Impact of angular momentum on the fly cast

How the angular momentum is able to influence the fly cast. Or the forth energy transfer property of the fly rod. What does it mean ?

History

When first I represented the revision 1.1 of my work „Experimental investigations on the fly rod deflection“ in Mai 2014 in the english speaking forum „flyfishing.co.uk“, I was absolutely surprised about the reactions. I expected an open minded discussion about my work an especially about the result, that the flexible fly rod enables a transfer of energy, which leads to an about twice efficiency (ratio of output / input) in relation to an absolutly ridig fly rod. But instead of this a general discussion arouse in which progress the conclusions of my work went into the backgroud more and more. Especially the conclusion of section F1, that the impact of angular momentum enables an additional energy transfer was not respected.

At the beginning of July 2014 the discussion about my work reached the forum of sexyloops.com. In allusion to my work under the thread „none flexible vs flexible fly rod“ the stated advantages of the flexible fly rod were questioned in general. Especially the 15th conclusion was questioned, according to which the impact of angular momentum could play an important role by transferring the energy between the grip and the tip of the fly rod.

Due to the not ending criticism on my work I added some investigations and published the revision 2.0 in November 2014, in which basically the impact of the mass of both fly rods (modification of the moment of inertia for both the flexible and the rigid one, see annex 2) was respected including further explanations about the impact of angular momentum (see annex 3). The revision 2.0 was confirming my findings of the revision 1.1 even more.

Properties of the fly rod concerning energy transfer

From the course of the discussion during the year 2014 continuing up to the beginning of 2015 it became evident, that the properties the fly rod provides transferring the energy were basically described with a) translation b) rotation c) spring.

The translation is also called parallel motion. If the fly line is casted solely out of the hand – as it is shown sometimes during casting shows – basically a translation acts on the fly line. As soon as a fly rod is used the rotation joins the motion due to its lever arm. For a flexible fly rod the spring function is added.

Until the beginning of 2016 the fly cast was basically faced by one dimensional models. Simply spoken those models concentrate the mass into a marble, which is accelerated by a spring. Interestingly already those one dimensional models were calculating a significant better efficiency in relation to a rigid fly rod.

The angular momentum as a further energy transfer property

The angular momentum is a physical energy conservation quality which is redistributed due to the deflection. This redistribution of the angular momentum enables that some additional kinetic energy could reach the tip of the fly rod. Simply spoken: along the deflected fly rod („spring“) some kinetic energy could climb up towards the tip.

About the impact of angular momentum I talked much with the physicist Dr. Franz-Josef Schmitt, who supported me a lot understanding this effect better. From conversations with other fly fishers I learned the best way to clarify this phenomenon is to divide it in its two ways it acts:

1.) „simple“ redistribution of angular momentum (“pirouette effect”)

Due to the deflection the projection of the fly rod shortens, its gravity center comes closer towards the grip. Similar to a pirouette during its run the figure skater attracts his arms, already this shortening generates an additional velocity of the tip of the fly rod. For this effect a deflection is not implicit necessary. A not deflecting fly rod which shortens similar a telescope rod during its rotation would lead to a comparable result (the figure skater doesn‘t „deflect“ his body, but redistributes the mass of its body by attracting his arms).

2.) „complex“ redistribution of angular momentum (“whip effect”)

Since the fly rod doesn‘t telescope as described under 1.) but deflects, a further redistribution takes place. This further „complex“ redistribution could be visualized by a „wave“, which shifts towards the tip of the fly rod. This „wave“ could be made visible by e.g. a circle adapting into the maximum curve of the fly rod. Or a dot adapted at the apex of the deflection. The comparison under 1.) could be used too with the difference that the figure skater doesn‘t remain on a spot but moves along a path during he turns the pirouette. This redistribution of angular momentum takes place quite similarly in a whip and the deflected fly rod is able to use this effect proportionally.

The video „Center of the rotation mass in fly casting“ tries to clarify both redistribution effects I talked about before.

Both previously described redistribution effects of angular momentum act together and are associated with the modification of the moment of inertia, which takes place due to the deflection (see annex 2). More precisely spoken the deflection causes not only a modification of the moment of inertia, but enables the mass elements of the fly rod to obtain different angular velocities too. In a closer physical meaning it is this varying angular velocity which redistributes the angular momentum, so that its impact could increase towards the tip (concentration effect). Therefore some kinetic energy could climb up along the fly rod shaft. This varying contribution of angular momentum and the accompanied energy transfer I try to explain in the video „Contribution of angular momentum in fly casting“.

Hence the fly rod has a forth property d) concerning the energy transfer, that can be stated:

energy transfer from the grip towards the tip = a) translation („parallel motion“) + b) rotation („lever arm“) + c) storing („spring“) + d) redistribution („angular momentum / moment of inertia“[=> pirouette and whip effect])

Practical benefit

It is evident, that the caster could influence the energy transfer significantly. The more he stimulates the properties for a better energy transfer, the more he is able to reduce his effort generating a high line speed, what increases the efficiency. For short casts as well as for tournament distance casting a high efficiency will not be the first aim, but for all the casting distances, which are important for practical fishing, the caster could profit of an efficient, power minimized fly cast. I myself appreciate to cast a whole day long without getting tired – especially fishing at the coast or at the lake.

The variation of the deflection, which leads to an better energy transfer and therefore to a high efficiency,I‘ve explained before. Now the caster‘s movements must be adjusted accordingly that the described variation of the deflection develops. To me it is about focussion on some elements of the casting stroke:

a) A Significant translatory motion at the beginning of the fly cast
Starting with a motion from the upper body and the shoulder the elbow precedes the casting movement, whereby the caster „pulls“ on the fly rod. If the elbow can‘t precede any longer the rotary motion starts to prevail. The wrist stays inactive.

b) The Rotary motion prevails very late
The rotary motion is initiated as late as possible, but then very dominant. The highest pressure on the grip takes place around the vertical position of the grip for a short moment. Therefore the fly rod gains a deep deflection, which is useful to exploit the redistribution effect.

c) A Tracking / follow up / follow through motion at the end of the cast
After the caster has pressured the grip around its vertical position for a short moment the fly rod has enough self dynamics (**„self dynamic mechanism“**), so that the caster is able to reduce the pressure on the grip significantly during the further rotary motion. This reduction of pressure on the grip along with a tracking / follow up motion in the direction of the fly cast seems important to me not only to minimize the casters effort but also to reduce the counterflex. Due to the „wave“ (see „complex" redistribution of angular momentum), which travels towards the tip, the cast „rolls out“ in a way, so that a big counterflex is prevented.

The previous described variation of the effort, the caster should apply into the grip, can the watched on figure XI of my work „Experimental investigations on the fly rod deflection“ (for the flexible fly rod it is represented by the green graph, the „torque“ Mf).

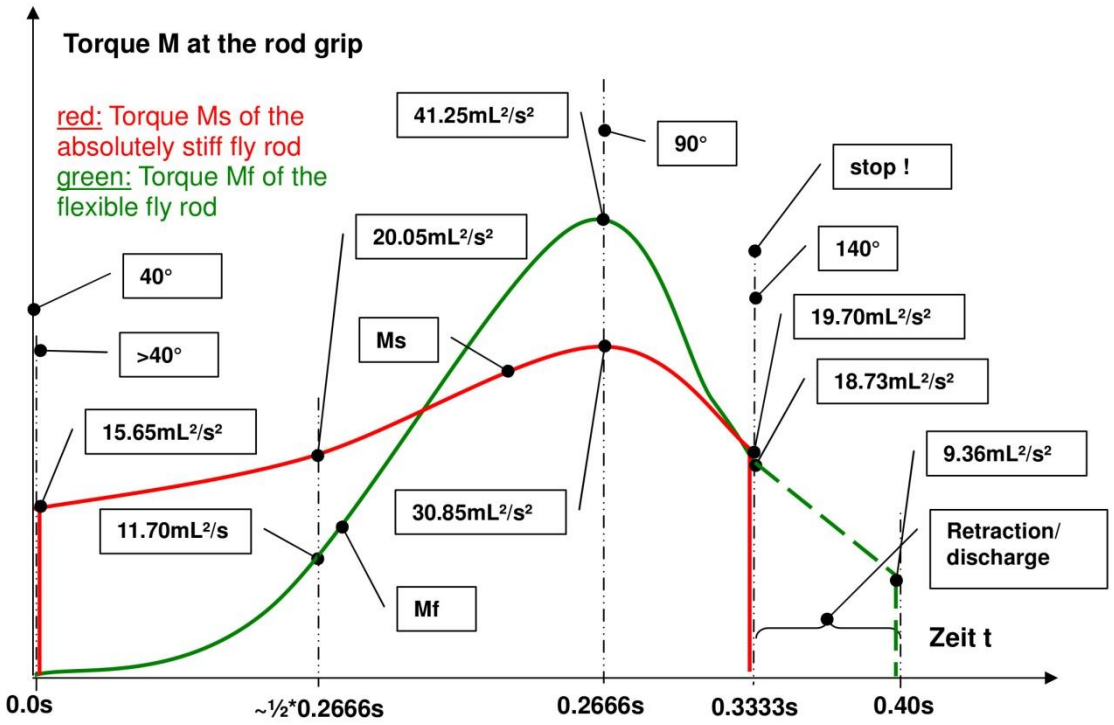

Figure XI

The elements, which benefit an efficient fly cast, are also described by the „Preceding elbow technique in fly casting“. This technique stimulates precisely the properties, which are required for an optimal energy transfer between the grip and the tip of the fly rod.

To me also the „Meadow cast“ by Hans- Ruedi Hebeisen visualizes the movements well, which generate an efficient fly cast.

Future

Meanwhile the redistribution effect is established and the energy transfer generally confirmed since 2016 by a two dimensional marble model (the „simple“ redistribution effect). The disapproval this effect was faced first by some people has been superseded by an open minded discussion about the meaning of the deflection.

The impact of angular momentum, moment of inertia respectively will move the properties of the fly rod in a fresh view a bit. Up to know the possibilities of our fly rod were rather underrated.

It remains exciting.

Tobias Hinzmann in October 2016