EXPERIMENTAL EVIDENCE OF FRICTION EFFECT INVOLVED IN PLAYING FRENCH BILLIARD

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KEYWORDS
Friction; Everyday life tribology; Third body; Visualization.

ABSTRACT

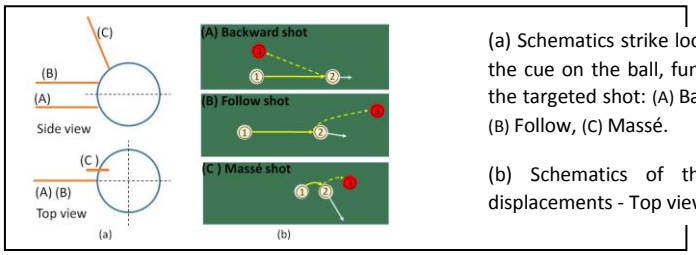
Billiard games involve collision between balls and friction phenomena between ball and ball, ball and table, ball and cue. In the literature, few studies are found on dynamics of billiards. From a theoretical point of view, it implied the collision of two rigid balls with spins or not [1, 2]. Others present some experimental results using high-speed camera to study ball-cushion collisions [2, 3] in the case of snooker or pool.

In this study, focus is made on French billiard game, involving 3 balls only (no table pockets). The basic rule is that the ball ① stroke by the player should strike the two others balls ② and ③ consecutively. In order to accurately place the balls on the table, the player has to control the force (consequently the velocity) applied on the cue-ball and its direction and motion. Those imply to choose the right impact location on the ball by the cue and thus which effect must be imposed. In this study three specific effects, backward, follow and Massé shots (fig. 1), are analyzed from a mechanical and tribological point of view.

The system can be described according to the tribological triplet. Multi contacts occurred and they involve the following elements:

- balls (first body), in phenolic resin, 61.5 mm of diameter,
- cue tip (first body), single layer of leather, 3 mm thick,
- cloth (first body),
- chalk (third body) put on the cue tip before each shot,
- cue (wood, 1.5 m of length), slate plates (billiard table) and player (mechanism).

In this study one focus on the impact by the cue tip on the ball ① (cue-ball), the motion and velocity of the ball ① until and after its collision with the ball ②. Nevertheless, it was verified that the ball ③ was contacted to validate the strike. A "Phantom® Miro® eX4" high-speed camera, with a 55 mm Nikon lens, was used to track the movements and velocity of the cue-ball. The sample rate was 1900 frames per second. Image tracking and processing algorithms were developed to extract from the recorded videos the cue ball speeds and accelerations function of time. The cue tip, balls, chalk and cloth were analyzed by optical and scanning electron microscopies in the aim to highlight the cleaning conditions of the cloth and the chalk distribution on the cue tip and transfer on the ball.



(a) Schematics strike location of the cue on the ball, function of the targeted shot: (A) Backward, (B) Follow, (C) Massé.

(b) Schematics of the balls displacements - Top views.

Fig.1 Displacements of the balls, as a function of the effect

Backward and follow shots allow to apply a spin rotation about a horizontal axis perpendicular to the direction of the displacement of the ball. Results showed different consecutive motions steps for the backward and follow shots: pure sliding (just after the first contact impact tip-ball ①), rolling and sliding, pure rolling (just after the impact ball ①-ball ②), rolling and sliding again. The phase depended on the applied effect, the presence or not of the chalk on the cue tip, and the cleaning conditions of the cloth. This highlighted different contacts involved and friction ratio. The Massé shot is more complex as it imposes spin about an axis not mandatorily horizontal neither perpendicular to the direction of the displacement of the ball. The spin rotation given to the ball ①, coupled with the friction between the table and the ball ends up curving the path of the ball ① (fig.1), involving significant Corriolis acceleration effects.

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