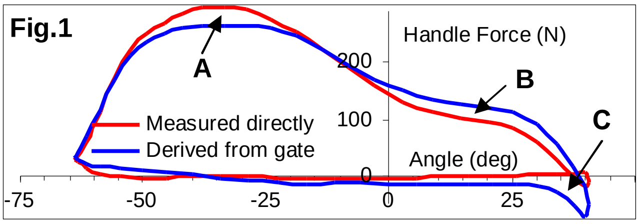
In the front line of research

Recently, we have tested a newly developed instrumented gate (1) with six single scullers of different level and sex. The main purpose was to compare and verify force measurements and power calculation with our standard method: measuring handle force using detection of the oar bend. We already discussed various methods of the force measurements in RBN 2010/03. As the new sensor measured gate force $\mathbf{F_{gate}}$ in a perpendicular direction to the oar, the handle force $\mathbf{F_{hnd}}$ was derived as:

$$F_{hnd} = F_{gate} * (L_{out} / (L_{in} + L_{out})) = F_{gate} * (L_{out} / L_{oar}) \qquad (1)$$

, where $\mathbf{L_{in}}$ is actual inboard (from the pin to the centre of the handle), $\mathbf{L_{out}}$ is actual outboard (from the pin to the centre of the blade) and $\mathbf{L_{oar}}$ – actual oar length equal to the sum of the first two values. Fig.1 shows force curves obtained using the above two methods in W1x at stroke rate 30 str/min:



It was found that force curves were slightly different:

- Directly measured handle force was higher during the first half of the drive (**A**);
- Derived handle force was higher at the second half of the drive (**B**);
- Gate sensor measured some negative force at the beginning of recovery (**C**), which can be explained by inertial force of fast accelerating oar. Oar sensor is not detecting this force because the oar is already feathered.

The power **P** was derived as:

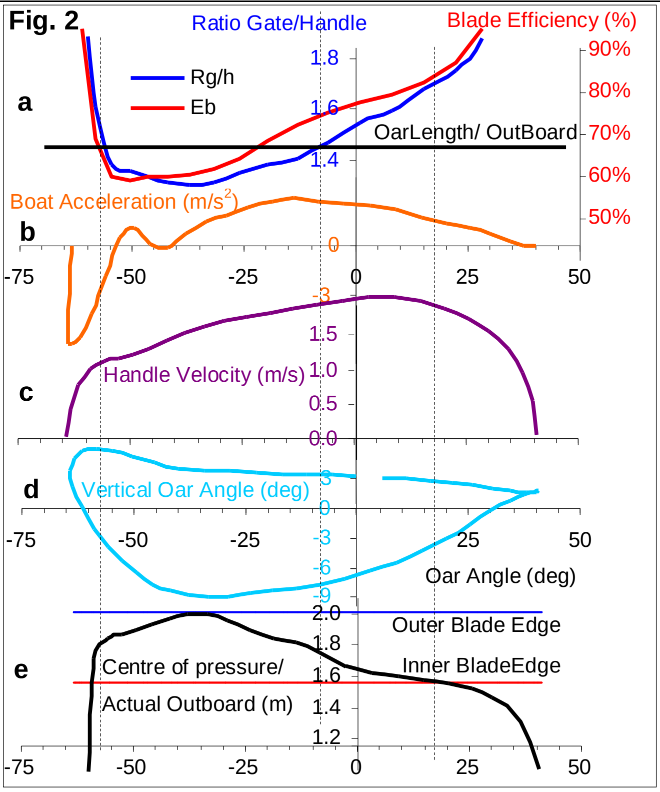
$$P = F_{hnd} * L_{in} * \omega \qquad (2)$$

where **ω** is angular velocity of the oar. It was found that values of power calculated using these two methods corresponded quite well: the average difference was 0.45%±0.17% (min. 0.11%, max. 1.07%). This allows us to conclude that the **new gate sensor can be reliably used for measurements of rowing power**.

Then, we tried to analyse the reasons for the differences in the force curves measured at the gate and at the oar handle. The ratio of these two forces ***Rg/h*** was derived, which from the equation (1) should be equal to the ratio of the actual oar length to outboard:

$$Rg/h = F_{gate} / F_{hnd} = L_{oar} / L_{out} \qquad (3)$$

When this ratio was plotted against oar angle (Fig.2a), it was amazing that the curve resembles the blade efficiency curve (***Eb***, RBN 2007/12). It is very unlikely that this resemblance could be explained by some systematic error of sensors because these two variables were derived completely independently: ***Rg/h*** from two force sensors, ***Eb*** – from the boat velocity, angular velocity of the oar and outboard.



The black horizontal line on the Fig.2a represents ratio of the actual levers $\mathbf{L_{oar}/L_{out}}$ derived geometrically, i.e. assuming that the resultant forces applied at the centres of the handle and blade. The ratio of forces ***Rg/h*** was equal to the ratio of levers $\mathbf{L_{oar}/L_{out}}$ at the middle of the drive, close to the perpendicular position of the blade. During the first half of the drive the ratio of forces was lower than ratio of levers, which could happen due to one of three reasons or a combination of them:

- If the actual outboard is longer, i.e. the resultant blade force is applied closer to the outer edge;
- If the actual inboard is shorter, i.e. the resultant handle force is applied closer to the inner edge;
- Inertia force caused by angular acceleration of the oar.

During the second half of the drive the ratio of forces ***Rg/h*** was higher than ratio of levers $\mathbf{L_{oar}/L_{out}}$, which could be explained by reversed reasons mentioned above.

It is unlikely that the actual inboard could be changed significantly in sculling, because in this case the resultant force should be applied far outside the handle. Also, small inertia force should not be a reason, because angular acceleration of the oar is very small during the drive.

Therefore, we have only one trustworthy reason left: variation of the actual outboard, which was already mentioned before (RBN 2003/08). It could be related to specifics of the blade hydrodynamics at various oar angles, depth (Fig.2d) and applied forces, which also affects blade efficiency, so the curves are similar. Fig.2e shows that **the derived centre of pressure moves outside of the blade at the end of the drive**. The reasons of these phenomena are not clear to us. All hypotheses are welcome.

References

1. BioRowTel Rowing telemetry system, http://www.biorow.com/PS_tel.htm