Felipe Igea – Rokos Report

This summer during eight weeks of July and August I had the opportunity to do further research on the subject of my fourth-year project (estimation of elastic constants for orthotropic plates using a Chladni setup). The internship took place in the Engineering Science Department, in the Dynamics, Vibration and Uncertainty Lab, under the supervision of Dr. Alice Cicirello. During the internship I performed further testing, and I introduced technical developments and improvements on the setup built during my fourth-year project.

An inverse procedure based on the Chladni patterns was investigated to assess the manufacturing variability of flat thin orthotropic rectangular panels. Ernest Chladni (1756-1827), a German scientist, designed a technique to show the different vibrating modes of plates. Fine powder was spread on horizontal plates that were excited into vibration scraping a violin bow along their edges. The powder moved from the plate’s vibrating areas to the nodal lines where no movement occurs. A plate sprinkled with powder which is excited at different frequencies shows different symmetric nodal lines called Chladni patterns. The figure below shows three different Chladni patterns on some of the investigated plates (FR4, plywood and aluminium).

The equations needed for estimating the elastic constants based on the knowledge of five natural frequencies of a flat thin orthotropic plate were derived. For one of the cases the mathematical derivation required the writing of a MATLAB code. Results combining the Chladni setup with Experimental Modal analysis were assessed. The picture below on the left shows the experimental setup and the instrumented hammer used for the experimental modal analysis. The picture below on the right shows the frequency response functions (FRFs) for the X and ring modes.

The part to part variability of three batches of panels (one of each material) was assessed. The study requires to calculate the elastic constants of each plate and calculate the means and standard deviations of each elastic constant for each batch of plates.
The repeatability and reproducibility of the results obtained with a procedure based on the Chladni setup were calculated. These results were compared to the part-to-part variability by using lean six-sigma approaches.

Results for three sets of nominal identical thin orthotropic plates (plywood, aluminium and FR4) were investigated showing that the measurement system of which is part the Chladni setup, can be assessed as adequate to measure all four elastic constants for the three studied materials.

In order to automatize and improve the procedure explained above, a new setup was built. An interface to combine image recognition with the code written for determining the elastic constants from the shapes of the nodal lines was developed.

A new Chladni setup was built. The new setup included a ported loudspeaker box designed according to the Thiele-Small principles, and a camera was fitted to collect the images of the nodal lines, so the modal shapes could be identified.

It has been planned to write the results found during the internship in the form of two journal papers. The first draft has been finalised, and the draft of the second is currently under development.