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Vibro-acoustic of table tennis rackets. Influence of the plywood design parameters. Experimental and sensory analyses.

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Abstract

The performances of a table tennis racket can be qualified with several adjectives like: fast, slow, stiff, adhesive, controllable, etc. These qualifications are subjective since they are relative to the sensory analysis made by each player. It appears that the noise produced at the ball impact on a racket has a great influence on the opinion that a player can give about a racket. Moreover, the sound emitted at the stroke can be appreciated differently among several players. Hence a good sound may give a positive a priori to the player abut the racket appreciation.

The study is based on a previous work that demonstrated: the correlation between the acoustic frequency spectrum and the vibration frequency spectrum of a racket following the ball impact – two vibrations modes of the racket blade are responsible of the sound emitted. The influence of the blade plywood composition is studied. Several prototype racket blades have been specially realized with some differences between them on: the thickness of the plies, the wooden essences. The analysis is first performed on the racket blades without rubbers glued on. The vibro-acoustic of each racket is analyzed by experiments on a lab test bench. The results obtained permit to clearly state on the effectiveness of these design parameters on the impact sound.

In the second part, the experimental observations obtained at the laboratory are compared with the results of a sensory analysis performed with the same prototype rackets by a panel of high level players which were asked to classify the sounds of the rackets. It is shown that the classification made by the players is consistent with the experimental laboratory observations.

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Keywords : Vibro-acoustic, table tennis racket, ball impact, plywood composition, sensory analysis

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1. Context of the work

The perception of the table tennis racket performances depends on many factors. Most of the appreciations expressed by confirmed players are subjective since they are relative to their proper sensory analysis. Usually, the rackets can be qualified as fast, slow, stiff, adhesive, controllable, etc. It can happen that two players of same level will give contradictory opinion for the same racket. The acoustic signature at ball impact is the first appreciation element of the racket performances; therefore it has to sound well in order give a positive a priori for the other evaluation parameters.

The ball-racket impact in table tennis had been studied in many works from the restitution coefficient point of view, the main results and ideas can be found in Kawazoe et al. (2003) and in Tienfenbacher et al. (1994, 1996). To our knowledge, there is no published work on the vibro-acoustic of tennis table racket. Nevertheless, numerous informations can be found and read on the internet forums and blogs edited by players and competitors.

This work is in the continuity of previous studies that had analyzed the vibratory behavior of racket blades and also the vibro-acoustic following the ball impact, Manin et al. (2012). The vibration modes were simulated and correlated satisfactorily with some experiments. The study presented here is concerned with the vibro-acoustic of table tennis racket at ball impact and more specifically on the influence of the racket blade plywood composition: type of woods, thickness of the plies. First, some previous work results are given about the correlation that exists between the structure and the acoustic vibrations. The structure vibration modes that produced the sound at ball impact were identified. Then, several racket blade prototypes have been realized to study the influence of the racket blade plywood composition on the vibro-acoustic behavior. The blade plywoods tested differed by the thickness of the plies and/or their wood essence. In parallel, a sensory analysis had been conducted with some high level players. Finally, the sensations of the players are analyzed versus the laboratory test results obtained.

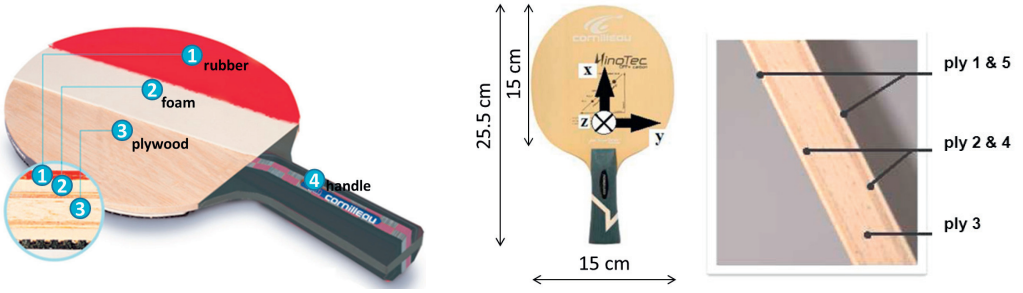

Fig. 1. Table tennis racket (a), blade (b), blade plywood composition (c)

2. Vibro-acoustic at ball impact

2.1. Experimental set up, previous results

The same experimental set up that in Manin et al. (2012) was used. The racket handle is tightened with a pneumatic membrane that reproduces the tightening of the player hand, the air pressure is fixed to 5 bars and controlled by a manometer (Fig. 2a). The ball is dropped over the racket from a height of 0.9 m with a zero initial speed, this leads to an impact velocity of 4.2 m/s. It is guided in a tube during the first 20 cm of the fall to ensure the repeatability of the impact point.