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Results of investigations on kinetic mass in tennis rackets

1. Introduction

Kinetic mass is incorporated by PRO KENNEX into the racket frame in form of small lead particles. The tendency of industry to build very light rackets (e.g. titanium) can cause higher stress for the arm because of small total mass (about 250 g) and the high stiffness of the racket frame. Thus the use of kinetic mass offers the possibility to counteract. The following three advantages of kinetic rackets compared with standard rackets have been claimed by PRO KENNEX:

1. They shall reduce the vibrations (absorption of "impact shock") which makes the arm feel more comfortable,
2. they shall have a larger sweet area on the string surface which means better stability and control of the racket for eccentric strokes and
3. they shall give additional speed to the ball.

Systematic measurements were carried out by PRO KENNEX. The physical mechanisms of the kinetic mass with respect to the above mentioned goals, however, are not absolutely clear.

2. Central issues

The central issue and the major purpose of the research was to find out

1. if and -in case of yes- how the kinetic mass generates the above mentioned physical benefits and
2. to consider improving the manufacturing of kinetic rackets, e.g. the amount and arrangement of kinetic mass.

3. Scientific approaches

Before the investigations started, theoretical reflections on how kinetic mass could work were modelled. Fig. 1 shows the behaviour of the particles in different phases of the tennis stroke from rest to the point of impact.

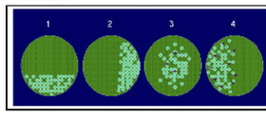

Fig. 1: Schematic description of the behaviour of kinetic mass within the chamber: in rest (1), at the forward swing of the racket (2), at the begin of impact (3), after the moment of impact (4)

The effect of kinetic mass was tested by different experiments. All investigations took place between December 1999 and January 2000.
The first approach was the **modelling** of the effect of kinetic mass on the dampening of vibrations. The own experiments as well as results from industry (e.g. aeroplane technique) and by PRO KENNEX (e.g. tennis roboter) demonstrated the effectiveness of the principle of kinetic mass.

In the **lab experiment** the dampening behaviour between two firmly fixed rackets with and without kinetic mass was compared. Ten drop tests were performed with a tennis ball from different heights.

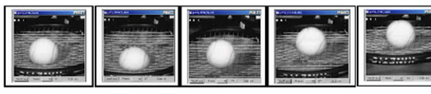

Fig. 2: Drop test on the fixed racket (2000 frames/s)

The occuring vibrations were measured by accelerometers on the racket (2000 Hz) and documented by a high-speed-video camera operating at 2000 frames/s.

The results showed that kinetic mass had unambiguous and considerable advantages concerning the dampening of the racket. The reduced oscillation can easily be seen in the acceleration-time-curves. So it can be concluded that the dampening effect of kinetic mass in the situation of the lab is very efficient.

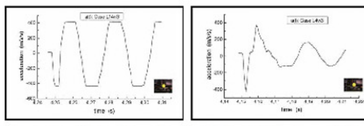

Fig. 3: Acceleration of the top of the racket without (left) and with kinetic mass (right)

The third approach was the practice test on a **tennis court**. The essential goal was to get information about the coupling of the human hand and the racket. Three tennis players of average and good level (2 trainers, 1 leisure time player) performed tennis forehand ground strokes with a racket with kinetic mass and a racket without kinetic mass (10 strokes for each condition). The ball was tossed by a ball machine with a moderate velocity of about 70 km/h (see fig. 4).

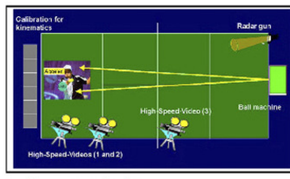

Abb. 4: Overview of the experimental conditions

Most modern technical equipment of approx. 0.25 million Euro was used. The forehand ground strokes and the points of impact were filmed with three high speed videos. The players were equipped with electrodes for electromyography (EMG) at the striking arm. There were three accelerometers (2000 Hz) fixed to the racket in the same positions as in the lab test (see fig 5).

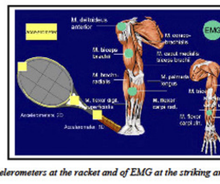

Fig. 5: Positions of accelerometers at the racket and of EMG at the striking arm

For automatical registration and recognition of the movements of the striking arm and the racket, fluorescent markers were chosen. The initial velocity of the ball was measured by a radar gun. The mini-computer for the registration of EMG and accelerometer data was placed on the back of the test person (see fig. 6 on the right side).

Fig. 6: Experimental conditions in detail (left) and equipment of the players (right)

The analysis of the frames of the high speed video (3) confirms the problems of average players to hit the ball centrally on the racket. Decentral points of impact lead to perceptible deflections of the racket in the hand (see fig. 7). This is probably the main reason for the tennis arm.

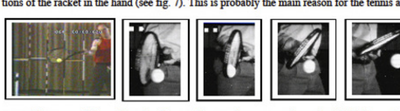

Fig. 7: Rotations of the racket after decentral point of impact on the racket (2000 frames/s)

The measurements (power density spectrum) showed that the racket with kinetic mass absorbed high frequency vibrations, which cause high stress for the striking arm, much better than the racket without kinetic mass. Moreover, the harmony of acceleration curves was improved.

4. Conclusions

On the basis of the actual results of the investigation the following can be acknowledged:

- The tested rackets with KINETIC MASS had distinct better dampening effectiveness than equal rackets without kinetic mass.
- Because of the better dampening qualities they offer an outstanding comfort of playing.
- As high frequency oscillations are in suspicion to be the origin of tennis injuries (e.g. of the tennis arm) it may be presumed that rackets with kinetic mass will have a positive effect.
- The better dampening effect of kinetic rackets can be considered the reason for better stability at decentral points of impact.
- On account of the basic physical qualities of kinetic mass, the KINETIC technology can be considered as a "raw diamond" in racket production.