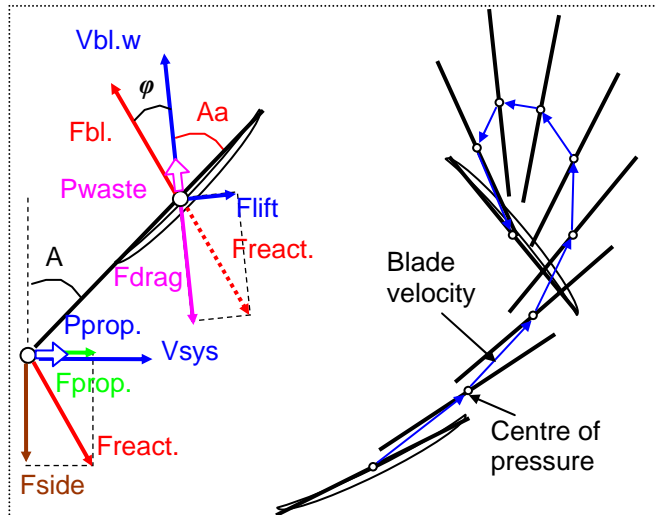


**Facts. Did you know that...**

...rowers lose 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:

$$Pw = Fb Vbl.w \cos\phi \quad (1)$$

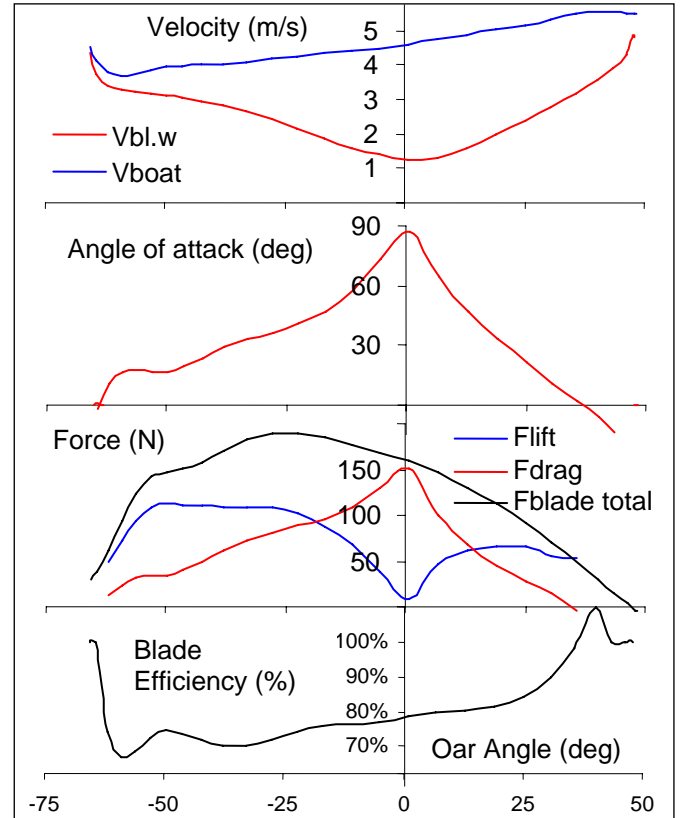
,where  $\phi$  is the angle between vectors.

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:

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

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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