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Theoretical and Experimental Analysis of Longitudinal Vibratory Systems

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***Abstract*— *The simple harmonic motion of a spring mass system generally exhibits a behavior strongly influenced by the geometric parameters of the spring. The application of spring mass systems to the animation of brittle facture is revisited. The motivation arises from the recent popularity of peridynamics in the computational physics community. Peridynamic systems can be regarded as spring mass systems with two specific properties. First spring forces are based on a simple strain metric, thereby decoupling spring stiffness from spring length. Second masses are connected using a distance based criterion. The relatively large radius of influence typically leads to a few hundred springs for every mass point. Spring mass systems with these properties are shown to be simple to implement, trivially parallelized and well suited to animating brittle fracture. This experiments provides the possibility of understanding the differences between theoretical models that include well known corrections to determine the technical terms of a spring mass systems.*

***Keywords*— *Pulley, Rope, Vibration, Longitudinal-. Transverse, Hoisting system.*

I. INTRODUCTION

Vibration is defined as a motion which repeats after equal interval of time and is also a periodic motion. The swinging of a pendulum is a simple example of vibration. Vibration occurs in all bodies which are having mass and elasticity. They are caused due to several reasons such as presence of unbalanced force in rotating machines, elastic nature of the system, external application of force or wind loads and earthquakes. Vibrations are undesirable in most engineering systems and desirable in few cases. A body is said to vibrate if it has periodic motion. Mechanical vibration is the study of oscillatory motions of a dynamic system. An oscillatory motion is a repeated motion with equal interval of time.

Our daily life is also associated with vibrations. The law of nature states that everything in the world has vibration. Examples for vibrations are sounds, earthquake etc.

II. EXPERIMENTAL PROCEDURE

Pulley

Pulley will be fabricated out of rolled mild steel plates/ seamless pipe of adequate capacity as per IS-226/made out of graded cast steel. The pulley will be grooved/UN grooved and suitable side flanges will be provided on both sides of the drum. The drum will be keyed to the main drum shaft.

Pully

Hook

According to the manufacturing method, the hook is generally divided into forging hook and laminated hook. Forging hook overall manufacturing cost is relatively low, is also very easy to manufacture, so the application is more extensive, but forging hook once destroyed, becomes scrapped.

The laminated hook is connected into a multi-piece rolled steel rectifying intermediate with buffer tableting, can buffer the pressure to bring the energy, even if the individual steel breakage took place, it will not affect the overall fracture and breakage

Ropes

Rope is made from multi-wire strands laid in spiral around a core of fiber or steel. It is always made larger, never smaller, than the nominal or rated diameter. For example, a 1-inch nominal diameter rope may vary between the finches. The core is the foundation of a wire rope and affects its bending and loading characteristics.

Rope

III. EXPERIMENTAL SETUP

Spring Mass System1

This system has a rectangular frame. A spring is hanging on the top of the frame the load is applied by using a hook on the spring.

The frame is formed by various processes include cutting, drilling, grinding, welding. All the other components are

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arranged together to form the whole system. It has one degree of freedom.

Spring mass system1

Spring Mass System2

This system has two springs. There is a bar attached horizontally on the frame to a length of 50 cm. one spring connect the bar and the frame. It is fixed at the midpoint of the bar. The other spring is hanging at the end of the bar vertically. The load is applied at the hanging spring by use of a hook. The height and width of the frame are 60cm and 50cm respectively. It has two degree of freedom. The basement is also made of mild steel.

Spring mass system2

Spring Mass System3

It is a single degree of freedom system. In this spring mass system two springs and one pulley is used. The diameter of the pulley is 20cm. The pulley is made of mild steel. One spring is attached with the top of the frame at one end and the other end is tied with a rope, the rope is passing through the pulley. The second spring is attached with the pulley end and the other end is used to hold the load. A scale is fitted in the side of the frame to measure the deflection when the load is applied.

Spring mass system3

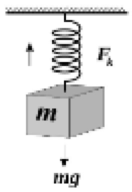
Spring Mass System4

This is the most complicated system of all the above. It has three degree of freedom. The height and width of the frame are 80cm and 120cm respectively. It has consists of two springs and two pulleys. One spring is connected with a rope at one end and fitted with the frame at the top. The second spring connected as the same as first spring but connected at the lower end of the frame. The deflection is measured when the load is applied.

Spring mass system4

IV. Experimental Results

Natural Frequency of Spring Mass System1



Spring with mass

Natural frequency $f_n = 2\pi\sqrt{\frac{s}{m}}$

S.No	Mass (Kg)	Time for 5 oscillations (Sec)	Static deflection (mm)
1	4	2.52	45
2	5	2.94	85
3	6	3.38	164

Spring mass system1

Stiffness, s = $\dfrac{Force}{static\ deflection} = \dfrac{5\times 9.81}{85}$ =0.57 N/mm

Experimental natural frequency $= \dfrac{No\ of\ \ oscillation}{mean\ time}$

$=$ 5/2.99 $=$ 1.70 Hz

Theoretical frequency, $f_t = \dfrac{1}{2\pi}\sqrt{\dfrac{s}{m}} \;\; = \dfrac{1}{2\pi}\sqrt{\dfrac{0.57\times 10^2}{5}}$

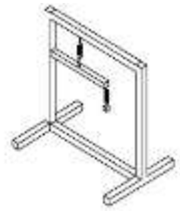
=1.70 Hz

S. No.	Mass Kg	Stiff ness N/mm	Time for 5 Oscillation Sec	Frequency	
				Theoretical	Experimental
1	4	0.87	2.52	2.34	1.98
2	5	.57	2.94	1.70	1.70
3	6	.35	3.38	1.51	1.47

Comparison of result

Natural frequency of 5 Kg = 1.70 Hz
Theoretical frequency 5 Kg = 1.70 Hz

Natural Frequency of Spring Mass System2



Force in spring1 $F_1 = W$

Force in spring, $F_2 = w\dfrac{l_1}{l_2}\left(F_1\times l_1 = F_2\times l_2\right)$

Deflection (Δ)= deflection of spring1+ $\dfrac{l_1}{l_2}\times$ deflection of spring2

$$= \frac{w}{s_1} + \frac{l_1}{l_2}\times\frac{Wl_2 / l_1}{s_2}$$

$$= w\left[\frac{1}{s_1} + \frac{\left(l_1/l_2\right)^2}{s_2}\right]$$

$$= mg\left[\frac{s_2 + s_1\left(l_1/l_2\right)^2}{s_1 s_2}\right]$$

$$F_n = \sqrt{\frac{g}{\Delta}}$$

$$= \sqrt{\frac{s_1 s_2}{\left[s_1\left(l_1/l_2\right)2 + s_2\right]m}}$$

Natural frequency $F_n = \sqrt{\dfrac{s_1 s_2\left(l_2/l_1\right)2}{\left[s_1 + s_2\left(l_2/l_1\right)2\right]m}}$

S. No.	Mass Kg	Time for 5 Oscillation Sec	Deflection Sec		Stiffness N/mm	
			Δ_1	Δ_2	S_1	S_2
1	1	5.56	11	1	0.89	9.81
2	2	5.63	67	6	0.29	3.27

Spring mass system2

Stiffness, s_1 = $\dfrac{Force}{static\ deflection}$ = 1 x 9.81/ 11 = 0.89 N/mm

Stiffness,s_2 = 9.81/1 = 9.981 N/mm
Experimental frequency, fn = 5/5.56 = 0.89 Hz

Theoretical frequency, $f_t = \sqrt{\dfrac{s_1\times s_2}{\left(s_1+s_2\right)m}}$

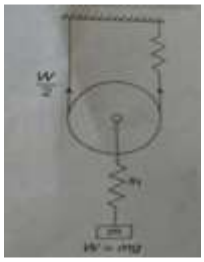
$$= \sqrt{\frac{0.89\times 9.81}{(0.89+9.81)\times 1}} = \sqrt{0.7921} \text{ = 0.89 Hz}$$

S. No.	Mass Kg	Theoretical Frequency	Experimental Frequency
1	1	0.89	0.89
2	2	0.85	0.80

Comparison of results

Theoretical frequency at 1 Kg = 0.89 Hz
Experimental frequency at 1 Kg = 0.89 Hz

Natural Frequency of Spring Mass System3



S. No.	Mass (Kg)	Time for 5 Oscillation (Sec)	Deflection (Sec)		Stiffness (N/mm)	
			Δ_1	Δ_2	S_1	S_2
1	4	0.63	12	1	3.27	39.35
2	5	0.55	32	4	1.53	7.84
3	6	0.44	65	10	0.90	5.88

Spring mass system3

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Stiffness, $s_1 = \dfrac{Force}{static\ deflection} = \dfrac{5\times 9.81}{31} = 1.53$ N/mm

Stiffness, $s_2 = \dfrac{Force}{static\ deflection} = \dfrac{5\times 9.81}{4} = 12.26$ N/mm

Experimental frequency, $f_t = \dfrac{5}{Meantime} = \dfrac{5}{0.45} = 11.1$ Hz

Natural frequency, $f_n = \sqrt{\dfrac{4\times s_1\times s_2}{(s_1+s_2)m}}$

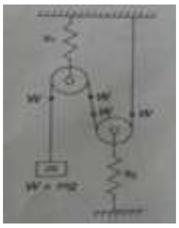
$$= \sqrt{\frac{0.9\times 5.8\times 4\times 10^2}{(0.9+5.9)\times 6}} = 12.3 \text{ Hz}$$

S. No.	Mass (Kg)	Theoretical Frequency (Hz)	Experimental Frequency (Hz)
1	4	27.2	7.2
2	5	13.5	9.0
3	6	12.2	11.1

Comparison of results

Theoretical frequency at 6 Kg = 12.2 Hz
Experimental frequency at 6 Kg = 11.1 Hz

Natural Frequency of Spring Mass System4



Force in spring 1 = *w*
Force in spring 2 = *w*/2
Deflection of mass= deflection of spring1 + deflection of spring2

$$= \frac{w}{s_1} + \frac{w/2}{2s_2}$$

$$= mg\left(\frac{1}{s_1} + \frac{1}{4s_2}\right)$$

$$= mg\left(\frac{4s_2 + s_1}{4s_1 s_2}\right)$$

Natural frequency, $f_n = \sqrt{\dfrac{4s_1s_2}{(s_1+4s_2)m}}$

S.No	Mass Kg	Time for 5 oscillations sec	Deflection of spring 1 mm	Deflection of spring 2 mm	Stiffness N/mm	Stiffness N/mm
1	4	0.72	5	2	12.26	19.62
2	5	0.66	12	5	4.08	9.81
3	6	0.53	19	9	3.09	6.54

Spring mass system4

Stiffness, $s_1 = \dfrac{Force}{static\ deflection} = \dfrac{6\times 9.81}{19} = 3.09$ N/mm

Stiffness, $s_2 = = \dfrac{6\times 9.81}{9} = 6.54$ N/mm

Experimental frequency, $f_t = \dfrac{5}{Meantime} = \dfrac{5}{.54}$ =9.37 Hz

Theoretical frequency, $f_n = \sqrt{\dfrac{4s_1s_2}{4(s_1s_2)m}}$

$$= \sqrt{\frac{3.09\times 6.54}{4(3.09+6.54)6}} = 9.37 \text{ Hz}$$

S. No.	Mass (Kg)	Theoretical Frequency (Hz)	Experimental Frequency (Hz)
1	4	21.6	7.92
2	5	12.01	7.57
3	6	9.37	9.37

Comparison of results

Experimental frequency at 6 kg = 9.37 Hz
Theoretical frequency at 6 kg = 9.37 Hz

V. CONCLUSION

The theoretical and experimental analysis of simple harmonic motion of a spring mass systems shows that the principal physical variables that characterize the frequencies are strongly influenced by the applied mass. The experiment is also very instructive for comparing the results of different models for finding the frequencies of the spring mass systems. By analyzing the frequencies for various longitudinal vibratory mass systems of simple harmonic motions, we can easily understand and apply the spring forces at where it requires.

REFERENCES

[1] Jouji Kimura, "Experiments and computation of crankshaft three dimensional vibrations and bending stresses in a vee-type ten cylinder engine," SAE paper 951291, pp. 1724-1732, 1995.
[2] N. Hariu and A. Okada, "A method of predicting and improving NVH and stress in operating crankshaft using nonlinear vibration analysis", SAE paper, 970502, pp. 678-687, 1997.
[3] H. Okamura and A. Shinno, "Simple modeling and analysis for crankshaft three-dimensional vibrations, Part1: Background and application to free vibrations", *Journal of Vibration and Acoustics, ASME Transactions*, vol. 117, pp. 70-79, 1995.
[4] Alexander Singiresu S. Rao, *Mechnical Vibrations*, pp. 295-303.
[5] E. Petkus and S. Clark, "A simple algorithm for torsional vibration analysis," SAE Technical Paper 870996, 1987.
[6] R. S. Khurmi and J. K. Gupta, *Machine Design*, 14th edition.
[7] Chand Publications. PSG college of Technology, "Design Data Book" Kalaikathir Achchagam publication.
[8] S. S. Ratan, *Theory of Machines*, 3rd edition, Tata Mcgraw-Hill, 2000.