Final Report -MEE 488

Human Powered Submarine- Dynamometer

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INTRODUCTION

The Human Powered Submarine is an annual competition where students from all over the country design and build a submarine that is powered by a SCUBA diver. Since the fall of 2001, the Mechanical Engineering Department at the University of Maine has been developing its own HPS which will be entered in the competition for the first time in summer 2006.

PROBLEM AND OBJECTIVES

Due to the abnormal aerodynamics of the HPS, drag of the fins, unknown force of the oscillating hydrofoil propulsion system, and many other variables, it is unknown just how much force it will take to get the HPS up to potentially world record breaking speeds. The Current record is 4.114 mph (3.574 knots). Our group's goal was to design and build dynamometers that would measure the dynamic drag and static thrust forces on the sub as it is being propelled through the water. Another goal for our group was to get the HPS ready for competition in June.

DESIGN OF DRAG MEASURING DYNO

The design of the dynamometer that measures the dynamic drag of the sub takes advantage of some very basic moment principles (see figure 1). It is designed to be attached to the back of a boat. The sub is attached to the moment arm of the dynamometer. The boat moves through the water and it's velocity is measured by a GPS device. The drag of the water on the submarine pulls on the moment arm of the dynamometer which is attached to a scale that measures that force at that velocity. With the length of the moment arm known, we can then very easily calculate the force of the water on the sub. This setup enables us to measure drag over a range of velocities and develop a correlation between drag and velocity. We conducted this test twice with the sub completely submerged.

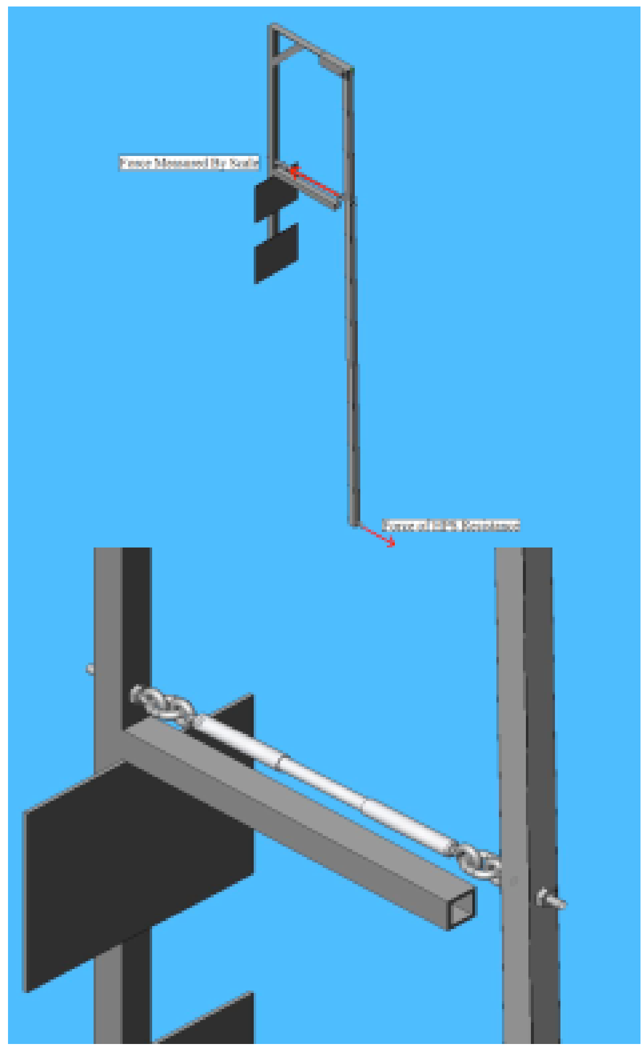
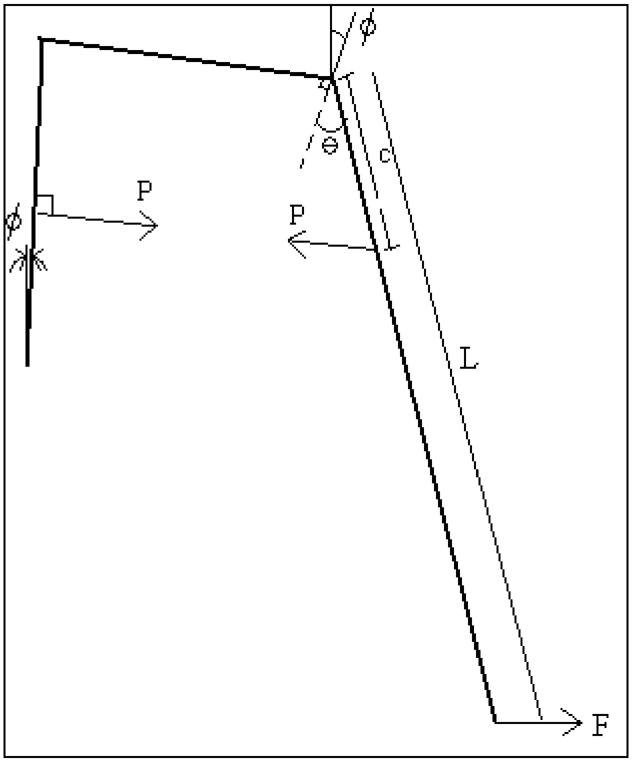


Figure 1. SolidWorks® Imaging of Dynamic Drag Dyno



Static Analysis of Dynamic Drag Dyno.

For this dynamometer, we measure the force, P and want to find the force, F, which is the dynamic drag. The force is given by the following equation:

$P\cos(c)=F\cos(\phi-\theta)L$

$F=P\cos(\theta)c/\cos(\phi-\theta)L$

DYNAMIC DRAG RESULTS

We first preformed the testing for the dyno with a rubber ball filled with water. The goal of this was to measure the drag of a known shape to see what orders of magnitude of dynamic drag we would be working with when we tested the HPS itself. After that, we measured the drag of the sub twice. Figures 2 and 3 are the graphed results of dynamic drag versus speed of the HPS. The force of drag increases exponentially as the speed increases. We are not sure how accurate these results are due to the fact that we could not get in the water to make sure that the sub was being dragged straight. The slight variation in the data could be attributed to an unknown underwater current or slight inaccuracies in measurement of boat speed.

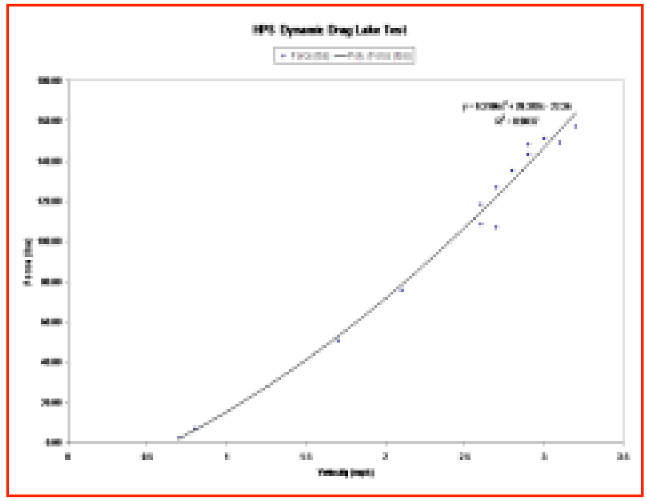


Figure 2. Drag Test 1.

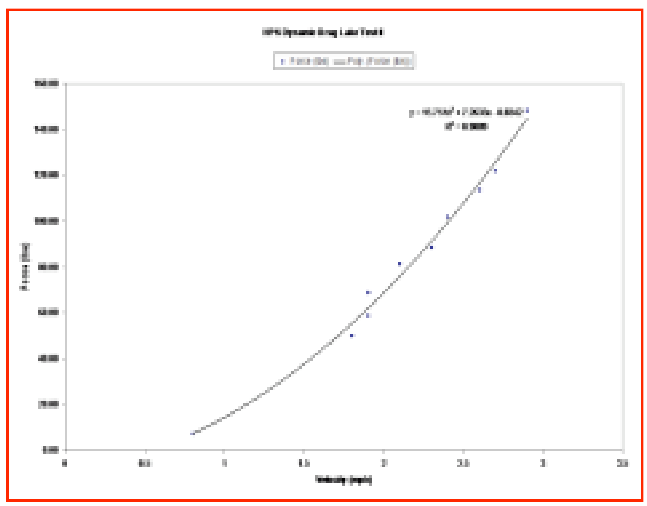
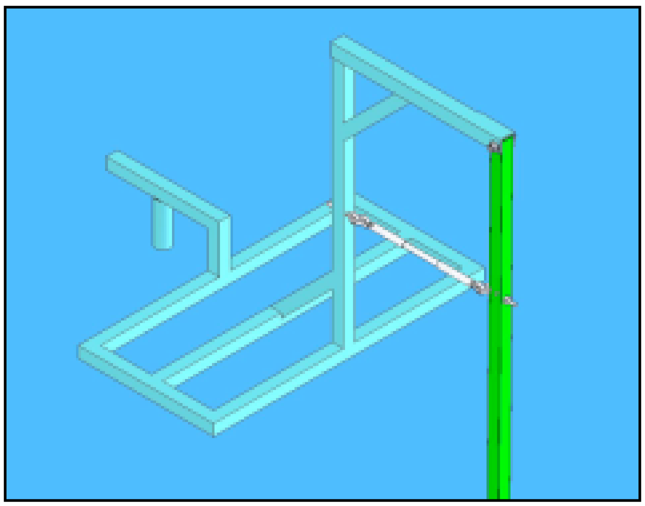


Figure 3. Drag Test 2.

DESIGN OF THRUST MEASUREING DYNO

The design for the thrust measuring dyno incorporates the same basic moment principles. The thrust dyno is anchored to the side of the pool and measures static thrust of the HPS while a SCUBA diver is in the sub pedaling. The thrust dyno, however, uses strain gages connected to a DAQ system and laptop instead of a scale like on the dynamic drag dynamometer. We also determined the strongest peddler using the thrust dyno data. Figure 4 is the SolidWorks® images of the thrust dyno.



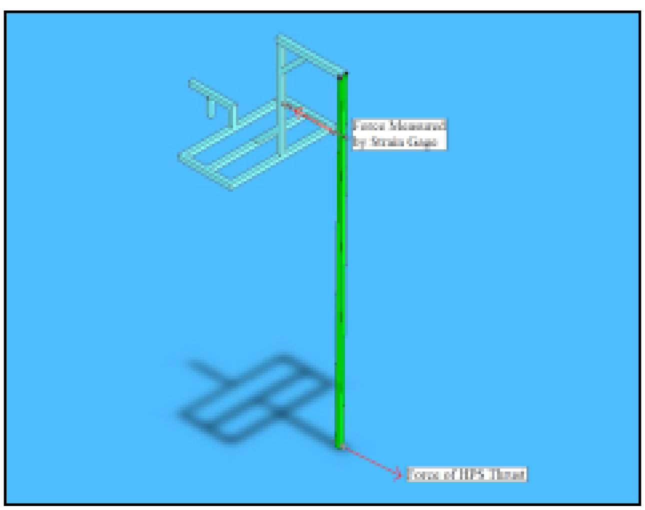


Figure 4. SolidWorks® Imaging of Dynamic Drag Dyno

THRUST RESULTS

Using the data collected, we determined that Chris Walker was the strongest peddler and the group member that would have the best chance at setting a new world record. Below are the graphs of the four test we ran.

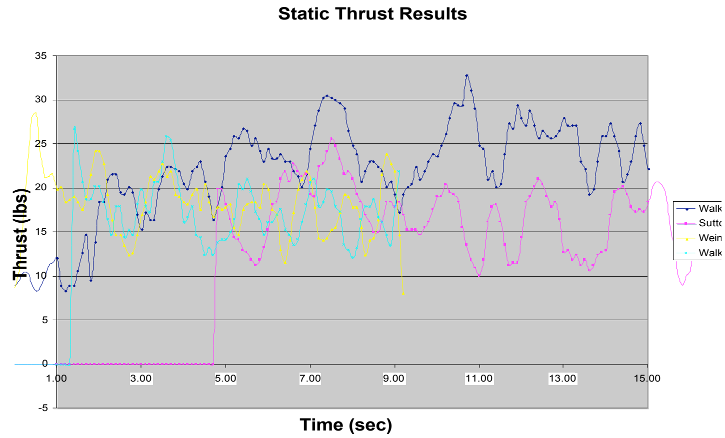


Figure 5. Static thrust for four tests