

Efficiency of Hobie Mirage Oscillating Foils

1. BACKGROUND

Rick Willloughby and John Hawley have been corresponding on the performance of Hobie Mirage oscillating foils (flappers) since early August 2006. The objective has been to assess the performance of the flappers in an objective way using the available analysis tools.

John has two versions of the foils and two boats. This assessment is primarily based on the adventure hull using the turbo foils.

A Magellan Meridian Gold GPS was used for speed determination. It was set to the finest distance resolution of 0.01 miles. Heart rate was monitored using a readily available chest band/wrist receiver set. Power calibration was undertaken on a semi-recumbent Precor C8641 exercise machine.

2. METHOD

The method of analysis was based on the following process.

- A. The Hobie Adventure hull was modelled in FREEship based on the hull specifications and photos that John provided.
- B. The FREEship offsets were exported into the michlet hull drag CFD program to determine hull drag versus speed.
- C. Wave patches from the michlet program were compared to photos of the wake from the Hobie hull at various speeds to give a level of confidence in the michlet model.
- D. John powered the boat for a period of time at set speeds until his heart rate stabilised and then recorded the speed and heart rate.
- E. John calibrated his power output at various heart rates using the exercise machine.
- F. Rick analysed the data from the exercise machine to arrive at power level at particular heart rates for John and this data was combined with the hull drag data to arrive at propulsion efficiency.

3. HOBIE ADVENTURE

The data provided for the Hobie Adventure is:

- Length 16ft
- Beam 27.5"
- Hull Weight 60lb
- Drive Weight 7lb

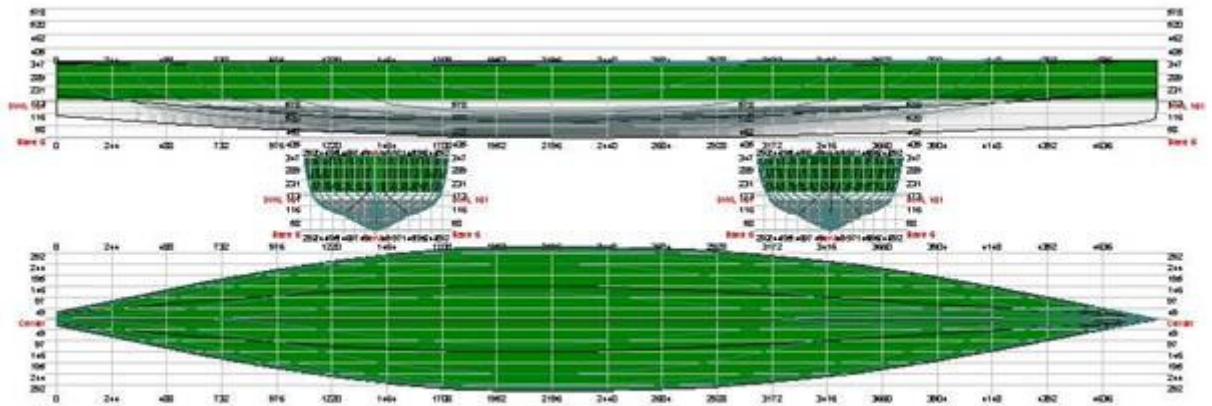
The hull has a reasonably flat rocker and a slight bulge along the keel line that is more pronounced in the bow and stern.

For modelling purposes the total displacement, including engine, was calculated to be 250lb.



4. THE FREESHIP REPRESENTATION

The approximate shape of the Adventure hull was modelled in FREESHIP to produce the following lineplan. Offsets from this model were exported to michlet for drag calculation.



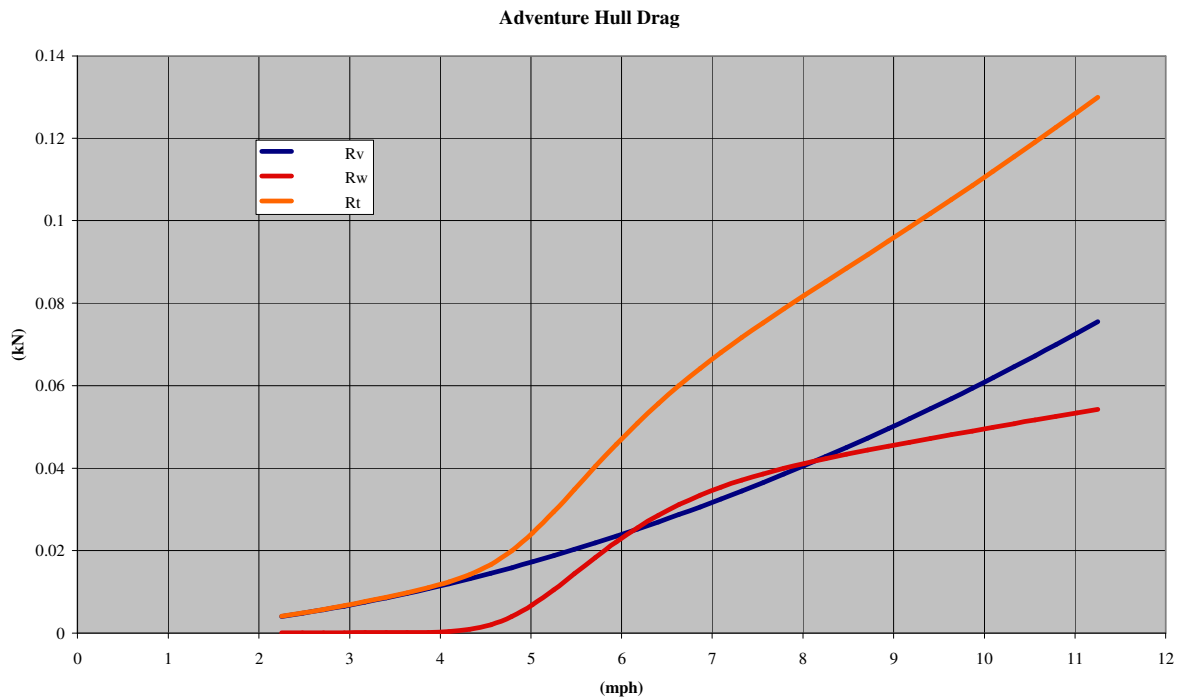
5. MICHLET WAVE PATCH

The following compares a photo showing the actual wake of the Adventure hull with the wave patch generated by michlet at 6mph. Michlet predicted a wave having peak-to-peak amplitude of 120mm (5") and this seems to fit the experience reasonably well.



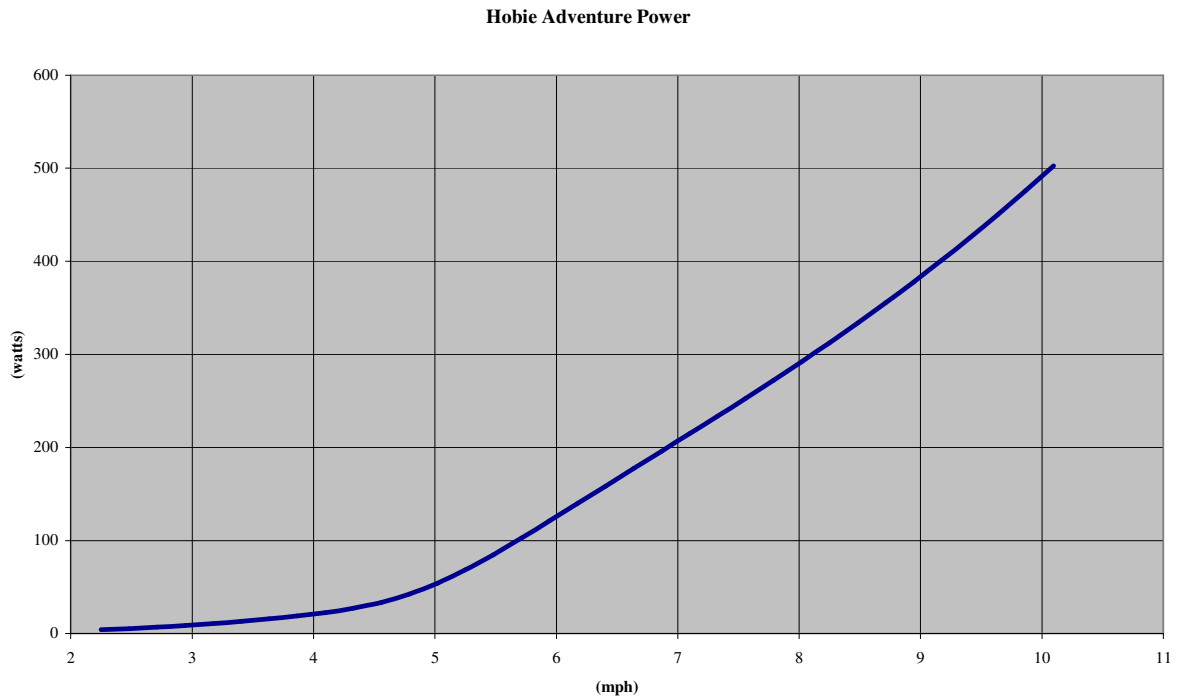
6. MICHLET DRAG DATA

The following chart was produced from the drag data generated by michlet. It is apparent that wave drag begins to be significant around 4.5mph. This is the speed that John found to be very easy going and felt the resistance build significantly above that speed.



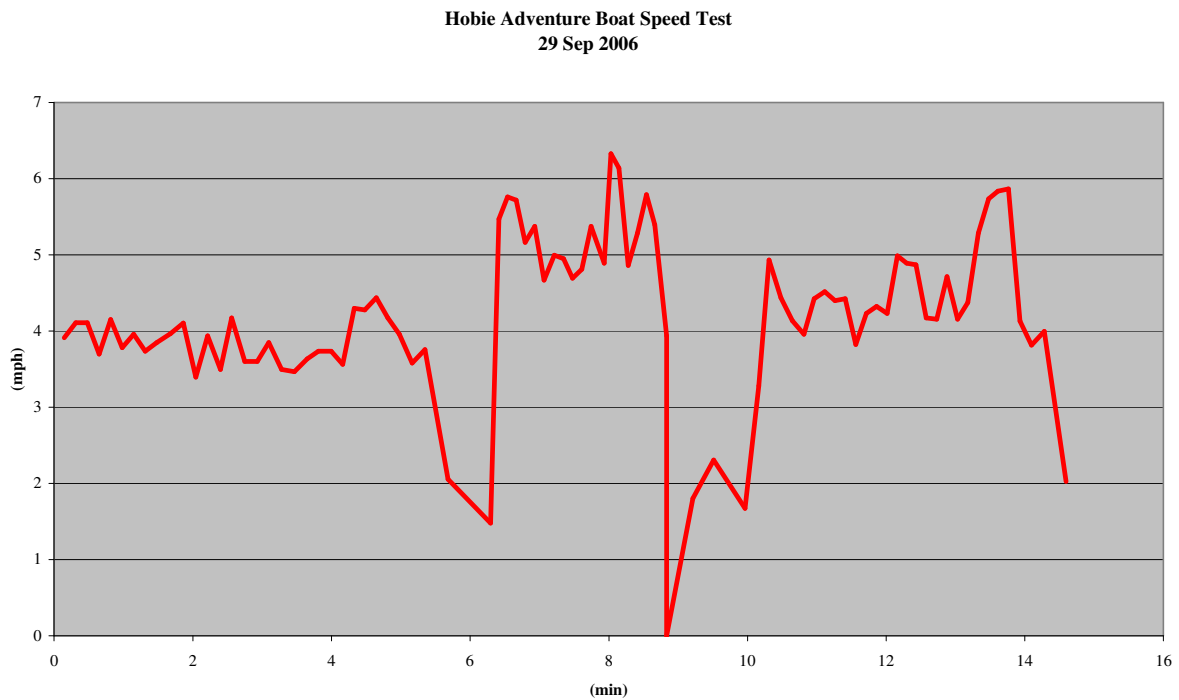
7. MICHLET POWER DATA

Michlet also produces power data based on the total drag and the hull speed. The following curve shows that data for the Hobie Adventure up to 10mph.



8. BOAT PERFORMANCE DATA

John carried out a number of different performance tests on 29th September 2006. The data set used for analysis purposes involved three runs in the Adventure hull using the turbo flappers. The following chart shows the actual speed recorded on the GPS during these runs and gives an indication of the variability in the data. Heart rate was recorded toward the end of each run.

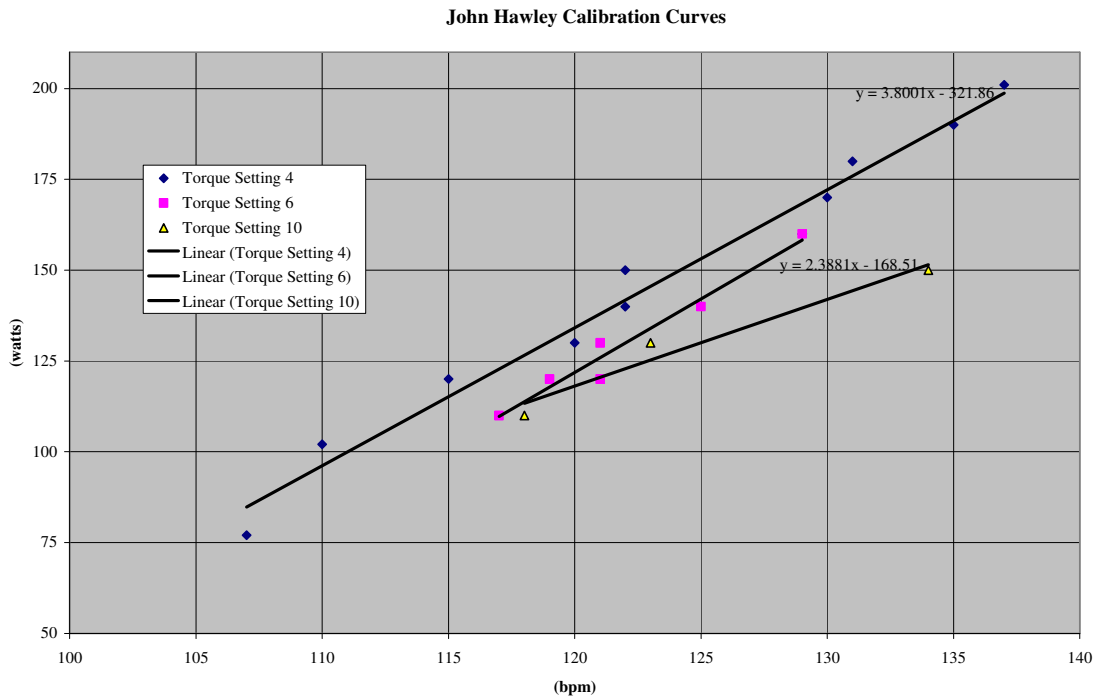


8.1. DATA RECORDED

Heart Rate	Boat Speed
(bpm)	(mph)
107	3.8
118	4.5
132	5.3

9. JOHN HAWLEY CALIBRATION

John carried out a series of tests on an exercise machine. There were three sets of data. Each produced at different resistance levels on the exercise machine. The resistance level was adjusted from 4 to 6 then 10 in that order.



The duration of operation at each power level may have been too short for the heart to stabilise and it is likely that fatigue was a factor on the higher torque setting. John felt the pedal weight at level 10 was closer to that felt with the turbo flappers than with the lower settings. The data indicates that the engine is more efficient at lower torque settings but the exercise would need to be repeated in reverse order to verify this.

The black lines show linear regressions for the three data sets.

9.1. REGRESSION DATA

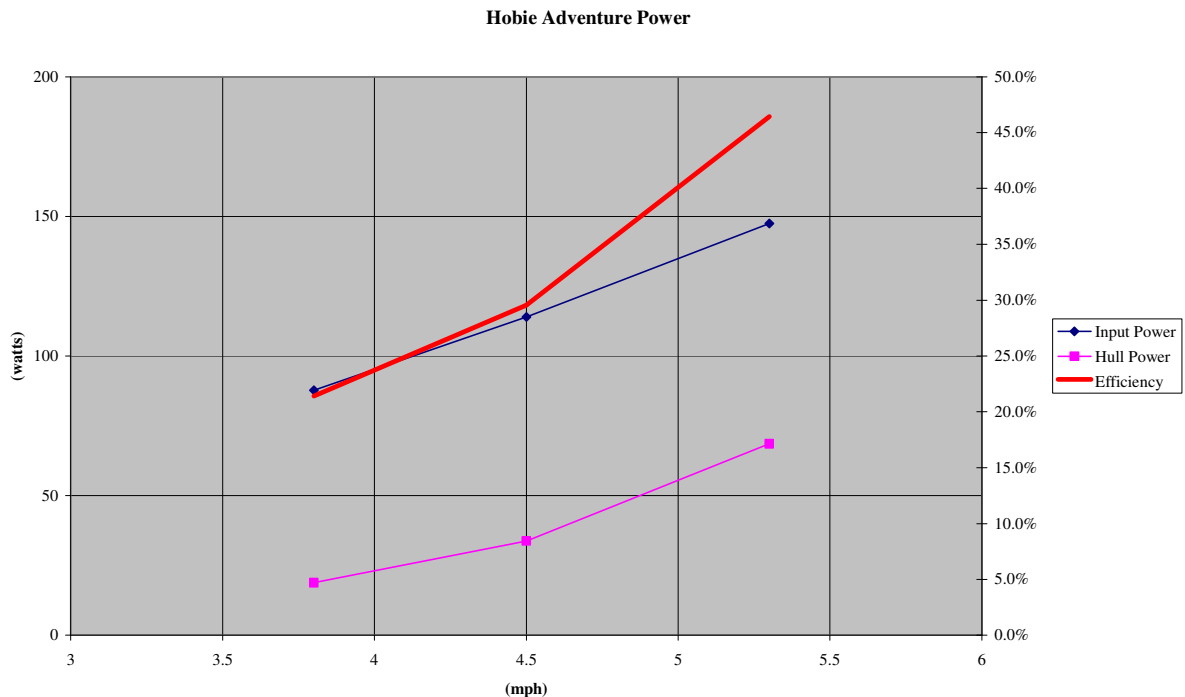
Heart Rate	J. Hawley Output	
	Level 4	Level 10
(bpm)		
107	84.6	87.7
118	126.4	114.0
132	179.6	147.4

The data in the table shows the variation in power level for heart at rate at the low and high load levels for the heart rates recorded during the three speed runs.

For efficiency determination the lower power output has been used as the higher load level was closer to the feel of the turbo flappers. This also provides the most optimistic efficiency figures.

10. FLAPPER EFFICIENCY

Combining the previous data with the michlet power data for the hull enables overall efficiency to be calculated for the three speeds that were tested. The following chart indicates that the efficiency improves as the speed increases. The highest efficiency determined is 46.4% at 5.3mph.



10.1. OBSERVATIONS

The poor efficiency at the lower speed is probably due to the stiffness of the flappers wherein they would be working at high angles of attack due to the light load causing little twist. In this regard they are akin to a variable pitch prop that is arranged to work to limit torque demand at higher speed. They would not build torque in the same way as a fixed pitch propeller does.

Taking the power calibration data from the low torque power test gives a best efficiency of 38.1% so there is wide variability in this data.

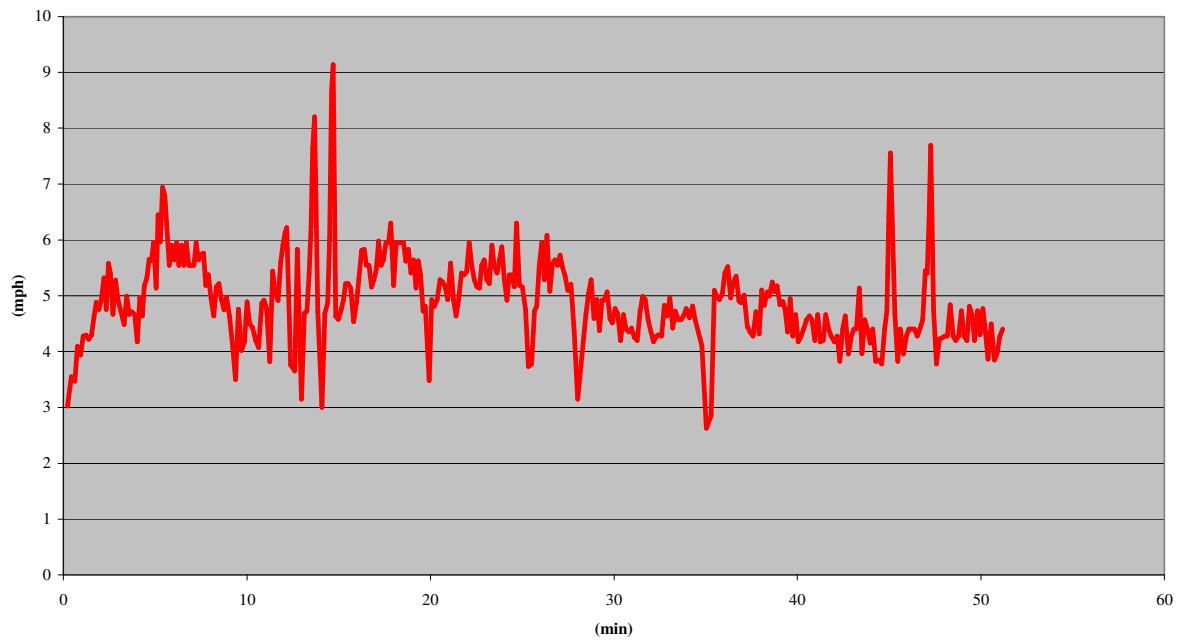
It is likely that the turbo flappers are suited to powerful individuals and it would be interesting to see data for higher speeds as the efficiency curve is still rising. It should be noted that the efficiency of the standard flappers and the turbo flappers is almost identical in the 3.5 to 5.5mph range.

John conducted more sustained cruising tests on 8th October 2006 and managed to push the Adventure hull to 9.14mph. The michlet data indicates that this requires 400watts so at 46% efficiency the power required would be 860W. John is yet to run the exercise machine to maximum output so this is yet to be determined.

The Hobie Adventure is a competent cruiser and readily achieves the often advertised cruising speed of 5mph with a well-tuned engine. The top speed recorded of 9.14mph exceeds any advertised performance claim from reputable suppliers. It is conceivable that the boats could be pushed to 10mph with an athletic pilot having experience with the pedal motion.

11. LATEST SPEED DATA

Hobie Adventure Boat Speed



Rick Willoughby
17th October 2006