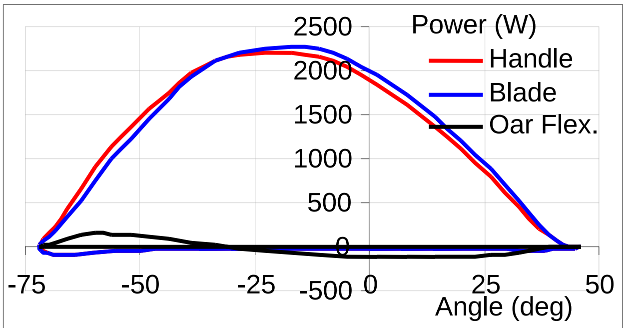
Q&A

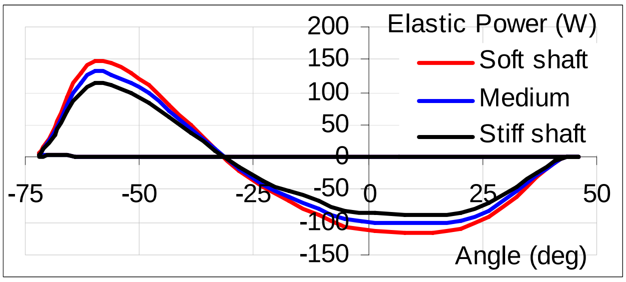
Q: Bruce Moffatt, Rowing coach and coordinator of Prince Alfred College, Adelaide, Australia is asking: "The latest newsletter is very interesting, especially the discussion regarding potentially inefficient use of muscle at high catch angles - static or near-static. One factor not mentioned is the flexure of the oar shaft imposed by the rower's muscles against somewhat transverse oar displacement during the early drive, at high catch angle. I wonder if in fact some energy is stored in the flexure of the oar shaft, to be release as propulsive force during the mid to late drive. If so it would add to the argument against nugatory energy expenditure at high catch angles.

Admittedly the flexure distances are small, however the forces may be somewhat large, and may perhaps result in some level of 'whipping' effect when the rower reduces the amount of input energy later in the drive. What do you think, is there any significant effect? Is potential energy stored in the oar shaft and returned later in the stroke?"

A: Basically, we agree with all points expressed by Bruce. In one of our first Newsletters 2001/05, we mentioned very briefly that "Bending of the oar shaft could be as much as 10 degrees … and absorb up to 25% of the rower's power over the first 15 – 20 cm of the drive". Now we will discuss it in more detail. The chart below shows the power curves of a male single sculler at a stroke rate of 35:



The red line represents power applied to the handle (product of the handle force and velocity). At the beginning of the drive, the force increases, the shaft bends and part of the handle power is stored in the elastic energy of the shaft (black line). Therefore, the power delivered at the blade (blue line) is less than handle power. When the handle force starts decreasing, the shaft recoils and returns energy to the system. The blade power became higher than the handle power. The following chart shows the difference in the storage of elastic power between soft, medium and stiff shafts (1) for the same handle force curve. The stiff shaft stores and then returns about 26 Joules of energy; medium shaft – 30 J (15% more); soft shaft – 34 J (30% more). The total work per stroke of this rower was 1022 J, so the share of elastic energy ranges from 2.5% to 3.3% (stiff and soft shafts).



These values don't look very high. However, at 34 deg of oar angle, where the peak force is achieved and the stored elastic energy is maximal, it amounts to 6.4% to 8.4% of the rower energy production up to that point in the drive. At an oar angle of about 60 deg (when the force gradient and the elastic power are maximal) the share of elastic energy ranges from 19.6% to 25.5%, which confirms our previous statement. The maximal flexure of the shaft measured at the middle of the handle ranges from 5.8 cm to 7.6 cm (stiff and soft shafts) at the max. force of 450 N on each handle.

Most of the elastic energy is stored at oar angles longer than 50 deg, when the gearing ratio is about 4 (RNB 2007/03). The return of elastic energy happens mainly near the perpendicular position of the oar, when the gearing ratio is about 2. This means more acceleration of the rower-boat system and higher effectiveness ("whipping effect"). The oar shaft may recoil not only at the handle, but also in the middle, where it pushes the pin forward, accelerates the boat and creates "trampolining effect" on the stretcher (RBN 2006/02). **Early peak force and optimal timing of the drive are important for effective use of elastic energy of the oar** (RBN 2004/01-02).

During the last World Championship in Munich some very obvious examples of rowing technique with early peak force were demonstrated by bronze medallist W1x Michelle Guerette, USA and the gold medallists Australian M2-.

References:

1. *Concept2: Scull Shaft Construction and Stiffness.* *http://www.concept2.com/us/products/oars/sculls/shaft.asp*

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