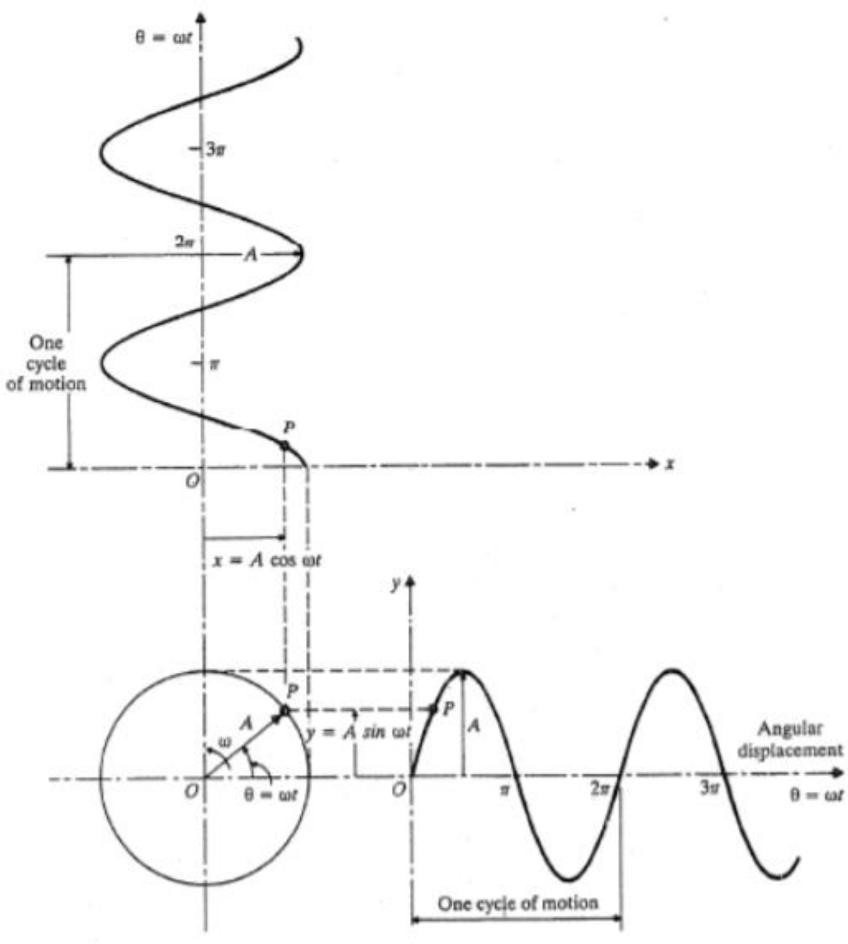

Table 1: sinusoidal oscillation with electrical motor's motion

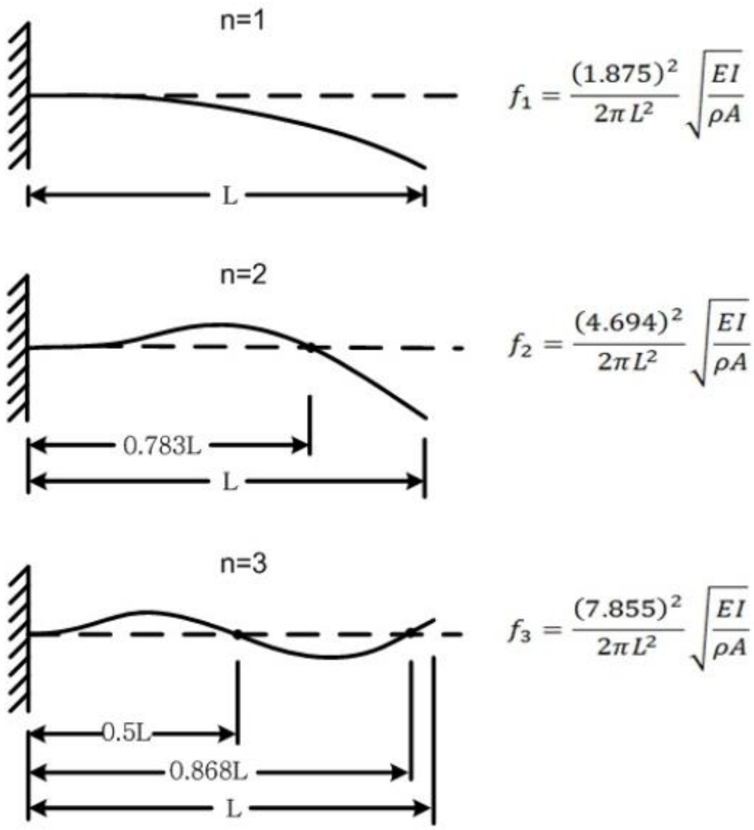

Table 2: Natural frequencies for the first three modes of flexural vibration of cantilever beam

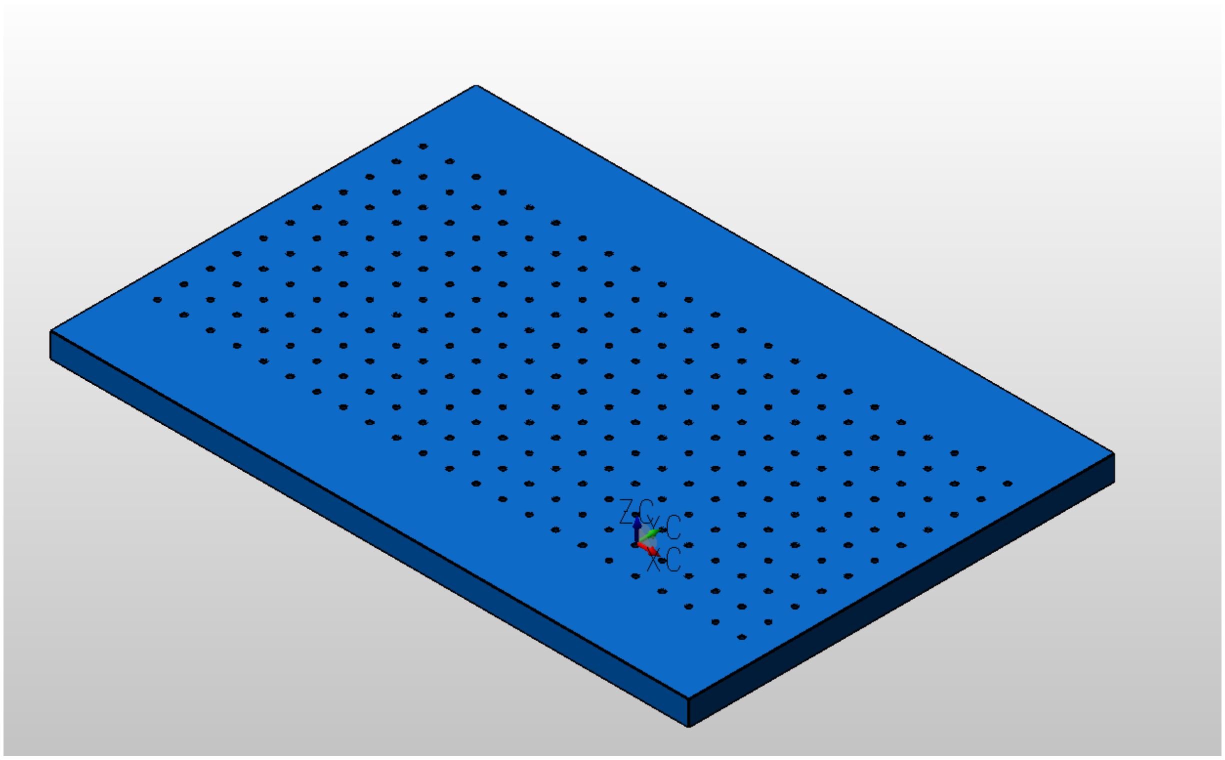

Table 3: Solid model of the wooden block

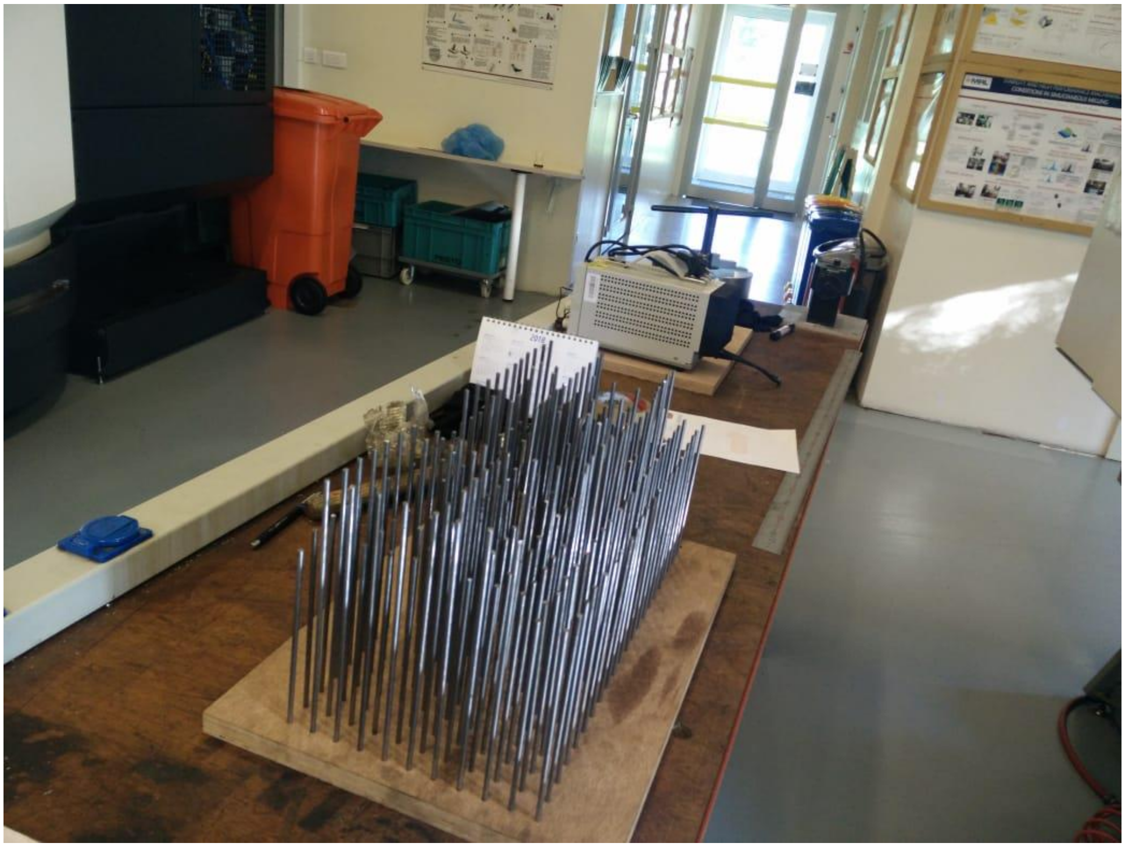

Table 4: Final version of wooden block and steel rods

References:

1. Zia, B. A., Ahmad, F., Lee, C., Kim, T., & Park, M. (2011). Structural Optimization of Cantilever Beam in Conjunction with Dynamic Analysis. Journal of the Korean Institute of Gas, 15(5), 31-36.