Analysis of the influence of stroke phase difference on the power delivery mechanism in racing kayak doubles.

The objective of this project is to identify the optimal phase difference between the entry time of the front and back blade of a kayak paddling crew that will provide maximum power delivery into the forward motion of a K2 (double racing) kayak illustrated in Figure 1.

Figure 1: K2 double racing kayak

The zero offset phase difference (two paddles entering the water with maximum force exertion at the same instance of time) is currently the most widely implemented technique used by kayak racing double athletes at present, however, this method results in a “surging” velocity curve for the kayak similar to that illustrated in Figure 2.

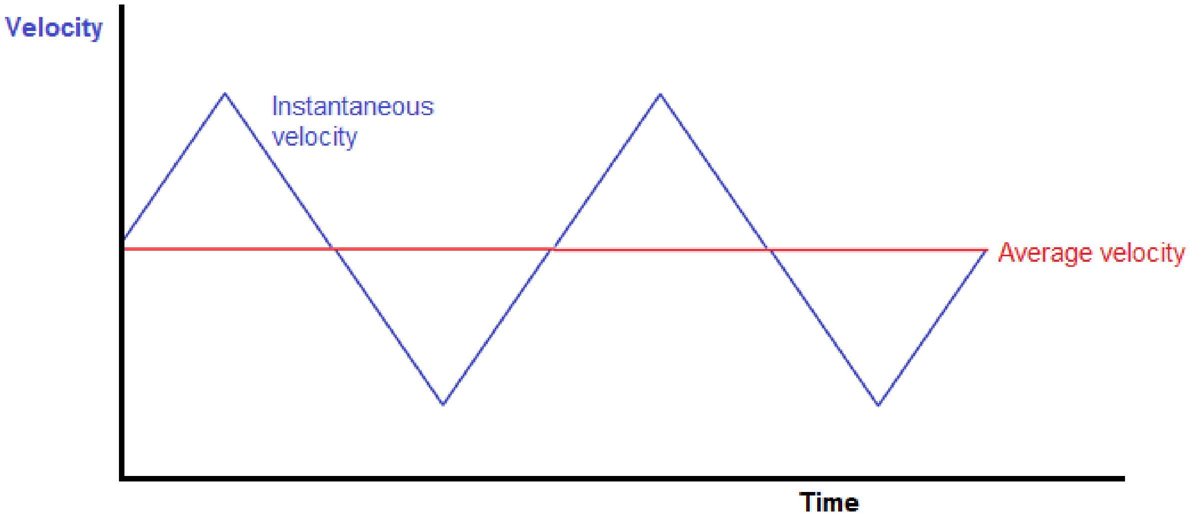

Figure 2: Surging velocity curve at 0 ^{o} phase offset paddling

The viscous drag force (F_d) between the kayak and water is quantified as follows:

$$F_d = {}^{1}\!/_{2}\,\rho V^2 S C_D$$

Where

ρ – Density of the water

V – Boat velocity

S – Wetted surface area of the kayak (surface area that gives rise to viscous drag forces)

C_D – Coefficient of drag between the kayak surface and the water

Since the power loss due to viscosity is proportional to the square of the velocity, there is a possibility that the power transfer mechanism could benefit from a more uniform mean velocity. This is achieved by reducing the peak velocity points when the maximum power exertion of the two paddles entering the water is staggered by a small degree. This method reduces the peak variation above the mean velocity and hence yields a reduction in the overall viscous losses of the kayak.

This project will analyse the power delivery mechanism to a kayak over a range of phase angles to determine the optimum. This will be implemented in the following steps:

1. Obtain power output data from a sample of 8 paddlers paddling at a number of pre-set cadences (paddles strokes per minute) over a range of resistances on a kayak ergometer. This information will be used to create average power output curves as a function of cadence over the range of resistances tested.
   A wireless load cell will record the load experienced by the kayak paddle shaft of the ergometer.
   A standard heart rate monitor will be worn by each paddler during ergometer testing to quantify the effort exertion over the range of resistances.
   The cadence at maximum power output for each participant will be identified. This information may aid the participant with the selection of a suitable paddle size and shaft length to achieve this optimum cadence.
2. The viscous drag forces for a K2 racing kayak will be determined by taking measurements of the wetted surface area of a range of 4 K2 kayaks alongside existing published hydrodynamic data such as the coefficient of drag. This information will be used in the viscous drag formula illustrated above.
3. A mechanical circuit to represent the power delivery sources and loads experienced by the kayak will be constructed using the results from steps 1 and 2 above. The force profiles recorded in step 1 will be used as the input for the circuit.
4. An analysis of the circuit described above will be conducted to identify the optimum point of power delivery using Excel, MATLAB and Simulink software packages.
5. Using the results of the analysis from point 4, a conclusion about the theoretical optimum paddle offset phase will be made. The benefits of the identified power transfer mechanism will be discussed.
6. Additional tests on-water will be conducted, if time permits, for comparison with the results of the circuit analysis (point 4). The test will be conducted on a body of still water such as a non-flowing lake or canal.
   Participants will be asked to paddle in time to a metronome to ensure the correct phase offset is achieved. Paddles equipped with a strain gauge will record the applied load

exerted on the paddle shaft. The velocity of the kayak will be measured using a GPS device located on the kayak shell.

A standard heart rate monitor will be worn by each paddler during on-water testing to quantify the effort exerted by each paddler when paddling at each phase offset.