Model capable of representing the strain influence on the dynamic properties of viscoelastic structures for the automotive sector

Prof. Dr.-Ing. Rainer Haas, Prof. María Jesús Elejabarrieta, Prof. Dr. Jon García Barruetabeña

Faculty of Automotive Systems and Production

INTRODUCTION

Increasing customer demands and the changing trends in the automotive industry have left all car manufacturers confused and unable to make a decision about the future of fuel-powered or battery-powered vehicles. At the same time, the rising fuel prices and the upcoming stringent emission norms set by the European Commission are major issues of concern contributing to this state of confusion. Thus, the most pragmatic solution for these problems is improving the fuel and the vehicle efficiency by reducing the overall weight of the vehicle [1]. Apart from the engine or batteries, the body is the second factor contributing to the vehicle’s maximum weight. This weight reduction can be achieved by the complete or combined use of lightweight materials such as composites, aluminium, zinc and other high strength steel instead of traditional steel. However, due to insufficient knowledge about the behaviour of these alternative materials their future remains unpredicted. Therefore, further study is required in this field [2].

METAL-POLYMER-METAL COMPOSITES AND AUTOMOTIVE APPLICATION

Traditionally, high strength steel is widely preferred for the manufacturing of the body largely due to strength, formability and the cost involved. Hence, full replacement of steel with any other material may result in compromising the feasibility of the structure at an increased cost [1]. Metal-Polymer-Metal (MPM) on the other hand seems to be a promising alternative. These sandwich structures composed of a thin adhesive layer (in microns) between the two outer constraining layers (could be either steel or aluminium) altogether show good mechanical properties such as improved fatigue strength, stiffness, and formability. The thin polymer layer gives an added advantage in damping and also helps with vibration control.

In the previous studies, the effect of viscoelastic film thickness on the vibrational response, loss factor and storage modulus has been observed and validated. Additionally, the mechanical behavior of MPM’s is largely influenced by frequency, temperature, and is strain-induced because of different production operations involved in the manufacturing stages [3]. However, the effect of the former two is known from various numerical models whereas there has not much work been done and no numerically validated model has yet been developed specifying the strain influence on the manufactured component and its mechanical properties.

Figure 1: Composite frontal panel of a vehicle

The current research project aims at getting a closer look at the influence of the viscoelastic film strain state on the dynamic properties, stiffness, and damping of thin sandwich structures using experiments and numerical validation. The experimental stage of the project involves Metal-Polymer-Metal sample preparation, a viscoelastic material characterization of the test samples through DMA and forced frequency response to obtain the results for natural frequencies, mode shapes and damping within the frequency range of 10 Hz – 1 kHz. The obtained results will further be used as the basis for numerical model development, experimental-numerical model co-relation, and model validation using a real automotive viscoelastic component. The successful validation of the model might result in a solution to the current situation of composites and lead to the start of new generation materials.

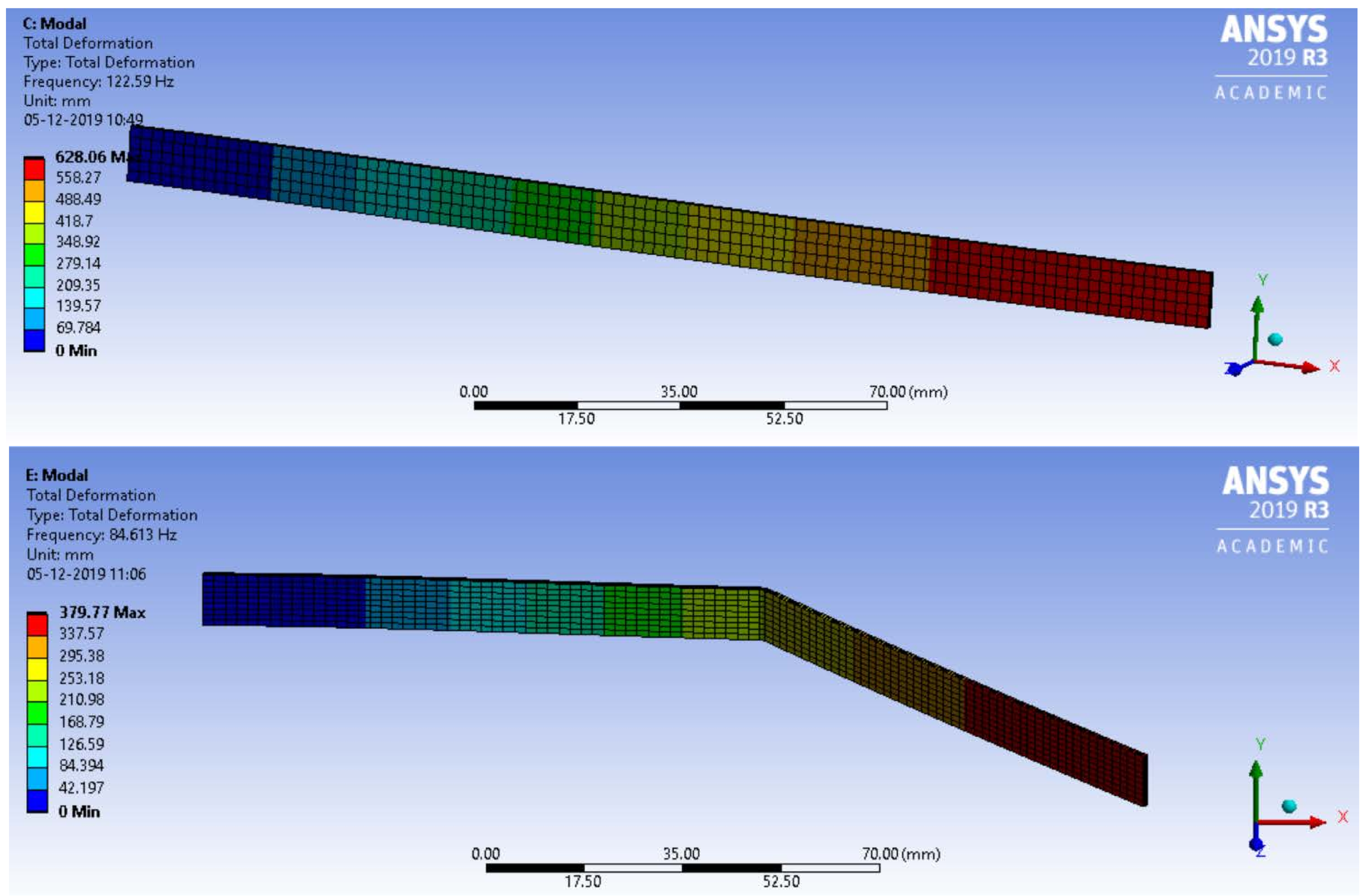

Figure 2: Modal analysis of MPM composite beam using ANSYS

REFERENCES

[1] Park, C. K., Kan, C. D. S., Hollowell, W. T., and Hill, S. I., “Investigation of Opportunities for Lightweight Vehicles using Advanced Plastics and Composites,” National Highway Traffic Safety Administration, Document ID: DOT HS 811 692, 2012.

[2] Palkowski H, Carradò A. Metal-Polymer-Metal Laminates for Lightweight Application. Key Engineering Materials 2016;684:323–34.

[3] Carradò, A., Faerber, J., Niemeyer, S., Ziegmann, G., & Palkowski, H. (2011). Metal/polymer/metal hybrid systems: Towards potential formability applications. Composite Structures, 93(2), 715–721.

Universidad de Deusto
University of Deusto
Deusto

Contact: rainer.haas@th-koeln.de