EVALUATION OF VIBRATION TRANSMISSION IN CYCLING

Marcela Munera[1], Samuel Crequy[1,2], Xavier Chiementin*[1], William Bertucci[1]

[1]GRESPI, Groupe de Recherche en Sciences Pour l'Ingénieur,

[2]LISM, Laboratoire d'Ingénierie et Sciences des Matériaux

Université de Reims Champagne-Ardenne, Reims Cedex, France

Introduction

The vibration is a movement found in the daily activities, during work and sports [Griffin, 1990]. In the literature, there are different studies of pathologies and the effects of the vibrations [Chiementin, 2011]. In this project we are interested in the physical risk associated with vibration when cycling, and we present the protocol to measure the transmission of vibrations in the bicycle, from the wheels to the steam. This transmission is represented with a mechanical equivalent model. This model shows the transmission of vibrations coming from the road to hand-bike interface.

Methods

The protocol to evaluate the transmission of vibrations for each wheel to the steam of the bicycle has three parts: experimental test, numerical modeling and validation. In the experimental test we place each wheel of the bicycle on a vibration plate (Fitvibe, Germany) and we measure the input acceleration at the plate and the output acceleration in the steam of the bike. With these results we have a transmissibility curve for each wheel. In the second part we do a mechanical equivalent modeling of the system. Each model is composed of seven basic mass-resort-damper systems in parallel. The third part is a validation of the model with the values of acceleration obtained by Chiementin [1] in a previous study on cobblestone in Reims (France). In this validation we do a mathematical representation of the input acceleration and by using the transmissibility we obtain the root mean square value ahv of the output acceleration for each wheel. The total output acceleration (ahv_{num}) is a linear combination of the ahv for each wheel, the coefficients used represent the influence of the two inputs and the energy absorption of the bike in this case. Finally, we compare the output acceleration obtained experimentally (ahv_{exp}) with the one of the model.

Results

The transmissibility curves obtained in the experimental test show several resonance frequencies in the studied range, these resonance frequencies represent different speeds in real condition of movement in which the acceleration is increased by the bicycle (Figure 1). The parameters for the numerical transmissibility function were found with an optimization script in Matlab (version 7.4) based on the simplex method. This script provides fitting curves with a determination coefficient R^2 superior to 0.96.

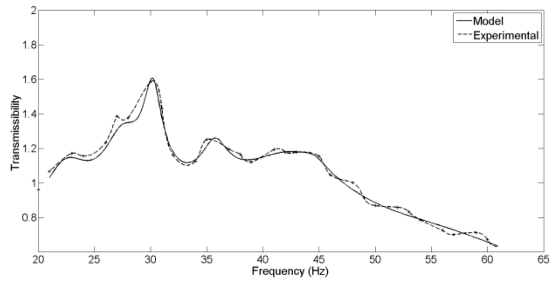

Figure 1 Experimental and numerical transmissibility for the front wheel

In the validation we compare the acceleration obtained experimentally and numerically for three different frequencies (Table 1).

Frequency (Hz)	ahv_{exp} (m/s^2)	ahv_{model} (m/s^2)	Relative Error
35	48,8	39,4	11%
45	49,4	61,8	11%
53	60,4	60,4	0,1%

Table 1 Experimental and numerical acceleration in the steam.

Discussion

The protocol shown in this paper presents the vibration response of a bicycle at different frequencies in the steam to predict the behavior of the system at different road profiles. With this response it is possible to predict the impact of these vibrations on the human body and the incidence of diseases. Additionally, we can observe the resonance phenomenon that increases the possibility of diseases due to vibrations in the rider. These vibrations in the hand-arm system can be the origin of musculoskeletal syndromes like the Raynaud syndrome and the carpal tunnel syndrome.

Acknowledgement

These investigations are financially supported by the Champagne-Ardenne region and by The European Found of Regional Development. The authors wish to thank Cycleurope of Romilly sur Seine (France) for their contribution, providing the bike for this study.

References

Chiementin, X., Rigaut, M., Crequy, S., & Bertucci, W. (2011). Hand-arm vibration in cycling. Journal Vibration and Control. doi: 10.1177/ 1077546312461024

M. J., Griffin. Handbook of human vibration. Academic press, 1990