THE KITESHIP PROJECT

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ABSTRACT

The objective of this project is the development of specialized airborne kites (instead of masts and sails) for boat propulsion in the merchant marine. Our kiteboat #2, a lightweight fiberglass proa 7.3 m long, has been sailed with 2 different sizes of kites in fresh water. The kites are shaped like wings, with areas of 3.7 sq m and 9.3 sq m. The proa is steered with two coupled rudders, one fore and one aft, which worked quite well. We have been encouraged by the boat speed and the handling, although we have encountered only light winds up to now, of no more than about 20 km/hr. In the near future we will receive a custom-built kite of 27.9 sq m, and will also start sailing in the ocean with heavier winds, of about 40 km/hr and higher.

1. INTRODUCTION

1.1 On Kiteships

When merchant marine vessels were wind-powered, only the use of masts and sails (Ref. 13) was possible. The use of kites would have required an understanding of the aerodynamics of wing cross sections, powered and computerized controls, plus sailcloth and rigging much lighter and stronger than was available at the time. The world is now different, but the current sailing sciences are still aimed primarily at the mast and sail combination (Refs. 5, 6, 8, 9, 10), although some of it is quite imaginative (Ref. 14).

If wind power is to become cost-effective in the merchant marine again (as a fuel saving measure), then large deployed wing-like kites are likely to be employed. Similar kites have recently become popular for wind surfing (or kite surfing), for kite buggies on dry lakes, and for some catamarans. Such kites can fly high up in the sky, far from the effects of the waves and of the boat hull, in steadier and stronger wind conditions. One can maneuver the kite back and forth in the sky, so that the kite travels through the air faster than the boat, hence increasing the available power significantly. The kites can achieve a lift-to-drag ratio of at least 6 to 1, which can give a boat more versatility and more power than is possible with masts and sails.

These kites can power a boat without the dangerous overturning moments associated with masts and sails. The traction to a kiteboat is provided at one point. Since the best location for this point will change depending on the heading of the boat and the wind direction, we use a track mounted on the boat to which a small trolley is rigged to hold the kite lines. It is anticipated to be relatively simple and cheap to retrofit this on existing freighters and other ships. There have been a number of publications in which the potential of kiteship technology has been considered (Refs. 1, 3, 7, 11, 12). We recently started work again in this area (Refs. 1, 3, 4, 12).

1.2 On The Fossil Fuel Competition

In our earlier ASES paper (Ref. 1) we mentioned that the foreseeable crude oil shortages (Ref. 2) can provide an incentive to use windpower in the merchant marine again, to save fuel by providing some of the propulsion power. At the time we were considering primarily the decrease one can expect in crude oil production when the reserves are depleted sufficiently so that oil production can not be made to rise any further. In a typical oil field or oil producing region (or in the whole world), that happens when about half of the recoverable oil has been produced. This was

first described by Hubbert in 1948 (Ref. 2), and has been demonstrated in many thousands of oil fields of all sizes, and in many regions and nations before and after 1948.

Even though the world oil resources are not yet depleted to the halfway point, recently the oil market has been tight, and crude oil prices have tripled. This may have been started by an OPEC production cut to get the oil price up to a reasonable level, but the problem goes deeper. Outside of the Middle East, the oil fields of virtually the whole world are already in decline, yet most of them are being pumped as fast as possible, as if there were no tomorrow. In the Middle East, during the years of oil gluts and low oil prices, the oil production infrastructure was not built up enough to handle the extra oil demand now being created by the current economic upturn in Asia. The result is a tight oil market, and high oil prices unlikely to go down soon, if ever (Ref. 2).

Things may get worse rather than better. Many oil or natural gas exporting countries (Norway, England, Mexico, Algeria, Indonesia, Canada, the Netherlands, etc.) have been developing, producing, and depleting their oil and/or natural gas fields as fast as they can (Ref. 2). When they realize that their own future depends on stretching out their supplies of oil and gas, the needs of the rest of the world may seem much less urgent, and the oil market may become ever tighter, no matter how cooperative OPEC wants to be, or how much new infrastructure is installed in the Middle East.

Coal and synfuels will not be able to help much. Concerns of global warming may even make it unwise to use up our fossil fuel resources much further. It is likely that in the next year or two the understanding of global warming will become clear enough to define the incentives (carbon taxes) that will be needed to slow down the use of fossil fuels as much as necessary. When the public realizes that oil and gas are limited resources, that the atmosphere needs protection, and that there is no need for higher total tax rates, it may be easy to replace other taxes by carbon taxes. If carbon taxes had been imposed earlier they might have limited the current S.U.V. (Sport Utility Vehicle) popularity. This S.U.V. popularity is not likely to last much longer.

It has been known for long that renewable energy devices like commercial kiteships would never be able to succeed so long as there was enough cheap crude oil to keep or force them out of the "free market" (Ref. 15). When it becomes recognized that abundant and cheap crude oil is gone forever, the "free market" may offer renewable energy a place at the table. That may be soon.

2. PROGRAM RESULTS

Boat #2 on our R&D program is a lightweight fiberglass proa built with the large hull 7.3 m long, and the small hull 6.1 m long. It has been sailed on a large lake called Frank's Tract in the Sacramento Delta in California. (See figure 1.)

Fig. 1
Proa on Frank’s Tract with Low Wind Speed

Starting in the near future it will also be sailed in the Monterey Bay. In both sites there are often steady wind conditions of about 40 km/hr in large open areas, but last summer in Frank's Tract we found winds no stronger than about 20 km/hr. The boat was sailed with two sizes of kites: 3.7 sq m and 9.3 sq m. (see figure 2). These were available at the start of the program, and had been used with kite buggies on dry lakes. They both have an aspect ratio (of wingspan to chord) of about 4 to 1. The next kite, a 27.9 sq m kite custom made for this program, has an aspect ratio of 3 to 1, and will be received shortly.

For the small kites the lines were led to a system of pulleys mounted on a rail on the downwind side of the proa. The pulling force or traction of the kite was transferred by the pulley assembly to the boat, and the pilot handled the control lines. With the large kite the pull can be as high as 4,500 N (1,000 lbs) and can be quite variable. For the large kite a pulley and reel system has been developed which also transfers the kite traction directly to the boat, enabling the pilot to handle only the control forces, and which makes it possible to reel the kite in and out. This can be used to launch or retrieve the kite, or to fly the kite further out or closer in.

The speed obtained with these kites has been encouraging. The 3.7 sq m kite pulled the boat at an estimated speed of 10 km/hr in windspeeds of about 20 km/hr. Under the same conditions the 9.3 sq m kite produced speeds of about 16

km/hr. In the near future we will be sailing with stronger winds, of up to 40 km/hr, and with our larger (27.9 sq m) kite.

Figure 2
Kite Flying Overhead

The proa is symmetrical fore and aft, so it can sail in either direction. It is tacked or gibed by changing the direction of travel, rather than by turning the boat and continuing forward in another direction. The steering is done with two coupled rudders, one fore and one aft, with rudder blade cross sections which have to be pointed in the direction of travel. Proas always present the same side to windward and to leeward, regardless of the direction of travel. This and other peculiarities of their geometry make them particularly suitable for kite power. Boat #2 has typically been sailed with a crew of two people: a pilot to handle the kite and a helmsman to handle the steering. The boat is very responsive to the steering, but getting accustomed to the steering arrangement has been tricky.

A supporting motorboat has been considered essential not only to tow the proa as necessary, but to provide help in case of emergencies. The kite-pulled proa is a lightweight experimental craft that could be subjected to very high power and stresses by wind gusts. Structural failures could happen quite suddenly, and it is desirable to have help nearby.

The supporting motorboat has still been used to launch or deploy the kites. The kites were retrieved by being dived into the water. The kites dried rather rapidly after going into the water, so that they could be deployed again in short order. Large kites might however be damaged, destroyed, or lost in the water, particularly in stormy weather. During the remaining work on our boat #2 and boat #3 we must develop better and more convenient ways of deploying and retrieving the kites, without the use of a second boat, and without having the kite go into the water.

3. CONCLUSIONS AND FUTURE PLANS

Results with our boats #1 and #2 have been encouraging, and we expect to continue work with boat #2 during this year. Subsequently we plan to obtain boat #3, probably a single- or multi-hulled vessel with a length of 15 to 20 meters. The objectives of boat #3 will include traction tests with larger kites, and computerized kite control using a computer with custom designed software and motorized reels for the control cables. In addition to the kites we have now, for boat #3 we plan to use kites with an area of about 100 sq m. By the time of the ASES meeting, we will present our new results, together with photographs and videos on our activities during the spring season.

4. REFERENCES AND BIBLIOGRAPHY

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