Why the center of the rotating mass of a flexible fly rod could escape the rotation point at the grip

By Tobias Hinzmann supported by Dr. Franz- Josef Schmitt - November 2015
http://www.passion-fliegenfischen.de

In my “Experimental investigations on the fly rod deflections” (revision 2.0 from November 2014) I compare the properties of a flexible with an (theoretical) absolutely stiff fly rod. In section F1) it is worked out, that for a flexible fly rod the center of the rotating mass is able to shift upwards towards the tip. In this essay I want to have a closer look on this phenomenon.

The center of the rotating mass is located in the center of gravity of all mass elements, which contribute to the angular momentum[1]. In the following this center is called ‘**center of rotation**’. This center of rotation must not be the same as the center of the gravity of the whole system, which in the case of a fly rod is near the grip and in which a rotation is introduced for example. In the following this center of the gravity of the whole system is called ‘**rotation point**’.

Basically the center of rotation is determined by all mass elements, which have a velocity component rectangular relative in relation to a coordinate system. In the simplest case the reference point would be placed in the rotation center in order to describe this physical issue.

An absolutely stiff fly rod represents a rigid system. As it is rotated around the grip at every moment all mass elements on the fly rod contribute to the angular momentum, because the velocity all mass elements have to each other don’t vary relative to the rotation point. For this reason the center of rotation and the rotation point are identical. In this regard a little deflected fly rod should behave quite similar to a rigid one, which is why the center of rotation can be assumed to stay close to the rotation point. But for a well deflected fly rod the properties of rotation could be basically different to a rigid or little deflected one, for which reason the center of rotation and the rotation point must not be located at the same place.

That the center of rotation could move along a flexible system could be explained by a whiplash. In annex 3 of my “Experimental investigations on the fly rod deflection” a whiplash is displayed and described. In this case the rotation point the whole system 'turns' around doesn’t escape the hand of the user. As he stops the movement all mass elements modify this flexible system in such a way, that the mass turns around a decreasing circle, which is located close to the vertex S and which moves up toward the tip (see section imaging). This equals a description of the angular momentum in a system with a time dependent point of origin. About the middle of the circular motion of those mass elements contributing the angular momentum, the center of rotation is located. This center of the remaining components of angular momentum shifts clearly towards the tip, as the angular momentum is approximately determined by all mass elements having a circular motion.

<u>So not the rotation point as the center of the systems gravity moves up towards the tip since it is hold at the grip by a constrain, but the center of rotation as the center of gravity of all mass elements, which contribute to the angular momentum.</u>

The properties of the well deflected fly rod are situated somewhere in between of both different behaviours of a rigid, a little flexible system respectively on the one side and a very flexible system on the other side. Especially starting from the 90 degree position (of the grip segment)

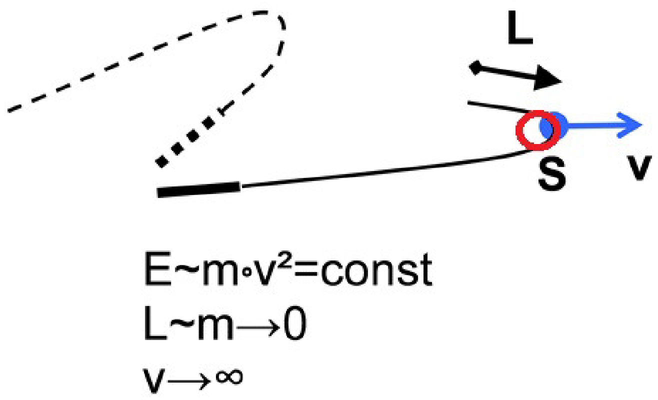
[1] Mass elements contributing the angular momentum must move, but not necessarily rotate.

in the case of my investigated cast the mass elements on the fly rod have a distribution of their velocities, which is quite similar to a whip. The velocity of mass elements being closer at the tip is significant higher in relation to those mass elements being closer at the grip, thus the mass elements of the tip must influence the center of rotation most. Similar to a whip where the mass turns around a decreasing circle, along the biggest deflection of the fly rod a circle develops too, around which the mass elements are turning (see section imaging). If the caster increases the deflection continuously as it does in my investigated casting sequence, then mass elements could not only turn around the rotation point at the grip, but the more the longer the cast takes around another center, which is located close by the biggest deflection. The turning circle can visualize this existing center of rotation well. Even over the path of retraction the mass elements are turning around this circle, which decreases the more the farther it moves towards the tip of the fly rod. This decreasing and upmoving circle shows that kinetic energy is concentrated towards the tip. This is a clear sign that for the flexible fly rod the center of rotation shifts along the deflection towards the tip and is not the same as the rotation point.

It is remarkable that for this kind of the varying deflection the circle continues moving up towards to tip during the path of retraction too. Hence over the path of retraction the fly rod does not only transform potential energy into kinetic (by “unloading”) but also - supported by the angular momentum - kinetic energy, which is moving along the shape of the deflection.

Imaging

The following picture of a whiplash is taken from the encyclopedia http://www.wikipedia.de and was already used in annex 3 of my “Experimental investigations of the fly rod deflection”. For this essay the circle, the mass elements are turning around, was added (in red). The more the circle moves away from the rotation point at the grip, the smaller it becomes.



The following pictures are also taken from my “Experimental investigations on the fly rod deflection”, they were supplemented by the circle too (in red).

On the pictures 1 to 4 the circle is adapted to the deflection of the fly rod. Especially starting from the 90 degree position (of the grip) the circle turns upwards to the tip meanwhile it decreases. Similar to a whip the center of rotation must escape the rotation point at the grip and shift upwards into the direction of the tip. Thereby kinetic energy – even over the path of the retraction – is concentrated towards the tip. In the 5th and last picture the circular motion ends. The circle disappears and a little rest of a tip segment turns over creating the counterflex (what explains the small counterflex of my investigated fly cast).


picture 1


picture 2


picture 3


picture 4


picture 5