

A Solution for Isolating the Source of Vibration Problem

Introduction

Under the continuous action of external periodic force, the vibration of forced vibration generated by the vibration system. There are some examples of application resonance, acoustic resonance of musical instruments, orbital resonances between satellites of some Jupiter planets in the solar system, resonance of basement membrane in animal ears, resonance of electric circuits, etc.

In this project, the forced vibration model is generated by two springs whose coefficient of spring, k , and an external periodic force, $P=P_m\sin(\omega_f t)$. The details are shown in Figure 1. This project will supply a problem-solving idea to obtain the relationship between the transmissibility T_m of the system, defined as the ratio F_m/P_m of the maximum value $F_m=kx_m$ of the fluctuating periodic force transmitted to the foundation to the maximum value P_m , and frequency ratios ω_f/ω_n .

Illustration

Analyze the question and determine constraints

1. In the first question, the transmissibility T_m of the system must be solved by changing the frequency ratios ω_f/ω_n from 0 to 5 when the damping factors c/c_c equal to 0.2, 0.4, 0.6, 0.8, 1.0 respectively. In this case, the relationship of the transmissibility and the frequency ratios, the damping factors.
2. As for the second question, it can get the damping factors qualified directly by the results of the first question. Filter out the appropriate damping factors to make the transmissibility small or equal to 0.5.

Analyze the forces

1. The differential equation of motion of a damped system with a single degree of freedom under the action of harmonic periodic forces can be deduced by analyzing the forced applied externally according to Newton's second law. The details of the force analysis diagram are shown in Figure 2.
2. The transmissibility T_m of the system can be obtained by solving this differential equation. The detailed calculation process is also shown in Figure 2.

Solute the result

1. The transmissibility changed with frequency ratios and the damping factors are shown in Figure 6.
2. The appropriate damping factors to make the transmissibility small or equal to 0.5 are shown in Figure 7. The corresponding value of transmissibility also shows.
3. As shown in the Figure 6, the transmissibility is always smaller than 0.5 when frequency ratio equals to 2.5.

Key Codes

Calculate the values of transmissibility according to the derived formula at first as shown in Figure 3.

Draw the figure of the transmissibility for frequency ratios. (Figure 4)

Calculate the appropriate damping factors to make the transmissibility small or equal to 0.5 and output the results of the values of the damping factors that satisfies the condition. (Figure 5)

Conclusion

By model and solve the problem of a damped system with a single degree of freedom under the action of harmonic periodic forces, the project explores the influence of the frequency ratios and the damping factors on the transmissibility. This model can be used to solve the problem of forced vibration in real life.

Appendix

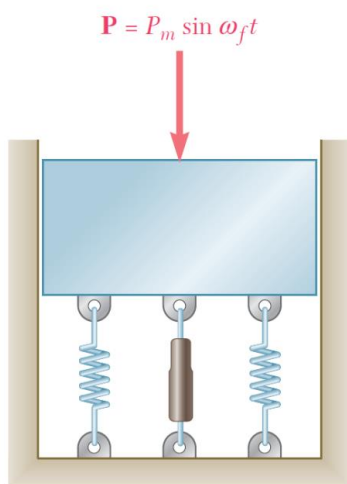


Figure 1 the problem model

Solu :

$$\frac{c \ddot{x}}{k \delta_{st} + \delta} = \frac{1}{m} \ddot{x}$$

$$mg + P_m \sin(\omega_f t) - c \ddot{x} - k \delta_{st} = m \ddot{x}$$

$$mg = k \delta_{st}$$

$$\therefore m \ddot{x} + c \ddot{x} + k \delta = P_m \sin(\omega_f t)$$

$$F_m = k \delta_{st}$$

$$T_m = \frac{F_m}{P_m} = \frac{k \delta_{st}}{P_m} = \frac{1}{\sqrt{[1 - (\omega_f/\omega_n)^2]^2 + [2 \zeta \omega_f/\omega_n]^2}}$$

Figure 2 problem analysis

```

1 % frequency ratios (wf/wn) named as wR
2 % damping factors (c/cc) named as cR
3 % transmissibility (Tm) named as Tm
4
5 wR=0:0.1:5;
6 cR=[0.2, 0.4, 0.6, 0.8, 1.0];
7
8 [wRrows, wRcolumns]=size(wR);
9 [cRrows, cRcolumns]=size(cR);
10 Tm=[0,0,0,0];
11 while cRcolumns>0
12     cRtmp=cR(cRcolumns);
13
14     wRcoltmp=wRcolumns;
15     while wRcoltmp>0
16         wRtmp=wR(wRcoltmp);
17         Tm(cRcolumns, wRcoltmp)=1/(sqrt((1-(wRtmp^2))^2+(2*cRtmp*wRtmp^2)));
18         wRcoltmp=wRcoltmp-1;
19     end
20     cRcolumns=cRcolumns-1;
21 end
22

```

Figure 3 keycodes of calculation of the transmissibility

```

24 % plot the figure
25 % Tm--(wf/wn) for different (c/cc)
26 figure(1);
27 fig1=plot(wR, Tm(1,:), wR, Tm(2,:), wR, Tm(3,:), wR, Tm(4,:), wR, Tm(5,:));
28 hold on
29 legend(fig1(1), fig1(2), fig1(3), fig1(4), fig1(5), 'C/Cc = 0.2', 'C/Cc = 0.4', 'C/Cc = 0.6', 'C/Cc = 0.8', 'C/Cc = 1.0');
30 title('Transmissibility (Tm) for frequency ratios (wf/wn)');
31 xlabel('wf/wn');
32 ylabel('Tm');

```

Figure 4 plot the transmissibility for frequency ratios

```

1 % frequency ratios (wf/wn) named as wR
2 % damping factors (c/cc) named as cR
3 % transmissibility (Tm) named as Tm
4
5 wR=2.5;
6 cR=[0.2, 0.4, 0.6, 0.8, 1.0];
7 [cRrows, cRcolumns]=size(cR);
8 Tm=[0,0];
9
10 fileID1 = fopen('Question2Results.txt', 'w');
11 while cRcolumns>0
12     cRtmp=cR(cRcolumns);
13     Tm(cRcolumns)=1/(sqrt((1-(wR^2))^2+(2*cRtmp*wR^2)));
14     if Tm(cRcolumns)<=0.5
15         disp('Tm = '+Tm(cRcolumns));
16         disp('C/Cc = '+cRtmp);
17         fprintf(fileID1, 'Tm = %f -> C/Cc = %f\n', Tm(cRcolumns), cRtmp);
18     end
19     cRcolumns=cRcolumns-1;
20 end
21 fclose(fileID1);

```

Figure 5 filter out the appropriate damping factors

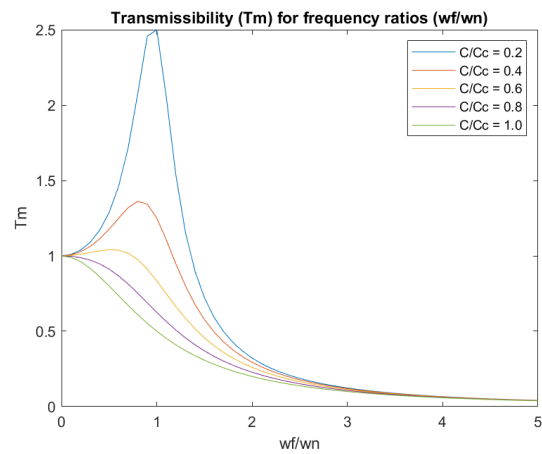


Figure 6 results for question 1

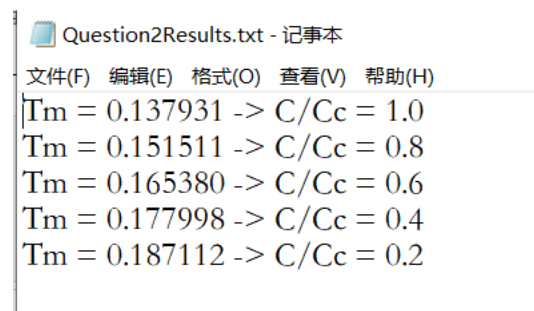


Figure 7 results for question 2