Extending Modal Frequency Impact Range

Alex Margetson, **Benjamin Halkon** and Zimu Guo
School of Mechanical and Mechatronic Engineering, Faculty of Engineering and IT, University of Technology Sydney, Ultimo, NSW 2007, Australia

Abstract. Vibration testing is conducted with an impact hammer, used for modal analysis to determine the internal characteristics of an object or structure, assessing how it responds to loads through high accuracy equipment. As the modal impact hammer tip stiffness dictates the impact duration and in turn the resulting frequency spectrum, this project will investigate the extension of the excitation frequency range of a soft impact hammer tip through slight adjustments to known stiffnesses, 3D printed via chemical additions to a photopolymer, Agilus. After assessing and confirming the tip design and integrity, each successive stiffness was tested and analysed on a specimen at a high frequency resolution to gain insight into key modal parameters. Vibration analysis techniques provided key frequency spectra trends, allowing for the potential merging of similar modal campaigns to eliminate the need to swap the impact hammer tip while maintaining frequency resolution.

Introduction

Vibration testing is conducted within experimental modal analysis to determine the natural frequencies of an object or structure, assessing how resistant they are to applied forces. There are various methods used to excite a test specimen, where an impact hammer is commonly used. Ultimately, the stiffness or hardness of the impact hammer tip determines the duration of impact and therefore the corresponding excitation frequency range where the energy is centralised [1]. Impact hammer tips with differing material properties will allow for the excitation over a number of frequencies to be calculated, where the excited frequency spectrum increases as the tip hardness increases [2]. Furthermore, the resulting frequency spectrum will also increase as the tip mass decreases, due to a reduction in the time that the measuring device is in contact with the specimen. From the research and quantitative analysis conducted, the extension of the modal frequency impact range provided an accurate representation to increase the available centralised energy for excitation. Ultimately, data were observed and analysed from corresponding frequency spectra after excitation from the soft tip range featuring successive, increasing stiffnesses as shown in Fig. 1.

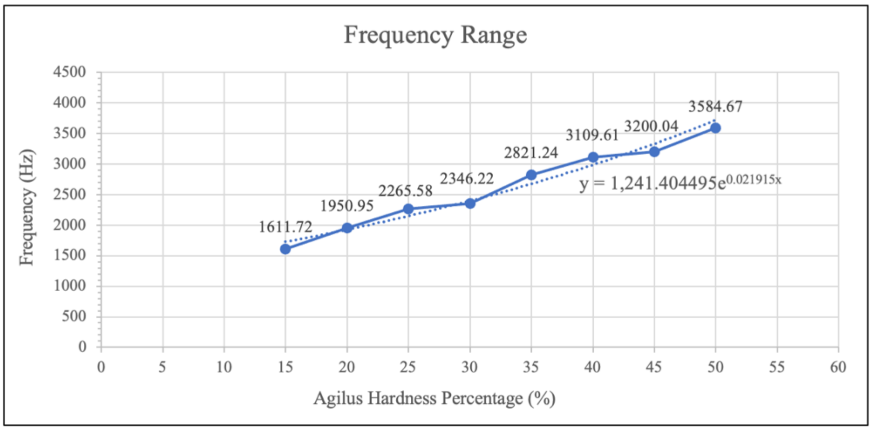

Figure 1: Usable modal impact frequency range vs. tip material hardness.

The tip design and implementation using Agilus, the rubber-like photopolymer with outstanding capabilities, provided quality modal impact data that adhered to a typical vibration investigation accuracy. As a result, the designed tips with modifiable hardness depicted a reliable trend in terms of the impact frequency spectra and time trace data, whereby the stiffness increases with frequency range and impact duration. Thus, the excitation range of a modal impact hammer soft tip provides an accurate resolution to vibration parameters, where the resulting power spectrum can be tuned relative to the tip stiffness determining impact duration. This could effectively allow for the merging of existing modal campaigns from impacts with different tips, where one tip providing accurate data reinforces another tip where a resonance is missed due to a "hole" in the force input power spectrum. Therefore, this extension of the modal frequency impact range can eliminate the need to swap hammer tips in future as the tuned Agilus tip represents an excitation range that can be analysed with respect to the time series relationship.

References

[1] Brüel & Kjær 1988, Structural testing: Mechanical mobility measurements.
[2] Avitable, P. 2018, Modal testing: A practitioner's guide, 1st edn, The Society for Experimental Mechanics and John Wiley & Sons Ltd, University of Massachusetts, USA