Analysis of Sounds Caused by a Golf Club Hitting the Ball

The sound of a golf club hitting a golf ball can be quite exhilarating, provided that the ball was hit correctly. A good golf club is expected to create the characteristic sound that tells the golfer that he made a good hit. Any new golf club that does not create this desirable sound, even with a good hit, would not survive in the market. Acoustics may not be the predominant factor a golfer relies on when choosing his clubs, but it still subconsciously influences the perception of quality.
The characteristics of the right sound can be easily determined with the analytic possibilities of Artemis SUITE. In the following, three sounds recorded with three different golf clubs hitting the ball are examined. The sound of the first club (Golfclub 1) is subjectively rated the best. The sound of the second club (Golfclub 2) is slightly worse, but still considered good. The sound created by the third club (Golfclub 3) is considerably worse. Of course, the golf ball used has an influence on the sound as well. However, in this Application Note, only different golf clubs are compared, not different balls.

Recording the Sounds

For an aurally accurate recording of the hitting sounds, a suitable solution is the BHS II (Binaural Head Set) in connection with the frontend SQuadriga II (see figure 1). The golfer wears the BHS II like a headphone, and its integrated microphones can be used to record the hitting sound. A windscreen is available for the BHS II, which can be used to reduce wind noise that may be present on the golf course. The BHS II is connected to a SQuadriga II unit operated in stand-alone mode, which is well suited for this kind of outdoor recordings due to its size, the built-in battery and its flash memory card.

Figure 1: SQuadriga II with BH II

Level Analysis

A simple, but useful analysis is the calculation of the sound pressure level. Recently, golf clubs made of titanium have attracted attention. With this kind of club, golfers can not only achieve higher distances, but these models also create louder hitting sounds than conventional golf clubs. In some cases, these sound events even reach a level where hearing can be damaged. While the level analysis cannot be used to determine the quality of the sounds created by different clubs, it can be used to identify clubs that might cause damage to the user's hearing.
Figure 2 shows the time-dependent level analysis of recordings of three hitting sounds.
All of the sounds have a high peak in the sound pressure level curve; yet it is unlikely that they would cause hearing damage, since the maximum sound pressure level is below 120 dB (SPL). Club 3, which has the worst sound, also has the highest sound pressure level, but this is not necessarily an indicator of sound quality. The level analysis should mainly be used to exclude the possibility of hearing damage, as it does not allow reliable conclusions regarding the perceived sound quality. To determine the quality, other analyses are better suited.

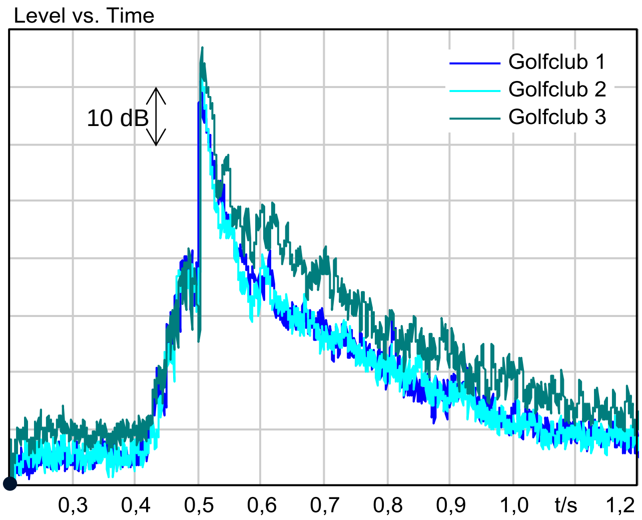

Figure 2: Time-dependent Level analysis of hitting sounds of three different golf clubs

Averaged FFT Analysis

With the averaged FFT analysis, the frequency spectrum curve can be determined. Figure 3 shows the FFT analysis of the three recordings. It is obvious that the sound of the third golf club has a prominent tonal component (between 1.6 and 2.5 kHz), which is not present in the other two sounds. This component is very dominant and has a strong influence on the sound quality. The frequency distribution in the sound of the third golf club is unbalanced.

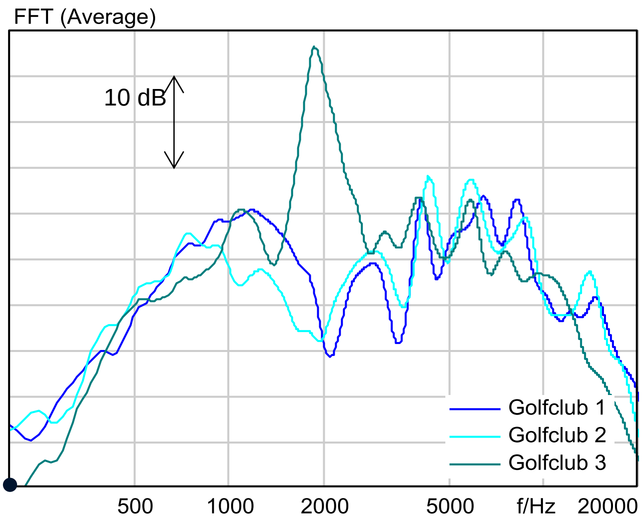

Figure 3: Averaged FFT analysis of hitting sounds of three different golf clubs

Time-dependent nth Octave Analysis

Another important aspect for the sound analysis is the temporal development of the sounds. It can be examined with time-dependent analyses, whose results are plotted against time. Figure 4 shows the results of a 12th octave analysis versus time. The frequency resolution of the nth octave analysis (finer at lower frequencies, coarser at higher frequencies) matches the frequency resolution of the human ear better than an FFT analysis, which has an equidistant frequency distribution. Furthermore, a time resolution of 2 ms was chosen for the analysis, which matches the time resolution of human hearing.

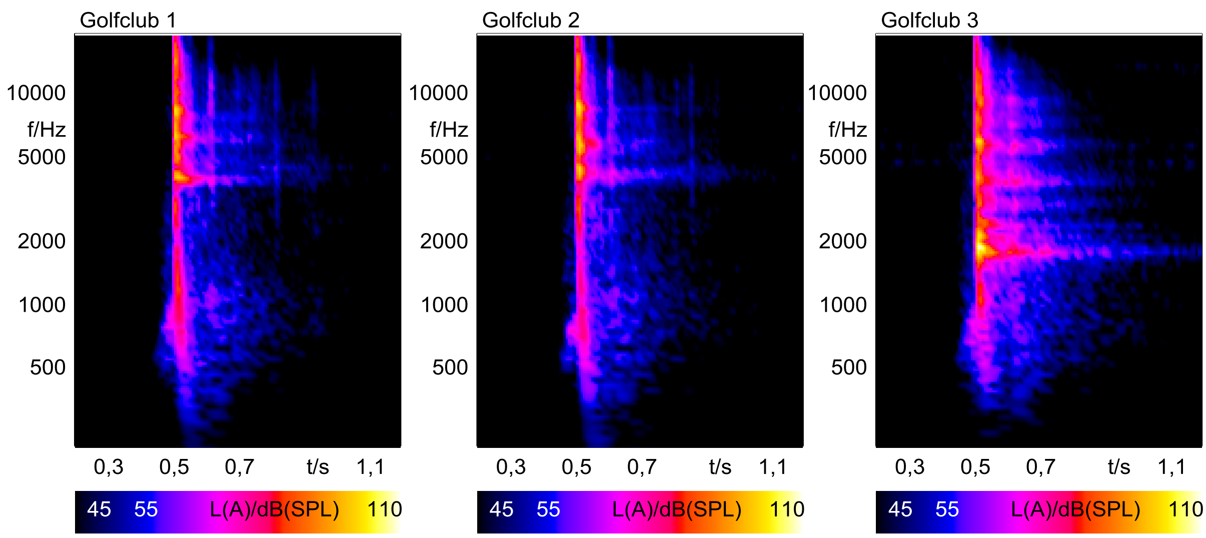

Figure 4: 12th octave analysis of hitting sounds of three different golf clubs

The comparison of the three sounds shows a small difference between the first and second golf club, and a significant difference to the third club. The tonal component is not only prominent in the frequency spectrum, but it also fades out more slowly than the other frequency components, which attributes even more to the bad sound quality.

Specific Loudness Analysis vs. Time

Loudness analysis examines sound events in accordance to the loudness perception of human hearing. Figure 5 shows a loudness analysis of the hitting sounds versus both time and frequency group (frequency resolution equivalent to human hearing).
This analysis shows the difference between the sounds very clearly. Between 10 and 17 Bark, the sound of the third golf club has a particularly high loudness curve compared to the two other sounds. Also, this analysis again shows the longer reverberation of the tonal component in the third sound.
This longer reverberation can be caused, for example, by insufficient damping of the shaft and could be improved by choosing a better material. This change might also reduce the tonal component. An additional possibility is changing the structure of the club head in order to achieve a more balanced frequency distribution and thus a better sound quality.

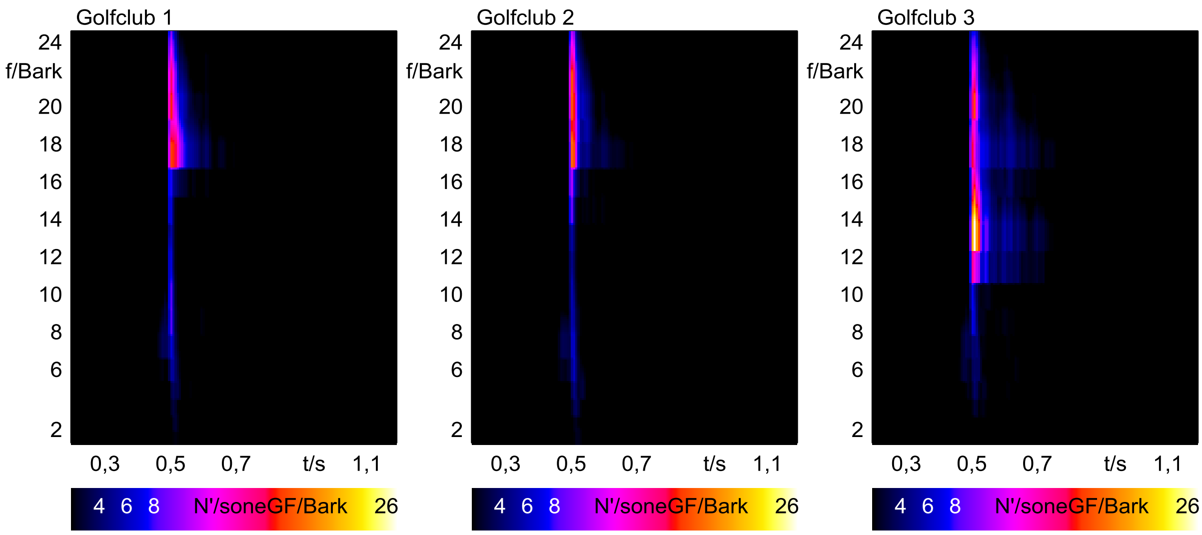

Figure 5: Specific loudness analysis of hitting sounds of three different golf clubs

The examination shows that the sound quality of golf club sounds can be visualized quickly and easily with the analysis functions provided by ArtemiS SUITE. The analysis results shown above clearly reflect the quality differences perceived by listeners and can yield suggestions how to improve the quality.

Notes

For the applications presented in this Application Note, you need the following ArtemiS SUITE modules: **ASM 00** ArtemiS SUITE Basic Framework (code 5000), **ASM 01** ArtemiS SUITE Basic Analysis Module (Code 5001), **ASM12** Psychoacoustics Module (Code 5012) and **ASM 14** Octave Analysis Module (Code 5014).

Do you have any questions or remarks? Please write to:
imke.hauswirth@head-acoustics.de
We look forward to receiving your response!