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Influence of spruce, wenge and obeche wood used for electric guitar prototype on selected sound properties

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Abstract: *Influence of spruce, wenge and obeche wood used for electric guitar prototype on selected sound properties*. In work different wood species were subjected to assessment regards to their usage in electric guitars. There were made three prototypes, each from another wood species: spruce *(Picea abies)* , wenge *(Millettia laurentii)* , obeche *(Triplochiton scleroxylon)*. Acoustic signal were registered for each of them. Moreover, there were taken into account acoustic signals for two kinds of strings – E2 and D3. Results were analyzed in order to estimate mean amplitude in four periods of time (2,5 sec. in each) and mean amplitude in four frequency intervals: 0-1kHz, 1-5kHz, 5-10kHz and 10-20kHz. Obtained results showed, that occur statistically significant differences in amplitude, investigated as well in time as in frequency domain. The lowest level of amplitude was observed in case of obeche and the highest in wenge. Besides, wenge distinguished by the most oscillations of amplitude level. In case of analysis in frequency domain are visible lower differences between amplitudes for different wood species than in time domain.

Keywords: acoustic signals analysis, electric guitar, sound, wood

INTRODUCTION

In twenty century, electronic particles were introduced to instruments which in following decades gained in importance in modeling of sound. This technological progress concerns among others guitar. Due to replacement of resonance box by electronic attachment which analyze string vibrations and processes signal was developed electric guitar. The beginning of electric guitar kicked off in 30-th years of XX century when George Beauchamp created first prototypes but fully useful instruments of this kind were produced in 50-th years [Waksman 1999]. Within latest dozens of years electric guitar producers manufactured instruments from different wood species. So far, some firms follow especially strictly appropriate choice of wood kind and proper preparation of material to further machining. Many guitarist find that besides electric elements which indeed convert string vibrations into sound, wood also has significant influence on sound.

Sound is dispersed in wood with different speed regards to its density and modulus of elasticity. These factors affected acoustic resistance. With increase of this one is observed decreasing of vibrations dumping ability. Therefore spruce is commonly used in instruments due to its low level of acoustic resistance (what means increasing of dumping ability) [Wegst 2006]. As result of high values of dumping coefficient considerable part of acoustic wave energy initiates material into self vibrations [Krzysik 1974]. It should be not omitted influence of wood humidity which can cause variations up to 13 dB [Harajda 1973].

Some authors presented opinion that there is lack of differences between signal registered by mean of electric guitars made of different wood species. This phenomena can be explained with the fact that sound from this type of instrument has not acoustic but electric character. In consequence timbre of sound should depends mainly on properties of elements which are responsible for its processing [Soper 2009]. In fact, mechanics of electric guitar

performance consist on excitation of electromotive force in speech coil winded on core as effect of spring vibrations. Height of sound and simultaneously its frequency depends on spring thickness which are marked in following way (from the thinnest to the thickest): E2, A2, D3, G3, B3, E4 [Waring et al. 2001].

In below showed experiments influence of chosen wood species used for guitar prototypes on sound parameters.

MATERIAL AND METHODS

In work were used following wood species: spruce *(Picea abies)*, wenge *(Millettia laurentii)* and obeche *(Triplochiton scleroxylon)*. All this kinds of wood distinguish by significant difference of density between wenge and others. Moreover, obeche and Norway spruce have similar density but there is visible opposite anatomic structure. This factors can lead to different sound parameters created with electric guitar prototype. During experiments their humidity (average values read on capacitive hygrometer) amounted respectively: Norway spruce - 8,7%, wenge - 7,7%, obeche - 8,9%. All samples had dimensions: 770 mm x 120 mm x 13 mm. Based on stereo metric measurement method average density amounted respectively: spruce - 458 kg/m^{-3}, wenge – 857 kg/m^{-3}, obeche - 450 kg/m^{-3}. Length and width of samples was fitted in this way that it was enough space on prototype to assemble all elements of instrument (on radial cross-section): supports, strings, converter, key and exciter of strings. However, thickness was adjusted to desired thickness of fret board. Through this one was passed guitar key.

Signal generated by guitar attachment was leaded with usage of shielded cable Jack-Jack (Proel) to plug-out socket mounted in converter A/C. Professional audio interface E-MU 0202 dedicated to studios applications was used. For all registration was settled the same level of signal enhancement. Signal was gathered on PC equipped with software Adobe Audition CS6 with following settings of sampling: 88,2 kHz and 24-bit. Particular elements of measurement chain were showed in Fig.1. Forty signals for each kind of wood (20 for each string) were subjected to analysis. Received signals were limited to 10 sec. long time periods. Sampling of amplitude took place each 0,0006s. In order to obtain average values of amplitude in time files were divided into four time windows: (time window 1: 0-2,5 s., time window 2: 2,5-5 s., time window 3: 5-7,5 s, time window 4: 7,5-10 s). Analysis in frequency domain was based on partition of signals on four frequency windows: 0-1kHz, 1-5kHz, 5-10kHz, and 10-20kHz. Then, average value for each of them was calculated. It’s worth to remark that first window always contain basic tone.

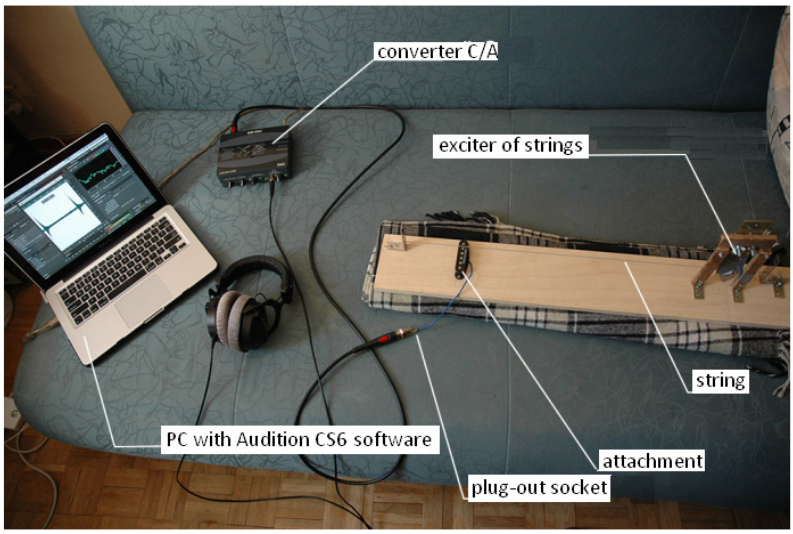

Figure 1. Elements of measurement chain used in experiment

RESEARCH RESULTS

For string E2, adjusted to frequency 82,41 Hz mean values obtained for first window (0-2,5s) don't give higher differences among wood species. The highest signal amplitudes were observed with prototype made of Norway spruce and the lowest in case of wenge (Fig.2). The difference amounted 2,63dB. Situation changes in the course of time because already in second time window (2,5-5s) it visible the most decrease of signal registered for obeche prototype.

Signal from Norway spruce prototype also became weaker but not so strong. The most steady turned out signal came from wenge prototype (Fig.2). Range between the strongest and weakest signal amounted there 5,79dB for obeche and 3,19dB for wenge. In turn guitar made of spruce performed very similar as wenge what proves difference between values of their mean amplitudes which achieved 2,51dB. In the other two time windows it is clear similar tendency. Level of mean amplitude slightly differs against wenge and signal in case of obeche drastically decreases. In the last window difference achieved 12,61dB in compare with signal origins from wenge prototype (Fig.2).

According to type of string, for string D3 range of amplitude mean is lower. The biggest differences 3,45dB and 3,71dB occur between wenge and Norway spruce in time windows 2,5-5s and 5-7,5s (Fig.2).

In analysis in frequency domain for string E2 was noticed that the strongest in each frequency window signals origins from Norway spruce prototype although range of values is not significant (Fig.3). Differences between the strongest signal (spruce) and the weakest (obeche) amounted respectively: 3,08dB, 1,04dB, 4,16dB and 4,68dB for each of examined intervals. The highest difference 4,68dB was noticed in the last window (10 - 20kHz). Similarly as it took place in analysis in time domain – the biggest variety occurred in case of D3 string. It is already visible in first frequency window that range between the strongest signal (spruce) and signal origin from obeche amounted 4,07dB. In the second window wenge prototype showed the weakest signal, too. In compare with Norway spruce this value decrease by 4,71dB. The most difference amounted 6,87dB (Fig.3) is remarkable in third window between Norway spruce and wenge.

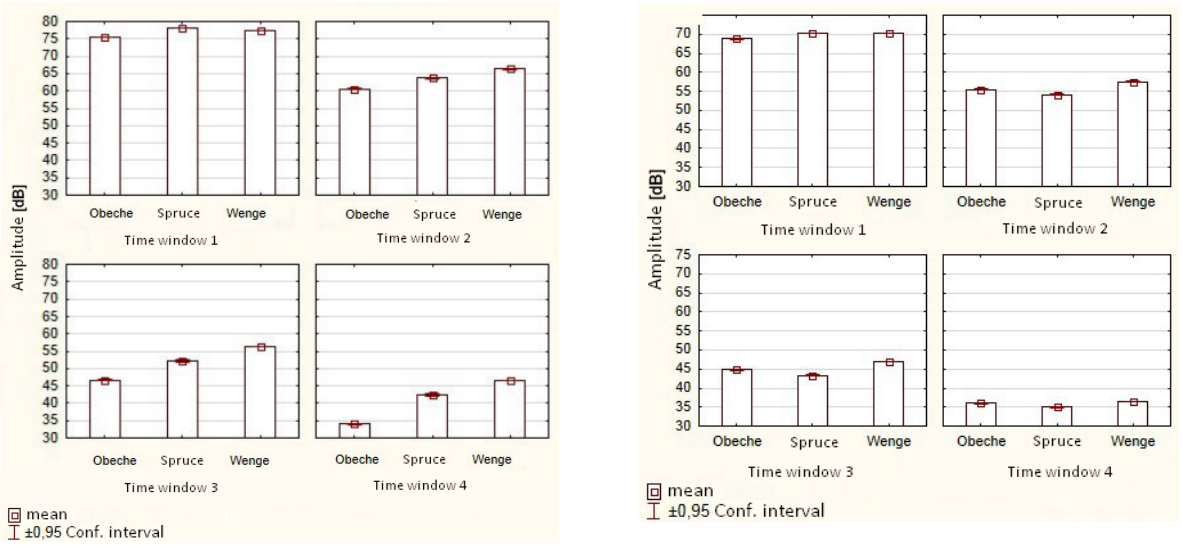

Figure 2. Mean amplitude in four time windows for particular wood species: string E2 (on the left) and string D3(on the right)

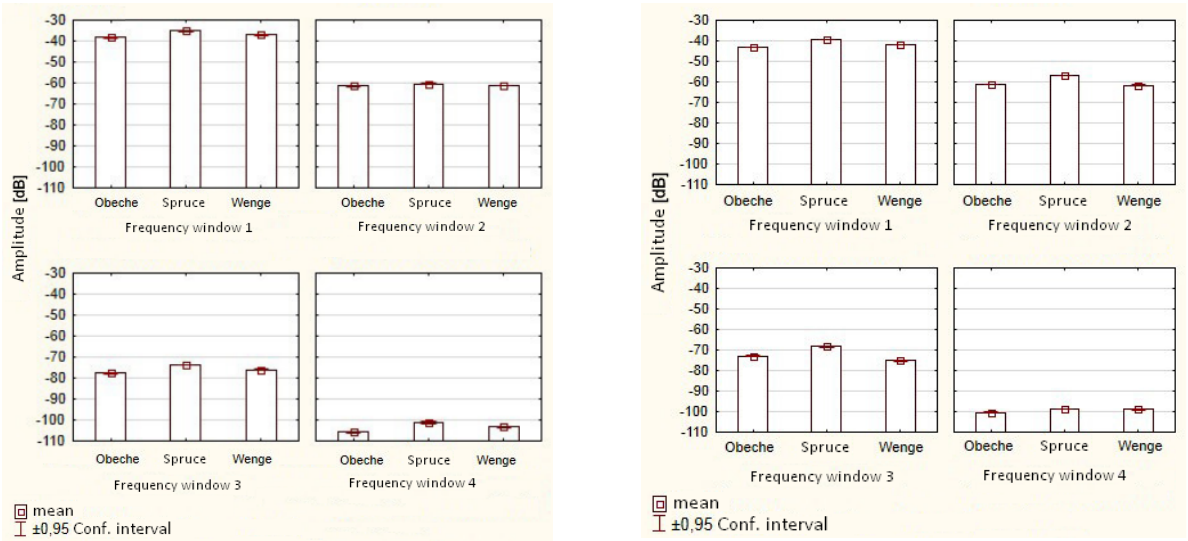

Figure 3. Mean amplitude in four frequency windows for particular wood species: string E2 (on the left) and string D3(on the right)

CONCLUSION

The results are summarized as follows:

1. Wood species have relevant influence on mean amplitude value in four time windows of length 2,5 sec. The most visible is this result in case of string E2. The lowest level of signal was registered for obeche. Its value was even 12,61 dB lower (fourth time window) in compare with wenge prototype.
2. In analysis in frequency domain wood species influence on obtained results was not proved.

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Streszczenie: *Wpływ drewna świerka, wenge i obecze z którego zbudowany jest prototyp gitary elektrycznej na wybrane właściwości emitowanego dźwięku.* W pracy poddano ocenie różne gatunki drewna pod kątem ich zastosowania w gitarach elektrycznych. Wykonano trzy prototypy gitary elektrycznej, każdy z innego gatunku drewna: świerk *(Picea abies)*, wenge *(Millettia laurentii)* i obecze *(Triplochiton scleroxylon)*. Dla wszystkich prototypów zarejestrowano sygnały akustyczne dla każdej z dwóch badanych strun – E2 i D3. Wyniki poddano analizie, w której przebadano średnią amplitudę w czterech przedziałach czasu po 2,5s każdy, oraz średnią amplitudę w pasmach częstotliwości: 0-1kHz, 1-5kHz, 5-10kHz i 10-20kHz. Otrzymane wyniki świadczą o tym, że występują istotne statystycznie różnice w amplitudzie analizowanej w dziedzinie czasu i częstotliwości. Najniższą amplitudą charakteryzował się gatunek obeche, a najwyższą wenge. Największe wahania poziomu amplitudy zarejestrowano dla gatunku wenge. W przypadku analizy w dziedzinie częstotliwości zaobserwowano mniejsze różnice między amplitudami dla różnych gatunków niż w analizie czasowej.

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