Electric guitar neck from densified poplar? Experimental and numerical analysis

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Electric guitar necks (EGNs) are usually made of hardwoods (i.e., maple, ash, etc.), including protected exotic species coming from overseas (mahogany, etc.), due to their aesthetics, high stiffness and density. Additionally, EGNs typically include a truss rod – a metal bar stiffening the neck against bending caused by string tension. In order to reduce the environmental impact of guitar production, we believe that EGNs can be made from local and fast grown plantation wood modified using a thermo-hydro-mechanical (THM) process. This approach for EGN production may be (i) more convenient due to higher mechanical properties of densified wood while preserving similar vibrational performance; (ii) more economical due to using local and cheap resources and absence of a truss rod; (iii) more environmentally friendly due to reduced logistics and energy costs. To analyze the hypothesis resulting from (i), we performed both experimental tests and numerical analyses. Experiments consist of poplar wood densification (dens. ratio 1.5) to obtain the elastic orthotropic material model of densified poplar suitable for finite element analyses (FEA). We aim to perform compression tests accompanied with digital image correlation, which will provide a set of elastic material coefficients – 3x normal elastic moduli (EL, ER, ET) and 3x Poisson's ratios (μLR, μRT, μLT); shear elastic moduli (GLR, GRT, GLT) were calculated theoretically. Developed material models were employed in FEA of (i) guitar neck deflection induced by string tension and (ii) modal analysis of a neck including sensitivity study for the role of density and elastic moduli on eigenfrequencies. FEA will use the following material scenarios: poplar, densified poplar, and maple. Preliminary results of the FEA with maple properties are shown in Figure 1. Figure 1a shows how deflection and PS1 changes with change of EL – deflection decreased 40 % and PS1 increased ~ 11 % as EL increased from 12.4 GPa to 22 GPa. Figure 1b shows the eigenfrequencies decrease with density but increase as EL increases (1st freq 17.4 %, 2nd freq. 21.4 % and 3rd about 27 %).

Keywords: densified poplar, orthotropic material model, finite element analysis, electric guitar, acoustics

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