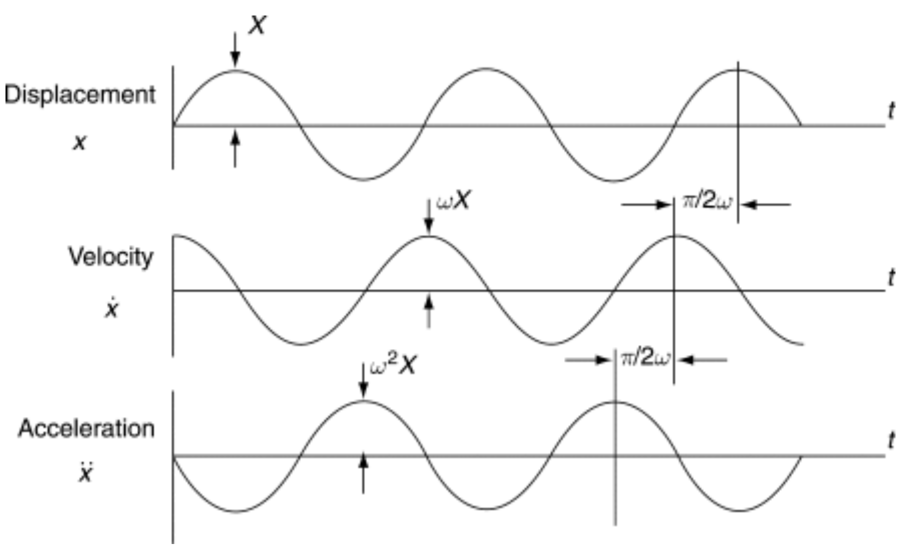
Our project aims to filter saffron using a vibrating sieve to prevent other parts from passing through the vacuum. In order to design an efficient sieve, we first determined the characteristics of the saffron flower and ensured that the sieve was lightweight.

The sieve will be rectangular in shape to fit inside the rectangular bag. Rectangular holes with curved edges were chosen to allow for easy passage of the saffron. The dimensions of the holes will be 30 mm x 1.09 mm, and the dimensions of the sieve itself will be determined later.

After careful consideration, we decided to use polyurethane plastic as the material for the sieve. This material is known for its high tensile strength, lightweight nature, low noise, and wear and abrasive resistance. It is also easy to maintain, making it an ideal choice for our vibrating sieve. These qualities ensure that the sieve has optimal vibration, which is crucial for the success of the project.

The vibration that will be applied on the sieve will be harmonic which means that the motion is symmetrical.



The sieve will be held inside a frame and then connected to two springs which means that there will be two degrees of freedom. Calculations were made to find the natural frequencies, natural modes, amplitude, and speed.

$m_1\ddot{x}_1 + (k_1 + k_2)\,x_1 - k_2x_2$
$m_2\ddot{x}_2 - (k_2x_1 + k_2x_2 = 0$

$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} k_1 + k_2 & -k_2 \\ -k_2 & k_2 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{matrix} 0 \\ 0 \end{matrix}$$

If $m_1 = m_2$ and $k_1 = k_2$

$$\begin{bmatrix} m & 0 \\ 0 & m \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} 2k & -k \\ -k & k \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{matrix} 0 \\ 0 \end{matrix}$$

Harmonic motion

We will assume that masses oscillate with the same frequency ω and different amplitudes a_1, a_2.

$$\begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{matrix} a_1 \\ a_2 \end{matrix} \cos(\omega t-\theta)$$

If we differentiate twice, we will get $\begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} = -\omega^2 \begin{matrix} a_1 \\ a_2 \end{matrix} \cos(\omega t-\theta)$

Then we substitute into 1

$$\begin{bmatrix} -m\omega^2 & 0 \\ 0 & -m\omega^2 \end{bmatrix} \begin{matrix} a_1 \\ a_2 \end{matrix} \cos(\omega t-\theta) + \begin{bmatrix} 2k & -k \\ -k & k \end{bmatrix} \cos(\omega t-\theta) = \begin{matrix} 0 \\ 0 \end{matrix}$$

Dividing by $\cos(\omega t-\theta)$

$$\begin{bmatrix} -m\omega^2 + 2k & -k \\ -k & -m\omega^2 + k \end{bmatrix} \begin{matrix} a_1 \\ a_2 \end{matrix} = \begin{matrix} 0 \\ 0 \end{matrix}$$

Solving for a_1, a_2,

$$\det \begin{bmatrix} -m\omega^2 + 2k & -k \\ -k & -m\omega^2 + k \end{bmatrix} = 0$$

yields to the characteristic equation.

$$m_2\omega^4 - 3km\omega^2 + k_2 = 0$$

Natural Frequencies are the roots of the characteristic equation.

$$\omega^2 = \left(\frac{3\pm\sqrt{5}}{2}\right)\frac{k}{m}$$

$$\omega_1^2 = \left(\frac{3\pm\sqrt{5}}{2}\right)\frac{k}{m} = 0.618\sqrt{\frac{k}{m}}$$

$$\omega_2^2 = \left(\frac{3\pm\sqrt{5}}{2}\right)\frac{k}{m} = 1.618\sqrt{\frac{k}{m}}$$

Natural Modes

From the first line of this equation

$$\begin{bmatrix} -m\omega^2 + 2k & -k \\ -k & -m\omega^2 + k \end{bmatrix} \begin{matrix} a_1 \\ a_2 \end{matrix} = \begin{matrix} 0 \\ 0 \end{matrix}$$

$$(-m\omega^2 + 2k)a_1 = ka_2$$

We can obtain the amplitude ratio.

$$\frac{a_1}{a_2} = \frac{k}{-m\omega^2 + k}$$

Therefore, the natural modes are

If $\omega_1 = 0.618\sqrt{\frac{k}{m}}$ then $\frac{a_1}{a_2} = 0.618$

If ω_2 =0.618$\sqrt{\frac{k}{m}}$ then $\frac{a_1}{a_2} = 1.618$

We have two natural frequencies and two natural modes because we have two degrees of freedoms. Each natural mode is associated with a particular natural frequency, and they describe the situation in which the entire system is oscillating at one frequency.

In general, the system's response will contain both natural frequencies.

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = A_1 \begin{matrix} 0.618 \\ 1 \end{matrix} \cos(\omega_1 t - \theta_1) + A_2 \begin{matrix} 1.618 \\ 1 \end{matrix} \cos(\omega_2 t - \theta_2)$$

Where $A_1, A_2, \theta_1, \theta_2$ are determined by initial conditions.

Determining the speed of a vibrating sieve plate is essential for ensuring its proper operation. The frequency of vibration can be measured using either a tachometer or a vibration meter, with the latter typically providing more accurate results. However, when a person is carrying a bag with a vibrating sieve inside, it is crucial to consider the allowable frequency of vibration to prevent any potential health hazards.

Several factors can influence the allowable frequency of vibration for a person carrying a bag with a vibrating sieve inside, including the weight of the bag, the amplitude and frequency of the vibration, and the duration of exposure to the vibration. Long-term exposure to high levels of vibration can cause health problems, which is why it is essential to limit exposure to vibrations and ensure that vibration levels are within safe limits.

The Occupational Safety and Health Administration (OSHA) sets the permissible exposure limit (PEL) for hand-arm vibration to an eight-hour time-weighted average of 5 m/s^2 for vibration frequency between 1 Hz and 80 Hz. To determine whether the vibration frequency of the sieve is within safe limits, it must be compared to the PEL. We decided to use a 0mmx2mm Mini Vibration Motor with a speed of 12000rpm and during testing we will decide how many vibrators we need to be within the safe limit. The sieve will have a frame to hold it and will be connected to compression springs to allow for horizontal movement.