THE SAIL WING WINDMILL AND ITS ADAPTATION FOR USE IN RURAL INDIA

Marcus M. Sherman

New Alchemy Institute
Woods Hole, Massachusetts

A 25-foot diameter sailwing windmill was built in 1973 in a small village near Madurai, Tamilnadu State, India. This windmill is the result of design research conducted in the U.S.A. at the New Alchemy Institute--East (refs. 1 and 2) and in India at the Indian Institute of Agricultural Research (refs. 3 and 4) and the Wind Power Division of the National Aeronautical Laboratory (ref. 5). It is to be used mainly in light winds during the dry winter months for irrigating small fields, watering dairy cattle and supplying water for domestic use.

In many parts of India there are adequate supplies of ground water which are unavailable to farmers during the dry season because of inadequate power resources for pumping. Three to eight horsepower diesel pumps are frequently used, but they are expensive to operate because of the high cost of imported oil and often must be taken out of service for costly and time-consuming repairs. Efficient 5-horsepower electric pumps are being used more and more as rural electrification proceeds, but only well-to-do farmers can afford to buy and maintain them. Recently in South India there has been a 75 percent power cut to the rural areas due to heavy use in the cities and to overexpansion of the power grid without a corresponding increase in supply. This power shortage means that there are only 4 hours of electric pumping per day. This situation is expected to worsen for the next 4 to 5 years until the Indian Government begins operation of atomic power plants in South India. At the present time bullock operated pumps remain the most common and reliable source of irrigation water for subsistence farming. Water for domestic use is usually hand-lifted with a rope and bucket from open wells.

During the early 1960's the Wind Power Division of the National Aeronautical Laboratory in Bangalore, Mysore, developed, tested, and produced two hundred 12-bladed fan-type windmills which demonstrate the feasibility of using wind power to pump water to South India (ref. 6). Several types of imported European and American multibladed windmills have also been used to harness India's abundant wind energy resources. However, due to lack of public awareness of the subject and the unavailability of an even simpler and less expensive device, wind power remains only occasionally exploited.

Cloth sails with a wooden framework have been used for hundreds of centuries for transforming the useful energy of the wind into labor saving mechanical work, especially grinding grain and pumping water. The use of windmills spread from Iran in the seventh century A.D. to coastal China where the application of the art of sailmaking significantly improved the sophistication of windmill construction (ref. 7). Heavy rigid wood windmill blades surfaced with cloth were increasingly used throughout northwestern Europe so that by the seventeenth century the Netherlands became the world's richest and most industrialized nation, largely as a result of extensive exploitation of windpower with ships and windmills. Cloth was a natural choice for windmill sails because of its acceptance and wide use in sailing ships. It is lightweight, easy to handle, readily and cheaply available, and most importantly it forms a strong uniform surface for catching the wind when firmly supported at three or more points.

In the Mediterranean region flour-grinding and oil-pressing mills were rigged with six to twelve triangular cloth sails set on simple radial spars. A three-dimensional array of guy ropes radiating from a central spar projecting out along the axis of the main shaft suspended the sails in position, rather than a heavy grid of wood as was used in the traditional Dutch-type windmills. This sailboat jib type of rigging was a significant improvement in windmill design which encouraged the spread of windmills throughout the deforested Mediterranean countries. The wind capturing area of these windmills was controlled by wrapping each cloth sail around its spar. Though requiring daily rigging adjustments and occasional replacement of tattered sails, the efficiency and simplicity of these windmills resulted in their widespread use in Rhodes, the Black Sea coast, the Aegean Islands, and Greece. In Portugal their use was accompanied by the sound of whistles attached to the rigging, an audible indicator of the wind at work. In the West Indies large sailing windmills were commonly used for crushing sugar cane (ref. 8). Many handcrafted windmills with eight triangular jib sails are presently pumping irrigation water in the Plain of Lassithi, Crete (ref. 9). In Japan four-bladed jib sail windmills are used to operate reciprocating pumps which supply water to vegetable gardens. A high-speed aerodynamic, two-bladed sail wing is being developed (refs. 10 and 11). Further construction simplifications may make it applicable to use in lesser developed countries.

A windmill with four self-adjusting cloth sails was developed for rural markets in less industrialized regions (ref. 12). Its relatively complex design is limited because of the difficulty in connecting it to a deep well pump. Unfortunately, it cannot be manufactured by hand using local materials. Those people who are in a situation to most benefit from a windmill are also those least able to pay for it. If the critical moving parts were separately available, a small farmer could purchase the remaining materials needed and assemble the windmill in his own village using local skills and labor. This way a major portion of the money spent would remain in the village.

The 8-meter-diameter prototype sail wing windmill recently erected on a small peanut and sesame farm in a dry hilly region in South India lifts 300 pounds to a height of 20 feet in 1 minute in a 10 mph wind. This is accomplished by a rope passing over a 6-inch pulley on the main drive shaft. This lift is used to lift soil and rock from the well being hand dug below the windmill. The windmill will be set up to operate a modified paternoster or chain pump like those used to drain mines in England many years ago. Recently chain pumps have been rapidly replacing the traditional square-pallet pump and the noria water lifting wheel throughout China. A chain pump, easily and cheaply built, is more efficient than most types of pumps. Most importantly, it operates well with a low-speed, variable power source.

This sail wing windmill is made of a 1-meter-diameter bullock cart wheel to which three bamboo poles are lashed in a triangular pattern with overlapping ends. Each bamboo pole forms the leading edge of a wing, and a nylon cord stretched from the outer tip of the pole to the rim of the wheel forms the trailing edge. A stable and lightweight airfoil results from stretching a long narrow triangular cloth sail over that bamboo-nylon frame. This wing configuration, a hybrid of low-speed eight-bladed Cretan sail wings and high-speed two-bladed aerodynamic sail wings, produces high starting torque at low wind speeds. The bullock cart wheel is attached at the hub to the end of an automobile axle shaft which rotates in two sets of ball bearings. The shaft and bearing assembly is mounted horizontally on top of a turntable. The turntable consists of two circular steel plates separated with a raceway of ballbearings and held together with a ring of eight bolts which encircle the bottom plate. A 1-foot diameter hole through the center of the turntable will allow the chain and gaskets of the chain pump to go up and around the "squirrel cage," which is mounted at the center of the automobile axle. If a reciprocating, deep-well piston pump were desired, the reciprocating rod, rather than a chain, would go through this hole and the crankshaft rather than an axle shaft would be mounted on top of the turntable. Since the blades have a slight built-in coning effect and the axle or crankshaft is mounted slightly off center from the centerline of the turntable, the blades act as their own tail, trailing in the wind. Because the blades are downwind from the tower, there is no danger of the bamboo poles bending in a monsoon wind and hitting the tower. The tower is made of five 25-foot long teak poles set in concrete at the base and bolted at the top to five angle irons welded at a slight flaring angle to the bottom of the turntable. The tower tapers in towards the turntable at the top from a 7-foot diameter at the base. It has cross bracing and a ladder.

It is hoped that other persons will continue to refine and adapt this windmill to their own needs and materials. Please send all inquiries, operating experience, and suggestions for improvement to: Marcus M. Sherman, New Alchemy Institute--East, Box 432, Woods Hole, Mass. 02543.

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THE SAIL WING WINDMILL AND ITS ADAPTATION FOR USE IN RURAL INDIA

Figure 1