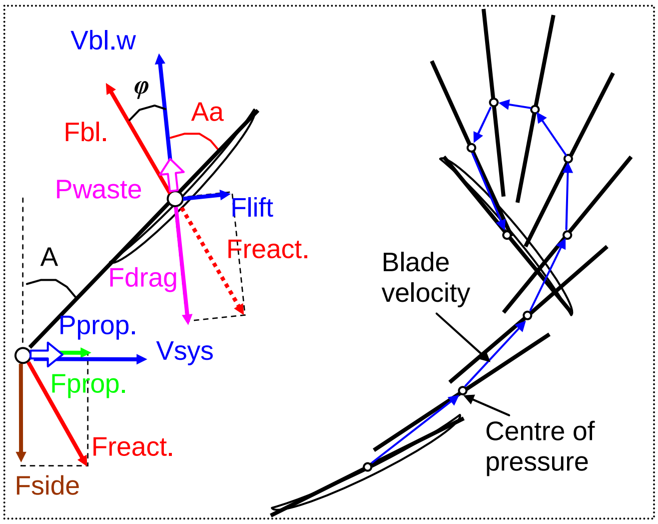
Facts. Did you know that…

…rowers loose an average of 18.5% of their power due to slippage of the blade in the water? Some publications on this topic are given below. We also mentioned it briefly in RBN 2001/04, 06, 07, 2003/08. With some assumptions (3) we define blade propulsive efficiency ***Ebl*** using measurements of the boat velocity ***Vboat***, oar angle ***A*** and the handle force ***Fh***. The chart below shows the path of the blade in the water during the drive and mechanics of ***Ebl*** calculations:



The force applied at the centre of the blade ***Fbl*** is calculated using measured ***Fh*** and actual oar gearing (RBN 2006/11). The velocity of the blade relative water ***Vbl.w*** is determined using oar angular velocity and ***Vboat***. The waste power ***Pw*** is calculated as a scalar product of the force ***Fb*** and velocity ***Vbl.w*** vectors:

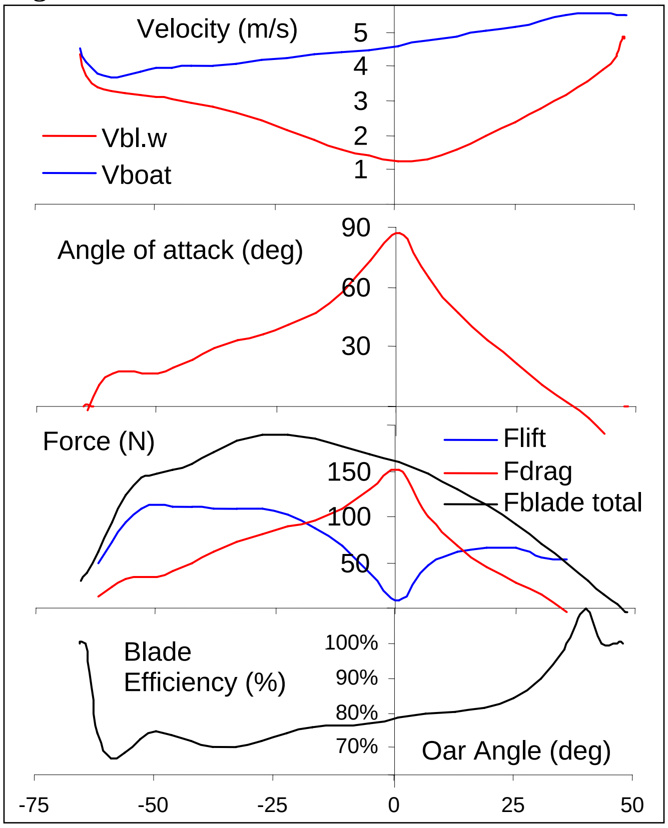
$$Pw = Fb\ Vbl.w\ \cos\varphi \qquad (1)$$

,where φ is the angle between vectors.

The total power applied to the handle ***Ptot*** is calculated as a product of ***Fh*** and handle velocity. Propulsive power ***Pprop*** can be derived as a product of the propulsive force ***Fprop*** and a velocity of the centre of mass of the rowers-boat system ***Vsys***. It is quite difficult to calculate ***Vsys***, so we derive ***Pprop*** as a difference between ***Ptot*** and ***Pw***. Blade efficiency ***Ebl*** is derived:

$$Ebl = Pprop / Ptot = (Ptot - Pw) / Ptot \qquad (2)$$

The blade moves through the water at the angle called the angle of attack ***Aa***. If ***Aa*** is not 90°, then a lift force ***Flift*** is developed and the blade works as a hydro-foil. ***Flift*** is directed perpendicularly to ***Vbl.w*** and has 100% efficiency. All energy losses depend on drag force ***Fdrag***, which has opposite direction to ***Vbl.w***. ***Flift*** and ***Fdrag*** are components of a total blade reaction force ***FblR***, which has the same magnitude and opposite direction as ***Fbl***. ***FblR*** is transferred through the oar shaft to the system and can be decomposed to ***Fprop*** mentioned above and ***Fside***, which does NOT create any energy losses (RBN 2006/06). The chart below shows data of a single sculler rowing at a stroke rate of 36 str/min plotted relative to the oar angle:



The lift and drag factors were taken from (2) for a flat plate, so they can be used quite approximately here. In this example ***Flift*** contributes to 56% of the average blade force and ***Fdrag*** contributes to the remaining 44%. Total distance of the slippage of the blade centre was 1.7m and minimal slippage velocity was 1.25m/s at perpendicular position of the blade. Overall blade efficiency was 76.5%. We will further discuss factors affecting blade propulsive efficiency in future Newsletters.

References

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2. Caplan N., Gardner T., (2006) A fluid dynamic investigation of the Big Blade and Macon oar blade designs in rowing propulsion. Journal of Sports Sciences, 1 – 8
3. Kleshnev V. (1999) Propulsive efficiency of rowing. In: Proceedings of XVII International Symposium on Biomechanics in Sports, Perth, Australia, p. 224-228.

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