Manufacturing and Material of Wind Mill: The Review

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Abstract: ***A windmill is a machine that converts the energy of wind into rotational energy by means of vanes called sails or blades. The name stuck when in the course of history, windmill machinery was adapted to supply power for many industrial and agricultural needs other than milling. The majority of modern windmills take the form of wind turbines used to generate electricity, or wind pumps used to pump water, either for land drainage or to extract groundwater. The wind wheel of the Greek engineer Heron of Alexandria in the first century AD is the earliest known instance of using a wind-driven wheel to power a machine. Another early example of a wind-driven wheel was the prayer wheel, which was used in ancient Tibet and China since the fourth century.A wind turbine is a machine that converts the wind's kinetic energy into rotary mechanical energy, which is then used to do work. In more advanced models, the rotational energy is converted into electricity, the most versatile form of energy, by using a generator.***

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1. Introduction

For thousands of years people have used windmills to pump water or grind grain. Even into the twentieth century tall, slender, multi-vaned wind turbines made entirely of metal were used in American homes and ranches to pump water into the house's plumbing system or into the cattle's watering trough. After World War I, work was begun to develop wind turbines that could produce electricity. Marcellus Jacobs invented a prototype in 1927 that could provide power for a radio and a few lamps but little else. When demand for electricity increased later, Jacobs's small, inadequate wind turbines fell out of use. The first practical windmills had sails that rotated in a horizontal plane, around a vertical axis. According to Ahmad Y. al-Hassan, these panemone windmills were invented in eastern Persia as recorded by the Persian geographer Estakhri in the ninth century. The authenticity of an earlier anecdote of a windmill involving the second caliph Umar (AD 634–644) is questioned on the grounds that it appears in a tenth-century document Made of six to 12 sails covered in reed matting or cloth material, these windmills were used to grind grain or draw up water, and were quite different from the later European vertical windmills. Windmills were in widespread use

across the Middle East and Central Asia, and later spread to China and India A similar type of horizontal windmill with rectangular blades, used for irrigation, can also be found in thirteenth-century China (during the Jurchen Jin Dynasty in the north), introduced by the travels of Yelü Chucai to Turkestan in 1219.

2. Types of Wind Mill

Horizontal windmills were built, in small numbers, in Europe during the 18th and nineteenth centuries, for example Fowler's Mill at Battersea in London, and Hooper's Mill at Margate in Kent. These early modern examples seem not to have been directly influenced by the horizontal windmills of the Middle and Far East, but to have been independent inventions by engineers influenced by the Industrial Revolution

Vertical windmills

Due to a lack of evidence, debate occurs among historians as to whether or not Middle Eastern horizontal windmills triggered the original development of European windmills In northwestern Europe, the horizontal-axis or vertical windmill (so called due to the plane of the movement of its sails) is believed to date from the last quarter of the twelfth century in the triangle of northern France, eastern England and Flanders.

The earliest certain reference to a windmill in Europe (assumed to have been of the vertical type) dates from 1185, in the former village of Weedley in Yorkshire which was located at the southern tip of the Wold overlooking the Humber estuary A number of earlier, but less certainly dated, twelfth-century European sources referring to windmills have also been found These earliest mills were used to grind cereals.

Blades Design

There are two classes of windmill, horizontal axis and vertical axis. The vertical axis design was popular during the early development of the windmill. However, its inefficiency of operation led to the development of the numerous horizontal axis designs.

Of the horizontal axes versions, there are a variety of these including the post mill, smock mill, tower mill, and the fan mill. The earliest design is the post mill. It is named for the large, upright post to which the body of the mill is balanced. This design gives flexibility to the mill operator because the windmill can be turned to catch the most wind depending on the direction it is blowing. To keep the post stable a support structure is built around it. Typically, this structure is elevated off the ground with brick or stone to prevent rotting.

The post mill has four blades mounted on a central post. The horizontal shaft of the blades is connected to a large break wheel. The break wheel interacts with a gear system, called the wallower, which rotates a central, vertical shaft. This motion can then be used to power water pumping or grain grinding activities.

The smock mill is similar to the post mill but has included some significant improvements. The name is derived from the fact that the body looks vaguely like a dress or smock as they were called. One advantage is the fact that only the top of the mill is moveable. This allows the main body structure to be more permanent while the rest could be adjusted to collect wind no matter what direction it is blowing. Since it does not move, the main body can be made larger and taller. This means that more equipment can be housed in the mill, and that taller sails can be used to collect even more wind. Most smock mills are eight sided although this can vary from six to 12.
Tower mills are further improvements on smock mills. They have a rotating cap and permanent body, but this body is made of brick or stone. This fact makes it possible for the towers to be rounded. A round structure allows for even larger and taller towers. Additionally, brick and stone make the tower windmills the most weather resistant design.

While the previous windmill designs are for larger structures that could service entire towns, the fan-type windmill is made specifically for individuals. It is much smaller and used primarily for pumping water. It consists of a fixed tower (mast), a wheel and tail assembly (fan), a head assembly, and a pump. The masts can be 10-15 ft (3-15 m) high. The number of blades can range from four to 20 and have a diameter between 6 and 16 ft (1.8-4.9 m).

3. Raw Materials

Windmills can be made with a variety of materials. Post mills are made almost entirely of wood. A lightweight wood, like balsa wood, is used for the fan blades and a stronger, heavier wood is used for the rest of the structure. The wood is coated with paint or a resin to protect it from the outside environment. The smock and tower mills, built by the Dutch and British prior to the twentieth century, use many of the same materials used for the construction of houses including wood, bricks and stones.

The main body of the fan-type mills is made with galvanized steel. This process of treating steel makes it weather resistant and strong. The blades of the fan are made with a lightweight, galvanized steel or aluminum. The pump is made of bronze and brass that inhibits freezing. Leather or synthetic polymers are used for washers and o-rings

A wind turbine consists of three basic parts: the tower, the nacelle, and the rotor blades. The tower is either a steel lattice tower similar to electrical towers or a steel tubular tower with an inside ladder to the nacelle.

The first step in constructing a wind turbine is erecting the tower. Although the tower's steel parts are manufactured off site in a factory, they are usually assembled on site. The parts are bolted together before erection, and the tower is kept horizontal until placement. A crane lifts the tower into position, all bolts are tightened, and stability is tested upon completion.

Next, the fiberglass nacelle is installed. Its inner workings—main drive shaft, gearbox, and blade pitch and yaw controls—are assembled and mounted onto a base frame at a factory. The nacelle is then bolted around the equipment. At the site, the nacelle is lifted onto the completed tower and bolted into place.

Most towers do not have guys, which are cables used for support, and most are made of steel that has been coated with a zinc alloy for protection, though some are painted instead. The tower of a typical American-made turbine is approximately 80 feet tall and weighs about 19,000 pounds.

The nacelle is a strong, hollow shell that contains the inner workings of the wind turbine. Usually made of fiberglass, the nacelle contains the main drive shaft and the gearbox. It also contains the blade pitch control, a hydraulic system that controls the angle of the blades, and the yaw drive, which controls the position of the turbine relative to the wind. The generator and electronic controls are standard equipment whose main components are steel and copper. A typical nacelle for a current turbine weighs approximately 22,000 pounds.

The most diverse use of materials and the most experimentation with new materials occur with the blades. Although the most dominant material used for the blades in commercial wind turbines is fiberglass with a hollow core, other materials in use include lightweight woods and aluminum. Wooden blades are solid, but most blades consist of a skin surrounding a core that is either hollow or filled with a lightweight substance such as plastic foam or honeycomb, or balsa wood. A typical fiberglass blade is about 15 meters in length and weighs approximately 2,500 pounds.

Wind turbines also include a utility box, which converts the wind energy into electricity and which is located at the base of the tower. Various cables connect the utility box to the nacelle, while others connect the whole turbine to nearby turbines and to a transformer.

4. The Manufacturing Process

Windmills are always erected on site using pre-made parts. The following description relates to the fan-type windmill. The basic steps include making the parts and then assembling the structure.

Making the tower parts

- 1 The tower parts are made from galvanized steel. This process begins with a roll of coiled sheet metal. The coils are put on a de-spooling device and fed to the production line. They are run under a straightener to remove any kinks or twists. The pieces are cut to the appropriate size and shape. In some cases, pieces may be put on a machine that rolls them and welds the seam. The ends are passed under a crimping machine and the pieces are moved to the finishing station.

- 2 At the finishing station, holes are drilled in the metal parts at specific places as required by the windmill design. The parts may also be painted or coated before being arranged in the final windmill kit.

Making the gearbox

- 3 The gearbox is an intricate assembly made up of various gears, axles, rotors, and wheels. The parts are die cast and assembled by hand. The are placed in an weather resistant housing that is designed to accommodate the gearbox parts and the attached wheel and tail assembly.

Making the fan

- 4 The fan is made up of a metal rim with slightly curved blades attached. The rim is produced on a machine that rolls steel strips into circular hoops. A hole is drilled in both ends, and they are connected with a small clamp and screw after the fan blades are attached. A center axle is then connected to the rim and attached with small steel spokes. A typical design will have five pairs of spokes attached a evenly spaced intervals along the rim.
- 5 The fan blades and tail are cut from pieces of sheet metal. The blades are then run through a machine that gives them a slight curve. They are attached to the metal rim with small bolts and metal clamps. They are attached in such a way that they can be raised or lowered depending on the wind conditions.

Preparing the site

- 6 Finding and preparing the construction site is a crucial step in creating a functional windmill. First, an area with a prevailing wind of at least 15 mph (24 km/hr) is needed. Then the area needs to be cleared of trees and other structures that may block wind. In some cases, a dirt mound or concrete base is erected to raise the windmill off the surface to catch more wind.

Final assembly

- 7 The parts of the main body are connected first. They are bolted together on the ground and then raised up vertically. The outer poles are joined with the connecting rods. Clamps are bolted at each joint for stability. After the tower is raised it is loosely bolted to the solid base. Next stay wires are strung from the frame down to the ground and attached to tensioners and ground anchors. When the structure is level, the bolts are tightened and the structure integrity is tested. In some cases a ladder is built into the frame design to allow access to the fan on top which makes cleaning an maintenance easier.
- 8 The fan wheel, gearbox, and main shaft are next attached. The gearbox is first clamped and bolted to the top of the tower. The main shaft is then inserted into the bottom of the gearbox. Next, the fan and its attached axle are connected to the gearbox. Finally, the tail section is attached to the gearbox. The pump is then hooked up to the main shaft and the windmill is operational.

Quality Control

Various tests may be done to ensure that each part of the windmill meets the specifications laid out in the design phase. The most basic of these are simple visual inspections. These will catch most of the obvious production flaws. Since windmills are erected by hand, the quality of each part goes through an additional visual inspection. The quality of workmanship that goes into construction of the windmill will be primarily responsible for the quality of the finished product. To ensure that it remains efficient during operation, regular maintenance checks are necessary.

5. The Future

Windmills have changed little over the last hundred years. In fact, one basic design conceived in the 1870s is still sold today. The major improvements have come in the types of materials used in construction. This trend will likely continue in future windmill products. However, the future of harnessing wind power is not in traditional windmills at all. The United States government has spent millions of dollars researching and developing wind turbines for electricity generation. In California, numerous wind farms are already in operation. Various other states and cities have plans for creating similar wind farms. In the future, wind power promises to be an environmentally friendly substitute for fossil fuels.

Wind power technology dates back many centuries. There are historical claims that wind machines which harness the power of the wind date back beyond the time of the ancient Egyptians. Hero of Alexandria used a simple windmill to power an organ whilst the Babylonian emperor, Hammurabi, used windmills for an ambitious irrigation project as early as the 17th century BC. The Persians built windmills in the 7th century AD for milling and irrigation and rustic mills similar to these early vertical axis designs can still be found in the region today. In Europe the first windmills were seen much later, probably having been introduced by the English on their return from the crusades in the middle east or possibly transferred to Southern Europe by the Muslims after their conquest of the Iberian Peninsula. It was in Europe that much of the subsequent technical development took place. By the late part of the 13th century the typical 'European windmill' had been developed and this became the norm until further developments were introduced during the 18th century. At the end of the 19th century there were more than 30,000 windmills in Europe, used primarily for the milling of grain and water pumping.

Modern Wind Generators

The first wind powered electricity was produced by a machine built by Charles F. Brush in Cleveland, Ohio in 1888. It had a rated power of 12 kW (direct current - dc). Direct current electricity production continued in the form of small-scale, stand-alone (not connected to a grid) systems until the 1930's when the first large scale AC turbine was constructed in the USA. There was then a general lull in interest until the 1970's when the fuel crises sparked a revival in research and development work in North America (USA and Canada) and Europe (Denmark, Germany, The Netherlands, Spain, Sweden and the UK). Modern wind turbine generators are highly sophisticated machines, taking full advantage of state-of-the-art technology, led by improvements in aerodynamic and structural design, materials technology and mechanical, electrical and control engineering and capable of producing several megawatts of electricity. During the 1980's installed capacity costs dropped considerably and windpower has become an economically attractive option for commercial electricity generation. Large wind farms or wind power stations have become a common sight in many western countries. In 2001 Denmark alone had 2000 Megawatts of electricity generating capacity from more than 5,700 wind turbines, representing 14% of their national electricity consumption (Source: http://www.windpower.dk). Wind is a clean, safe, renewable form of energy. B

Battery Charging

Depending on the circumstances, the distribution of electricity from a wind machine can be carried out in one of various ways. Commonly, larger machines are connected to a grid distribution network. This can be the main national network, in which case electricity can be sold to the electricity utility (providing an agreement can be made between the producer and the grid) when an excess is produced and purchased when the wind is low. Using the national grid helps provide flexibility to the system and does away with the need for a back-up system when windspeeds are low.

Micro-grids distribute electricity to smaller areas, typically a village or town. When wind is used for supplying electricity to such a grid, a diesel generator set is often used as a backup for the periods when wind speeds are low. Alternatively, electricity storage can be used but this is an expensive option. Hybrid systems use a combination of two or more energy sources to provide electricity in all weather conditions. The capital cost for such a system is high but subsequent running costs will be low compared with a pure diesel system.

In areas where households are widely dispersed or where grid costs are prohibitively expensive, battery charging is an option. For people in rural areas a few tens of watts of power are sufficient for providing lighting and a source of power for a radio or television. Batteries can be returned to the charging station occasionally for recharging. This reduces the inconvenience of an intermittent supply due to fluctuating windspeeds. 12 and 24 volt direct current wind generators are commercially available which are suitable for battery charging applications. Smaller turbines (50 -150 watt) are available for individual household connection.

References

[1] "Mill definition". Thefreedictionary.com. Retrieved 2013-08-15.
[2] "Windmill definition stating that a windmill is a mill or machine operated by the wind". Merriam-webster.com. 2012-08-31. Retrieved 2013-08-15.
[3] Gregory, R. The Industrial Windmill in Britain. Phillimore, 2005
[4] Dietrich Lohrmann, "Von der östlichen zur westlichen Windmühle", *Archiv für Kulturgeschichte*, Vol. 77, Issue 1 (1995), pp.1-30 (10f.)
[5] A.G. Drachmann, "Heron's Windmill", *Centaurus*,(1961), pp. 145-151
[6] Lucas, Adam (2006). *Wind, Water, Work: Ancient and Medieval Milling Technology*. Brill Publishers. p. 105. ISBN 90-04-14649-0.
[7] Sathyajith, Mathew (2006). *Wind Energy: Fundamentals, Resource Analysis and Economics*. Springer Berlin Heidelberg. pp. 1–9. ISBN 978-3-540-30905-5.
[8] Wailes, R. Horizontal Windmills. London, Transactions of the Newcomen Society vol.XL 1967-68 pp125-145
[9] Ahmad Y Hassan, Donald Routledge Hill (1986). *Islamic Technology: An illustrated history*, p. 54. Cambridge University Press. ISBN 0-521-42239-6.
[10] Dietrich Lohrmann, "Von der östlichen zur westlichen Windmühle", *Archiv für Kulturgeschichte*, Vol. 77, Issue 1 (1995), pp. 1–30 (8)
[11] Donald Routledge Hill, "Mechanical Engineering in the Medieval Near East", *Scientific American*, May 1991, p. 64–69. (cf. Donald Routledge Hill, Mechanical Engineering)
[12] Needham, Volume 4, Part 2, 560.
[13] Hills, R L. Power from Wind: A History of Windmill Technology. Cambridge University Press 1993
[14] Farrokh, Kaveh (2007), *Shadows in the Desert*, Osprey Publishing, p. 280, ISBN 1-84603-108-7
[15] Lynn White Jr. *Medieval technology and social change* (Oxford, 1962) p. 86 & p. 161–162
[16] Lucas, Adam (2006), *Wind, Water, Work: Ancient and Medieval Milling Technology*, Brill Publishers, pp. 106–7, ISBN 90-04-14649-0
[17] Bent Sorensen_(November 1995), "History of, and Recent Progress in, Wind-Energy Utilization", *Annual Review of Energy and the Environment* **20** (1):387–424, doi:10.1146/annurev.eg.20.110195.002131