

Acoustical comparison of two different guitars, made of untreated tropical wood and thermally modified wood, using a frequency response analysis

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Introduction

Part of this study is an acoustical comparison of two different guitars, one traditionally made of tropical wood and another made of thermally modified wood. The used frequency response analysis which was developed at the IfM (*institute for musical-instrument making*) enables a substantial proposition of the acoustical performance of string instruments according to their natural frequencies. The aim of the study is to acquire more experience concerning the performance of a guitar made of thermally modified wood compared to a guitar made of tropical wood.

Methods

During the measurement the guitar was held in playing posture and the strings were damped at the fifth fret. The bridge gets excited by means of an impact hammer (B&K Type 8204) and the emitted acoustical signal is recorded by a measuring microphone (PCB Model 377B02) one meter distant and vertical to the sound hole. The data was recorded by a front-end (m+p VibPilot). For determining the averaged frequency response functions (FRFs) of three single impacts the processing of the data was enabled by the analysis software SO Analyzer 4.4 (m+p). For verification of the measurements the coherence and the power spectra of the impact hammer was used. The frequency range was set from 0 to 5000 Hz with a linear resolution of 3,125 Hz by 1600 grid points.

The FRFs contain different acoustical information about bass, volume, loudness, clearness, brightness and sharpness of the instruments. To identify these information the FRFs are divided into various parts and the sound pressure level mean values are calculated by the energetic determination of the mean level. Further the frequency of the cavity resonance, the dampening of the first top plate resonance and the sound pressure level of the resonance in the range of about 400 Hz were determined.

Tab. 2: Comparison of the calculated sound pressure mean values of the FRFs of both guitars, the cavity resonance and the damping of the first top plate resonance

	Cavity resonance f1 [Hz]	Damping [/] b2	3. Top plate resonance [dB] L3	Bass [dB] L50...200 Hz	Volume [dB] L100...400 Hz	Clearness [dB] L0,8...1,2k Hz	Brightness [dB] L2,0...4,0k Hz	Sharpness [dB] L2,0...5,0k Hz	Loudness [dB] L50...5k Hz
Thermally modified wood:	97	0,08	-3,6	-4,2	-6,1	-12,0	-18,7	-16,8	-9,4
Tropical wood:	100	0,13	-3,0	-5,0	-6,1	-10,2	-17,6	-16,8	-9,6

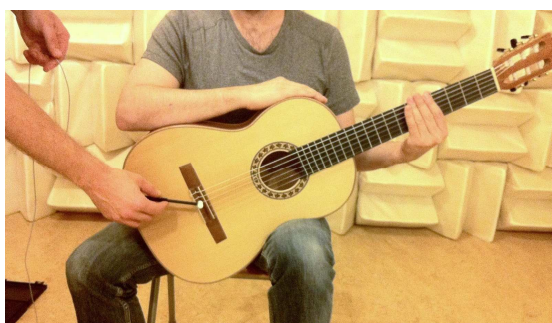


Fig.2: Guitar in playing posture during the measurement

Results

Result of the research obtained to the calculated sound pressure level mean values for the different ranges of the FRFs is an acoustical similarity of both instruments due to the comparable construction and independence of the different types of wood. Slight differences are especially visible in the bass and volume ranges, where the guitar made of modified wood shows a higher average level. The clearness shows more obvious differences whereat the guitar made of untreated tropical wood offers a higher average level. The main difference of the two FRFs can be seen in the shape of the first top plate and first bottom plate resonance at about 200 Hz. The guitar made of thermally modified wood has a higher value for the top plate resonance and the guitar made of tropical wood has a higher value for the bottom plate resonance. The differences can have their cause in the material but more likely in the kind of the battens or the way how the bottom plate was prepared.

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Dill Klassik Thermo

Dill Klassik Rio



Fig.1: The two analysed guitar models, on the left side thermally modified wood and on the right side tropical wood guitar

Tab. 1: Guitar parts and the used material of the two analysed guitars

	Thermally modified wood	Tropical wood
Top plate:	Spruce (<i>Picea abies</i> [(L.) KARST.])	Spruce (<i>Picea abies</i> [(L.) KARST.])
Bot. plate:	Pearwood (<i>Pyrus</i> [L.])	Palisander (<i>Dalbergia nigra</i> [(VELL.) ALLEMÃO])
Side:	Pearwood (<i>Pyrus</i> [L.])	Palisander (<i>Dalbergia nigra</i> [(VELL.) ALLEMÃO])
Neck:	Alder (<i>Alnus</i> [MILL.])	Cedro (<i>Cedrela odorata</i> [L.])
Fretboard:	Blackwoodtek	Ebony (<i>Diospyros</i> [L.])
Bridge:	Blackwoodtek	Palisander (<i>Dalbergia nigra</i> [(VELL.) ALLEMÃO])

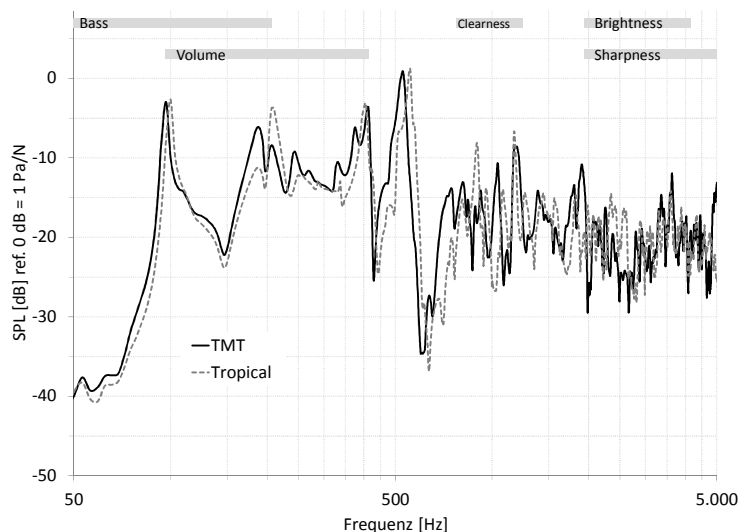


Fig.3: Frequency response functions of both guitars and evaluated ranges for the acoustical characterisation

In summary the method gives an efficient acoustical impression as a function of the natural frequencies of both guitars. Interestingly the acoustical properties of the guitars are similar except for slight differences. Whereupon much more effects like the psycho acoustical feelings or the taste of music of the audience are relevant for a complete acoustical impression of an instrument.