FEBRUARY 2015
www.craneworld.com
A KHL Group publication

INTERNATIONAL cranes AND SPECIALIZED TRANSPORT

Working at height

Industrial lifting

The Knowledge

Truck cranes

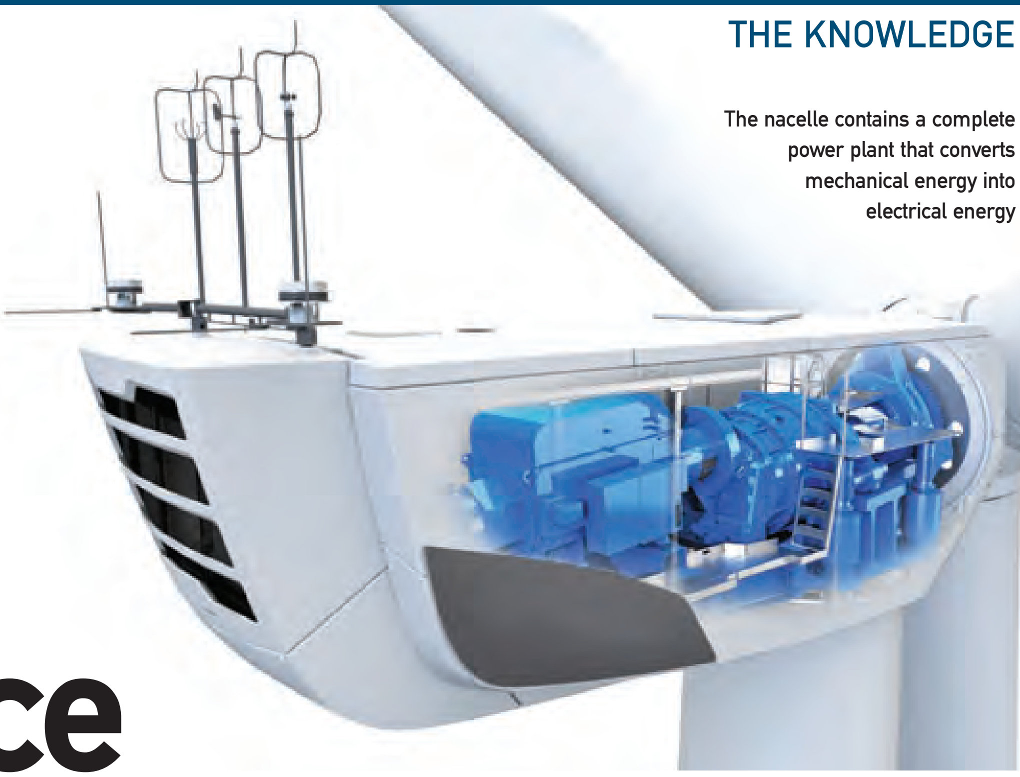
SHOW PREVIEW
Intermat

Refurbishment

S&RA OFFICIAL MAGAZINE

THE MAGAZINE FOR EQUIPMENT USERS AND BUYERS

This month, MARCO VAN DAAL looks at the common dangers of erecting the latest generation of wind turbines and discusses ways to prevent wind-associated accidents



The nacelle contains a complete power plant that converts mechanical energy into electrical energy

A force to be reckoned with

Windmills have been around longer than most of us realise. Since about 1000 BC the very first primitive windmills were used to grind grain and to pump water. It wasn't until the 1300s, however, that the Dutch redefined and refined the design. At the time, a number of revolutionary improvements included the use of sails on the blades to improve efficiency, a rotating top (nowadays calls the nacelle) to always catch the wind head on and the ability to slow down or completely stop the blades in case of excessive wind. This entire process took some 500 years and created the foundation of the modern day windmill design.

It is noteworthy to state that some of the early Dutch windmills have withstood the test of time for hundreds of years and are still operational, although most of them now serve as public attractions.

Despite the challenges with modern windmills, such as the rotating shadows on the ground disrupting wildlife, balancing the generated power frequency with the grid, and horizon pollution (a term that did not exist ten years ago), the windmill or wind turbine industry has exploded and has shown double digit growth for years in a row.

Reason for this growth is twofold; on the one hand wind is free, so it is an economic benefit. On the other hand, wind energy contributes to a greener environment as the energy is produced with a smaller carbon footprint. The carbon footprint definition being, "The total amount of greenhouse gases produced to directly or indirectly support human activities generally expressed in equivalent tons of carbon dioxide (CO_2)."

Studies have shown that the larger the wind turbine the greener the energy. At first glance this makes perfect sense as a smaller area is required for fewer turbines of higher capacity. In addition, there is money savings from shorter production and installation time and, last but not least, fewer units to maintain. The market demand for turbines has supported this as the number of larger installations has increased over time.

The installation of larger turbines, however, comes with its own challenges and also at a price; sometimes at a terrible price.

Main parts

Despite the many manufacturers around the world, wind turbines consist of a few main components across all brands and types.

First, there is the so-called foundation ring. This is the ring that is embedded in a concrete foundation and is the connection for the (first) tower section. Installed on the foundation ring is the first tower section. Depending on the capacity of the turbine the tower becomes a larger height,

ABOUT THE AUTHOR

Marco van Daal has been in the heavy lift and transport industry since 1993. He started at Mammoet Transport from the Netherlands and later with Fagioli PSC from Italy, both leading companies in the industry. His 20-year plus experience extends to five continents and more than 55 countries. It resulted in a book *The Art of Heavy Transport*, available at: www.khl.com/books/the-art-of-heavy-transport/

Van Daal has a real passion for sharing knowledge and experience – the primary reason for the seminars he holds around the world.

sometimes consisting of two, three or four individual sections.

On top of the tower sits the nacelle. The nacelle contains a complete power plant that converts mechanical energy into electrical energy. Among the components in a nacelle are a brake mechanism (to prevent the blades from spinning out of control in high winds), a gearbox and a generator. Some nacelles also contain a transformer although this transformer is commonly also installed at ground level serving multiple turbines.

The pitched blades provide the mechanical energy, in the form of rotation under influence of the wind, to the gearbox and generator. The pitch of these blades can be changed to catch the wind in an optimum way and increase efficiency across various wind speeds and directions.

The blades connect to the gearbox by means of a hub. The hub is the rotating part to which the blades are connection (mostly a bolted connection). The hub in turn is connected to the gearbox shaft.

Turbine erection

Common sense and practice dictate that during a (critical) lift one would try to keep the load close to the ground. This gives the operator the opportunity to set the load down in case an extraordinary situation occurs. One would also try to execute a lift when the wind conditions are most favourable but, definitely, within the crane's operable conditions. In addition, the crane should be set up on a solid base.

When erecting wind turbines, the most critical lift is the placement of the nacelle on top of the tower. The nacelle is the heaviest component and is installed at the highest elevation. There is no possibility of "keeping it close to the ground" and consequently there is no escaping when an extraordinary situation occurs.

By definition, wind turbines are erected in windy areas, either in large empty fields or in mountainous areas in relatively narrow valleys; these areas are ideal for energy production because of the increased wind speed in those valleys. Knowing this we also know that the first two common practice principles have to be violated to erect a wind mill. This in itself does not have to create a problem, as long as the increased risk in those areas is acknowledged and accounted for.

So why, compared to other industries, do so many accidents occur in the wind turbine erection business?

Often these accidents are entirely avoidable if a few basis checks are carried out and, most importantly, carried out correctly. Every crane chart is developed for a certain maximum wind speed. Mostly it is mentioned on the chart itself. If not, the manufacturer can give you a "not to exceed" wind speed for safe lifting operations. Here is the first challenge; this wind speed is often measured at ground level. It should, however, be measured at the tip of the boom as that is where the nacelle will be when installing it. Wind speeds at that elevation are much higher as they have not been slowed down by obstructions such as buildings, trees, etc.

Even when the wind is measured at the correct elevation, an allowance for wind gusts should be taken into account. The gust factor is difficult to determine as there are little or no guidelines. The turbine manufacturer, however, can often offer a helping hand. They have designed the foundation and in this design a certain gust factor is included. This factor is most probably more conservative than you may need as the foundation should be able to withstand a 5-year, 25-year, 50-year or even a 100-year recurrence period. This depends on the location and local laws.

Due to the number of accidents, not only with erection of wind turbine equipment, insurance companies have formulated a set of gust factors. They suggest a gust factor of 1.59 for hilly or wooded terrain and 1.32 for flat open areas. These gust factors apply at an elevation of 30 feet (9.14 m). Source: *Cranes and Derricks* by Howard, Jay and Lawrence Shapiro.

By definition, wind turbines are erected in windy areas, either in large empty fields or in mountainous areas in relatively narrow valleys

Lift the nacelle

Let us have a look at what happens when a nacelle is lifted. The centre of gravity (CoG) of the nacelle, as well as of the entire crane with nacelle, moves up as the nacelle is lifted. This makes the crane less and less stable. As long as you stay within the crane's load chart this does not pose any problem. As the nacelle is lifted the crane (mainly the boom) is subjected to a phenomenon, and every load lifted swings a bit. This is due to wind, slewing, travelling (in case of a crawler crane) or any other external force. When the load is suspended by long rigging or a long lifting wire, the oscillation time is also long and the movement is slow. The same applies when lifting the nacelle; when the nacelle is still, at, or near, ground level, it sways in slow and long movements.

As the nacelle is lifted near its final height it sways in short and often pretty violent and short movements. These movements can have two effects; it can move the CoG beyond the crane's capacity. This risk is present during the entire lift, even when the nacelle is near ground level. It also introduces forces in the crane boom that may be beyond what the crane is designed for.

The formula shown below is used to calculate the oscillation time of a suspended load. As can be seen, the weight of the load plays no part in determining this time. Only the length of the rigging and, or, the lifting wire is of influence on this oscillation time:

$T=2\pi\sqrt{(l/g)}$

In short, when underestimated, the wind forces in combination with potential gusts and the short and rapid swaying of the nacelle at height and near the capacity of the crane have caused more than a fair share of accidents in this industry.

Prevention is better than cure

To prevent accidents in the wind industry it is good to be on the safe side. The crane should have sufficient lifting capacity even in the event of strong gusts and when taking into account the swinging and swaying of the nacelle (being the heaviest item). Some companies have wind departments that are trained in dealing with the particulars and restrictions of a wind turbine erection site. ■