GENERAL MOTION OF AN INCLINED IMPACT DAMPER WITH FRICTION

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ABSTRACT

Here an exact approach to analyze the stable periodic N impacts/period motion of an inclined damper with friction and collisions on either one or both sides of a container with identical and nonidentical coefficients of restitutions is presented. The proposed theory can be easily modified for the cases of a pressurized damper mass and a damper mass oscillating on a spring supported platform. The comparison of theoretical predictions with previous results and with results obtained by numerical simulation of motion on a digital computer indicates a good agreement. Few results are presented.

1. INTRODUCTION

An impact damper is a light weight auxiliary device, which consists of a container with a loose mass. The superior effectiveness of this device as a damper has been demonstrated. Device is most effective in damping vibrations in the resonant range when damper mass moves freely in the horizontal direction and has vibroimpact motion with alternating two equispaced impacts/cycle of an external sinusoidal load. This particular motion has been studied extensively for last few decades [1,2]. However, in many practical applications damper may operate in the nonhorizontal direction and with friction and hence it is important to know its damping properties under realistic operating conditions. Few investigations which account for the effect of friction or gravity on impact damper are reported [3-6]. However, an exact analysis of the general motions of an impact damper with friction or gravity is not available. Hence such an approach was developed.

2. THEORY

The model of an impact damper shown in Figure 1 consists of a primary mass, M, a linear spring, K, and a viscous dashpot with damping constant, C. An impact damper consists of a loose mass, m, moving in a container atached to the main mass with gap, d. The system was assumed to oscillate along a plane making an angle θ with the horizontal plane.

Governing nonlinear equations of assumed motion were developed by combining approaches used in references [2] and [6]. After lengthy algebraic manipulations and using various relations between impact velocities before and after impact and average velocity between impacts etc., the 2N nonlinear equations in 2N unknowns were obtained. These equations are generally solved iteratively for all values of N. Equations can be further simplified for a practically important case of two impacts/cycle motion. Stability of motion was studied by extending approaches presented in references [1] and [2].

When gap becomes so large that impacts occur only on side 1, then the resulting model represents the vibratory conveyor system widely used in industry; cast shake out grids and vibroimpact test rigs to name a few [7]. Impact damper with compressed air can also be studied using these equations [8].

3. RESULTS

The theoretical predictions were checked with the previous results and the agreement is good. The correctness of the newly developed elements of the stability matrix were checked by additionally comparing the theoretical and numerical simulation results.

The effect of gravity on amplitude reduction and time duration between three consecutive impact of an two unequispaced impacts/cycle motion is shown in Figure 2. Figure indicates that gravity has detrimental effect as Xmax/A increases with the angle θ. The effect is more pronounced on the time duration between impacts near the resonance.

The effect of gravity on the stability regions is shown in

Figure 3. It indicates that system just below resonance is unstable. However, above and below resonance system has reasonably sized stability regions.

The effect of nonidentical coefficients of restitution on the amplitude reduction, shown in Figure 4 indicates that the identical coefficients of restitution case is the most efficient from the point of view of amplitude reduction and a small difference in the coefficients of restitution has little effect on the amplitude reduction.

4. CONCLUSION

An exact approach to study general periodic motion of an inclined damper with friction and nonidentical coefficients of restitution is developed. The theoretical predictions are compared with the results obtained using a simulation approach and indicates a good agreement.

6. REFERENCES

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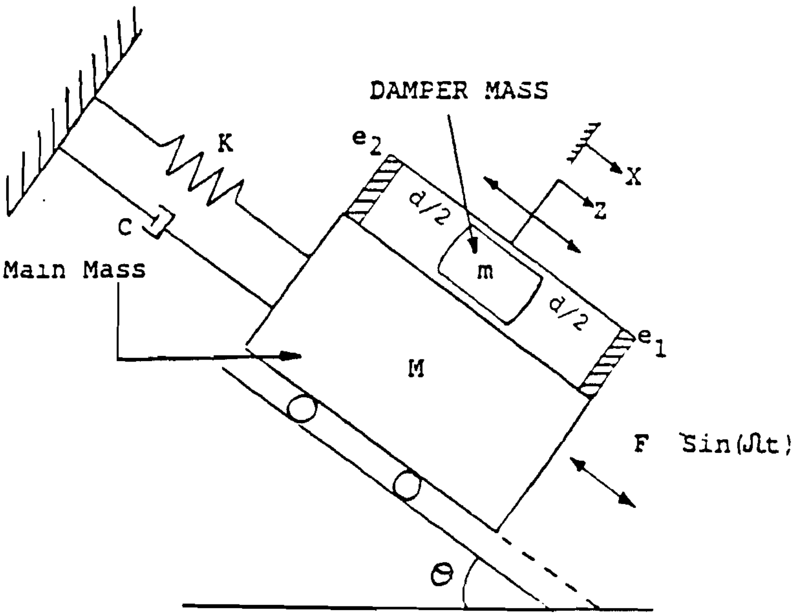

FIGURE 1. MODEL OF AN INCLINED IMPACT DAMPER.

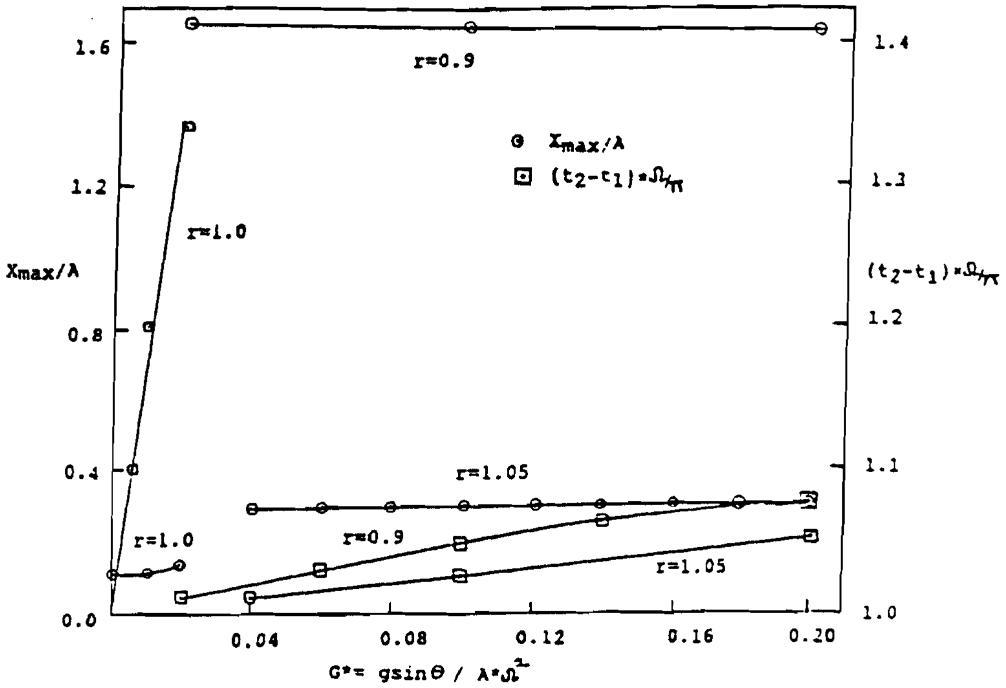

FIGURE 2. EFFECT OF GRAVITY ON AMPLITUDE REDUCTION AND TIME DURATION BETWEEN IMPACTS.
ξ_1 =0.005, m/M =0.042, dk/F = 37, $e_1=e_2=0.75$.

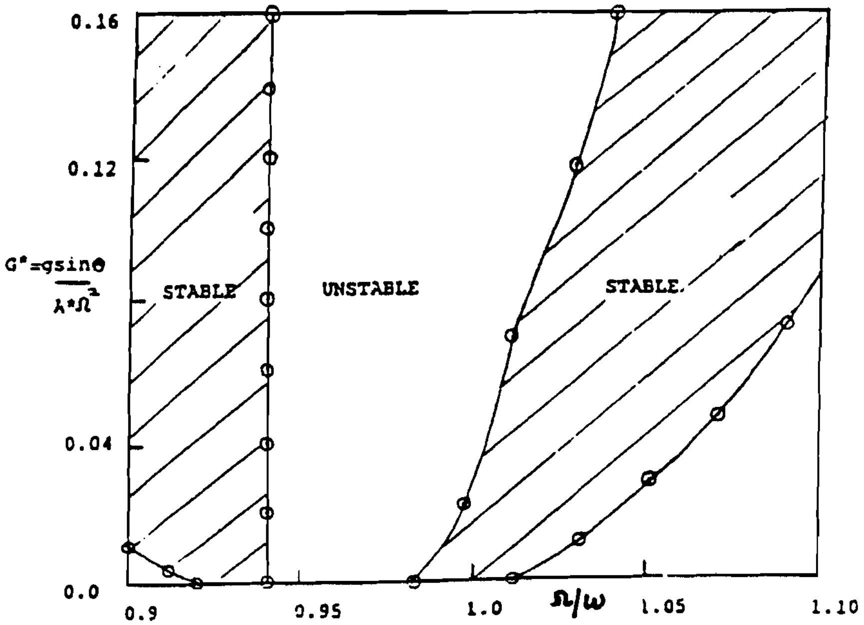

FIGURE 3. STABILITY ZONES OF TWO IMPACTS/CYCLE MOTION OF AN IMPACT DAMPER. ζ_1 =0.005, m/M =0.042, dk/F =37, $e_1=e_2=0.75$.

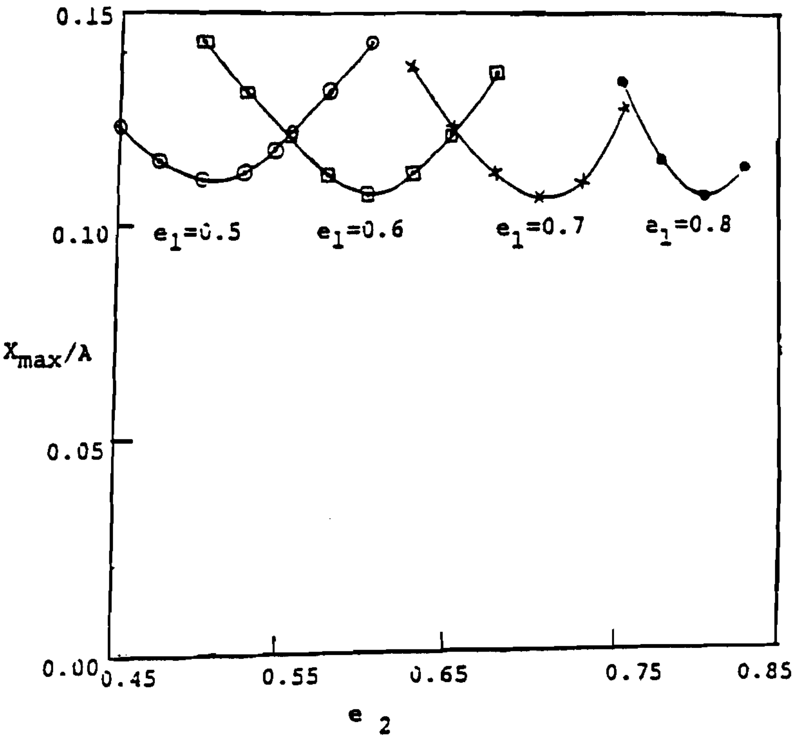

FIGURE 4. EFFECT OF NONIDENTICAL COEFFICIENTS OF RESTITUTION ON AMPLITUDE REDUCTION. r=1.0, ζ_1 =0.005, g=0.0,dk/F=37, m/M=0.042.