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BIOMECHANICS REALATED TO RACKETS DESIGN AND CUSTOMIZATION

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INTRODUCTION

The new composite materials applied to tennis, supply the racket designers of many degrees of freedom. It is now possible, for instance, to build very light rackets, to differentiate the stiffness along the frame, to chose the mass distribution; to vary the position of the vibration nodes, the position of the center of percussion and the one of the point of maximum rebound. The impact sound can also be changed. To take advantage of the design freedom for this technological piece of equipment a computer simulation approach is essential. The same approach is profitable to identify the best suited racket for a specific player and to evaluate the consequences of the racket customization. Customization is usual for the elite athletes equipment – because they often are forced to use rackets chosen by their sponsors – but it is also very common among non professional players. A racket is often customized by adding extra masses, by stringing the oval by means original procedures or by adding some kinds of shock absorbers. Many customization procedures can produce some not desired, collateral effects which affect both the stoke and the action transmitted to the body of the athlete . This work mainly deals with the theoretical and experimental analysis of the customization concerning racket comfort.

METHODS

A quantitative approach to the problem require to build complex models capable to simulate the impact dynamics.

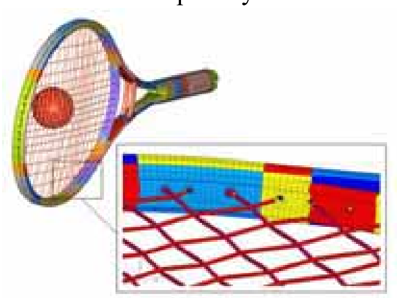

Figure 1: F.E. model that take into account the orientation of the reinforce fibers of the layers of the frame and of the interaction among the strings

The main parameters to be monitored are: center of percussion location, the frequency and the nodes of the vibration modes, the strings tension and moment of inertia with respect to the handle.

Experimental tests are required to validate the models and also to identify level of the parameters related the subjective feeling of comfort with a racket.

RESULTS AND DISCUSSION

As an example the influence of an extra mass, added in two locations on a popular racket frame, is analyzed. (10 grams are added at the top or at the bottom of the stringed oval). Influences on maneuverability (J) can be easily evaluated, such as the influences on the position of the racket centre of percussion. About vibration (fundamental mode) fig.3 shows that when the racket is handled (the hand is represented by the black dot) one of the vibration nodes (white triangle) is forced to move at the handle (a) and is not influenced (c)(d) by the extra mass. This mass affects, on the contrary, the position of the other node that is the point to which the impact don't excite that vibration mode. The little added mass, placed at the racket top, has a significant effect in lowering the fundamental mode of vibration frequency (fig.2)

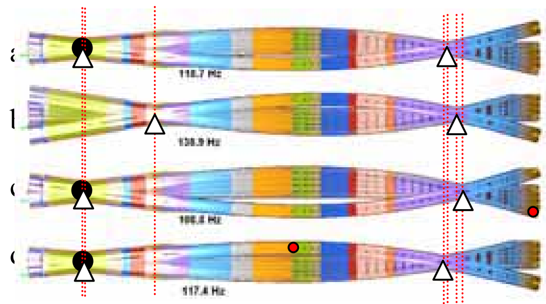

Figure 2: extra mass influence on the fundamental mode

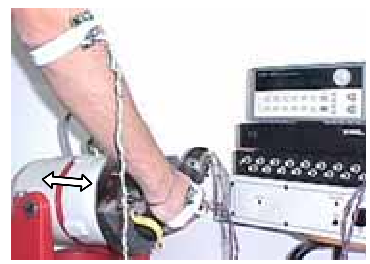

Figure 3: shaker and arm instrumented by accelerometers

Experimental tests (fig.3) prove that lower frequencies propagate more on the arm and are less comfortable. Strings tension also affects rebound and comfort but the simulation of the stringing procedure show (fig.4) that at the end of the process string tension are different by the theoretical tension

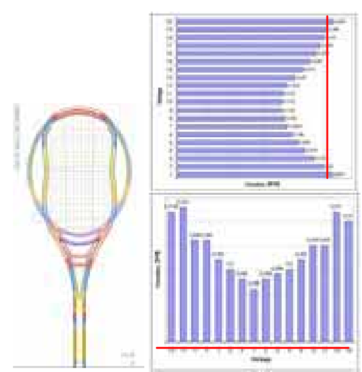

Figure 4: a) Deformation of the frame (amplified) under the strings forces b)Graph of the string tension at the end of the stringing process.
The red line is the theoretical string tension

set on the stringing machine because of the frame deformation

CONCLUSIONS

Racket customization must be accurately planned and simulated to avoid collateral negative effects on the player. Special stringing techniques must also be tested to check the effective string tension on the frame at the end of the process.

REFERENCES

1. Casolo F., Ruggieri G. *Dynamic analysis of the ball-racket impact in the game of tennis,* Meccanica, 1991