A REVIEW PAPER ON DESIGN AND ANALYSIS OF SYSTEM OF THREE WHEELER

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ABSTRACT

The study of vibration in vehicles was almost exclusively based on test results until a few years ago. Then came the practice of using rigid body model with two parameters namely viz., the sprung mass and unsprung mass. Recently, the vehicle models based on finite element method have become a practical alternative to rigid body models. This approach enables the analyst to generate a model based on structural blue print dimensions and continuously varying displacements impose at the tyre contact points of the vehicle traversing on a road may be considered to be an input excitation of a dynamic system of masses, stiffness and dampers. A wobble instability is one of the major problems of a three wheeled vehicle commonly used in India, and these instabilities are of great interest to industry and academia. In this paper, we have studied this instability using a multi-body dynamic (MBD) model and with experiments conducted on a prototype three wheeled vehicle (TWV) on a test track. The MBD model of a three wheeled vehicle is developed using the commercial software ADAMS-CAR. In an initial model, all components including main structures like frame, steering column and rear forks are assumed to be rigid bodies. A linear eigenvalue analysis, carried out at different speeds, reveals a mode that has a predominantly steering oscillation, also called a Wobble mode, with frequency around 5 to 6 Hz.

Keywords: three wheeled vehicle (TWV), multi-body dynamic, Wobble mode, ADAMS-CAR.

1. INTRODUCTION

When you submit your paper print it in one-column format, including figures and tables. In addition, designate one author as the power driven three-wheeled road vehicles, typically used in India on a large scale, are important part of transportation system in major cities and also becoming increasingly popular in smaller towns. This vehicle, commonly known as an Auto-rickshaw is shown in 1.1. The next two decades are likely to witness a sharp rise in the use of three-wheeler. The main compelling reasons for this are scarcity of energy resources and space. Three wheelers also have the advantage of being a compromise between two wheeled and four wheeled vehicles in various aspects like cost, load carrying capacity, fuel consumption, space occupied, weight etc. Any efforts in solving the above problems will directly and/or vehicle dynamics is of great significance and increasing importance. The three-wheeled vehicles operating in India have their front steering with one wheel similar to those of motor cycles and motor scooters, the two rear wheels are the driving wheels with a differential and a suspension, which are similar to those of automobiles. The three wheeled vehicle is a very common public transport vehicle in India, with a maximum speed of about 14 m/s. similar vehicles are used throughout the world, especially in Asian countries, for public transport as well as to carry freight. The total weight of the vehicle is around 650 kg including the driver and three passengers. It has one front wheel with linkage (trailing or leading) suspension attached to the steering column and two rear wheels attached to corresponding swinging arms that are pivoted to the frame.

2. LITERATURE

The study of wobble instability problem of a three wheeled vehicle. The main focus is to model the vehicle close to reality to predict the frequency and damping of the wobble mode more accurately. The implication of this study is that the flexibility of the main structures shall be included in the dynamic model of a three wheeled vehicle; such considerations will predict the stability issues more precisely in design stage. To predict the wobble instability and study it in detail, we have used finite element based flexible model. Although flexible models based on finite element meshes is common in multi body simulation, its use in study of stability for two and three-wheeled vehicles has not been published more often.

The development of a dynamic model of a three wheeled vehicle (TWV), using ADAMS-CAR. A schematic of the model is shown in Figure 1. The rigid model has 25 degree of freedom. These are: 6 degree of freedom for the frame plus rigidly attached rider, 6 degree of freedom for the powertrain, 3 rotations of each trailing arm (total 6), 1 rotation of each rear suspension (total 2), 1 rotation at the steering pivot, 1 front trailing link rotation and 3 wheel rotations.

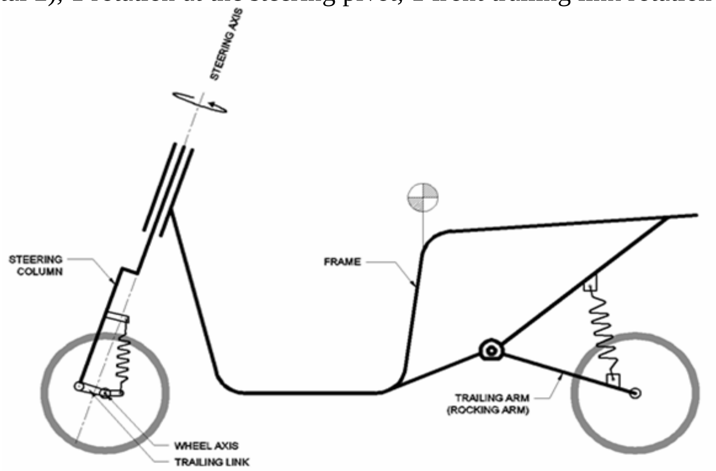

Figure 1: A schematic of a three wheeled vehicle. [1]

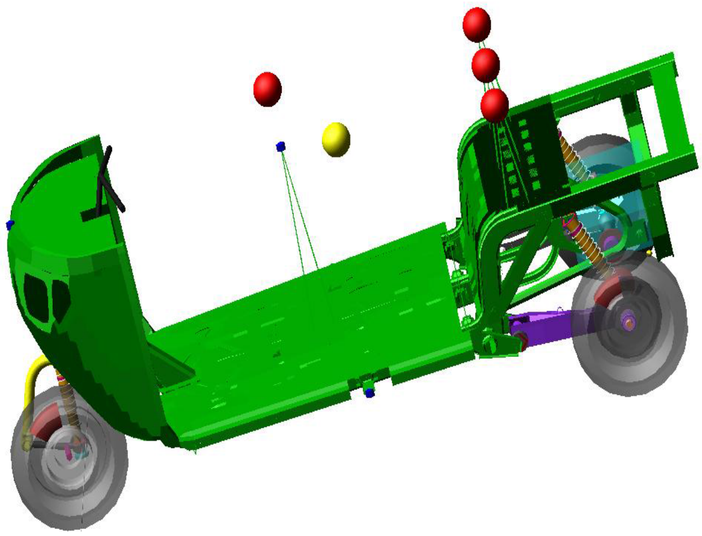

Figure 2: Multi-body dynamic model of a three wheeler. In this figure D, P1, P2, P3 and O represent the CG location of the driver, three passengers and the chassis.

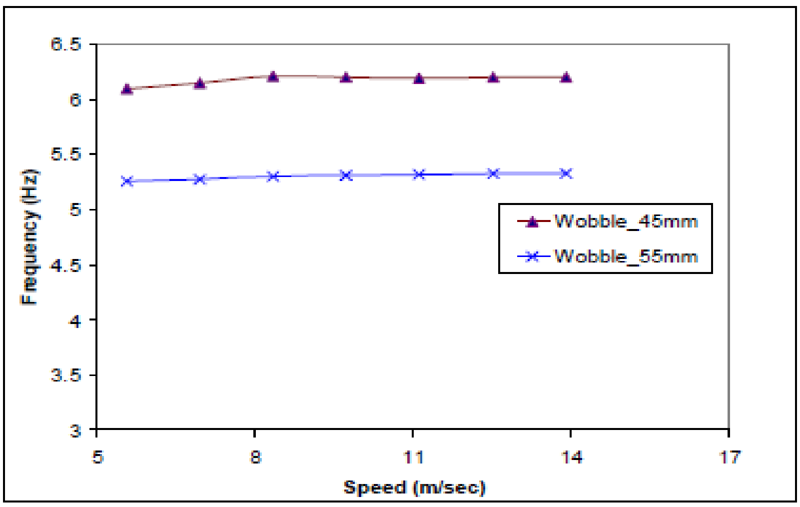

Figure 3: Variation of Wobble mode frequency (for 45 mm and 55 mm steering offset) with speed.

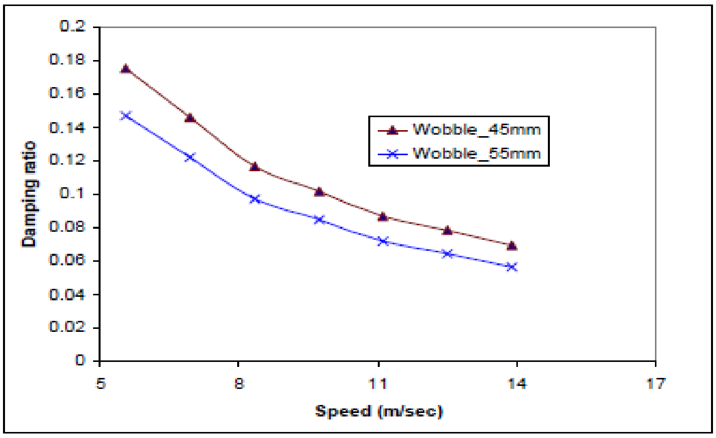

Figure 4: Variation of Wobble mode damping ratio (for 45 mm and 55 mm steering offset) with speed.

The simulation results show that there are 50 eigenvalues including 6 rigid body modes. Each mode shape was examined visually and only the steering oscillation mode is selected for presentation here. This mode predominantly involves steering oscillation, small body movements, and has low damping. The mode seems similar to the Wobble mode of a two-wheeler and hence we have called it a Wobble mode. Figure 2 shows the imaginary parts of these Wobble mode eigenvalues each divided by 2π to give frequencies in Hz. The variation of frequency with the vehicle speed is plotted for Wobble mode. The results show that the frequency of oscillation is nearly constant, around 5.5 Hz for 55 mm steering offset and around 6.1 Hz for 45 mm steering offset. Similarly, Figure 3 shows the variation of damping ratio with vehicle speed. The results show that the damping of the mode is positive at all speeds below 13.89 m/sec (50 Kmph) and the damping decreases as the speed increases. Overall, the results show that the mode is stable.
The model analysis different mode shapes like bounce; roll, front hop, and yaw were found and observed the obtained displacement using the model analysis. In the harmonic analysis the change in displacement with frequency over the entire range (0 – 80 Hz) was obtained. For transient analysis a semicircular bump was taken as excitation force and noticed the variations in displacement.

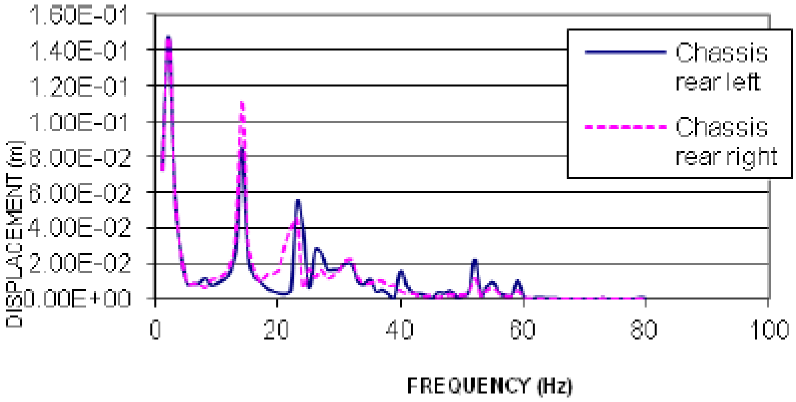

Figure 5: Variation in displacement at the left and right end of the rear chassis

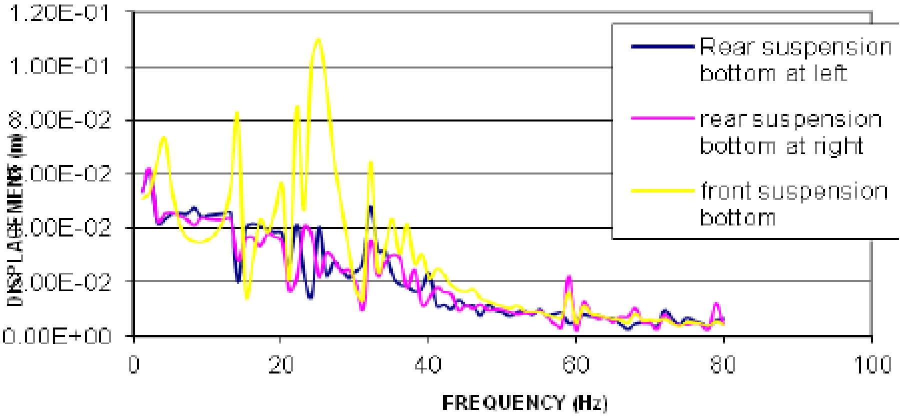

Figure 6: Variation in the displacement values at the suspension bottoms

the displacements of various nodes and stresses for different elements over the entire frequency range 0 – 80Hz with amplitude of 0.05m were obtained. The displacements at various nodes were plotted against frequency and are shown in figures 5 and 6.

3. CONCLUSION

A detailed simulation of a three wheeled vehicle using a multi body dynamic model is very useful in industry, especially in the design stage. One important aspect of this vehicle is instabilities of steering oscillations especially at lower speeds. Also the steering column flexibility may be one of the main reasons for these instabilities.
The maximum displacement 0.1474m was observed in rear right chassis in harmonic analysis. Also in the SVM method maximum displacement is observed in rear right chassis. The displacement is 0.153m, when compared with finite element model the error is 3.6%
The dynamic model, results and findings of this study can be used not only in future industrial design oriented studies, but also will lead to improved understanding of three wheeler dynamics as well, especially the wobble instability. Future work will include experimental study of wobble with steering column flexibility and study of modal interactions of various modes that may lead to instabilities at particular vehicle speeds.

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