Design and Fabrication of Invelox Wind Turbine

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ABSTRACT : *A new concept in wind power harnessing is described which significantly outperforms traditional wind turbines of the scale diameter and aerodynamic characteristics under the same wind conditions and it delivers significantly higher output, at reduced cost. Its first innovative feature is the elimination of tower-mounted turbines. These large, mechanically complex turbines, and the enormous towers used to hoist them into the sky, are the hallmark of today's wind power industry. They are also expensive, unwieldy, inefficient, and hazardous to people and wildlife. The second innovative feature of INVELOX is that it captures wind flow through an omnidirectional intake and thereby there is no need for a passive or active yaw control. Third, it accelerates the flow within a shrouded Venturi section which is subsequently expanded and released into the ambient environment through a diffuser. Simulating the performance of this wind delivery system is quite challenging because of the complexity of the wind delivery system and its interaction with wind at the front end and with a turbine at the back end. The objectives of the present work are to fabricate the model and understand the flow field inside the INVELOX where the actual wind turbine is located as well the external flow field. Increased wind velocities result in significant improvement in the power output.*

Keywords: *Invelox, venturi, windpower, omnidirectional, turbine*

1. INTRODUCTION

Humans have been putting the wind to use as far as 7500 years ago, in sails by the Egyptians. The Greek Engineer Heron of Alexandria designed a wind wheel in the first century A.D., the earliest known effort to use wind of powering a machine. [3] Persians built a type of windmill known as a Panemone sometime between 500 and 900 A.D., it comprised a vertical shaft attached to light weight wooden blades that had sails made of reeds or cloth. Within a few centuries, windmills of vertical designs – and with either vertical or horizontal shafts- were built across the Middle East, central Asia, and eventually in India, China and Europe. These Windmills were used for grinding grains, draining land, pumping fresh water or salt water to make salt. Threshing, powering sawmills and other purposes. Although modern wind turbines began to emerge in the 1970s they have been used to generate electricity since late 19th century. Ohio inventor Charles F. Bush built the first large wind Mill for electricity in the USA in 1887, made of 144 cedar blades, it could generate 12 kilo watts for batteries or his mansions lights. On the Eve of the World War II, the world's first megawatt turbine- a large machine with 98-foot blades began delivering electricity to local grid in Vermont.

1.1ADVANTAGES OF WINDPOWER

- Wind is a domestic source of energy. The nation's wind supply is abundant and inexhaustible. Over the past 10 years, U.S. wind power capacity has grown 15% per year, and wind is now the largest source of renewable power in the United States.

- It's sustainable. Wind is actually a form of solar energy. Winds are caused by the heating of the atmosphere by the sun, the rotation of the Earth, and the Earth's surface irregularities. For as long as the sun shines and the wind blows, the energy produced can be harnessed to send power across the grid.

1.2 DISADVANTAGES OF WINDPOWER

There is no denying that wind turbines produce noise, and if you live near them, this may be a problem. The sound they produce can travel, some estimate up to 2 km [2], but they aren't any noisier than a busy highway and aren't situated near populated areas. The sound will also carry depending on the direction of the wind that day, and if there's no wind, there's no noise.Aesthetically, it has been argued they are not attractive to look at, but compared to the extensive damage mining and fracking causes, this should be a minor concern.Wind farms built at sea nearly eliminate both of these negatives, and this is becoming more common.

2. DESIGN & CALCULATION

2.1INVELOX system

Wind Power plants are established mostly in open grounds to get open stream of air. A stream of air contains more potential energy than kinetic energy, this available kinetic energy was utilized by bare wind turbines to generate power, a recently developed technology, INVELOX (increased velocity), has shown promise. INVELOX is a new and innovative wind power generation system that significantly outperforms traditional wind turbines by using a new design of harnessing wind energy. INVELOX delivers superior power output, at a reduced cost, and solves in its process all the major issues that have so far undermined the wind industry, such as low turbine reliability and intermittency issues.

2.2Acceleration of airflow velocity

Giovanni Battista Venturi (1746 – 1822), accredited with the effect named after him, is an example of Bernoulli's principle of incompressible gasses where an acceleration of airflow must occur through a constriction to satisfy the equation of continuity. Pa + ½ ρ V2 + ρ g h = constant (1)

The acceleration of the airflow was achieved with the use of a converging duct.Therefore, $VV2 = (AA1 *VV1)/AA2$ (2)

2.3Power and power transfer

Efficiencies can be gained with a ducted system as this gives the ability of accelerating the airflow through a convergent path much like a venturi.

Simply the theoretical power that can be extracted is: Power (W) = ½ * (ρair(kg/m3)) * (turbine swept area(m2)) * (wind velocity(m/sec))3 $PPPPPPPPPP = ½ *\rho\rho*TTTTTT*VV$ 3 (3). This shows that power is directly proportional to half the cube of the wind velocity. If we consider the mass in terms of density and volume

Dimensional analysis gives:

$EE = ½ *\rho\rho*VV*VV2$

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$EE = ½ *\rho\rho*VV3$ (5). To investigate the change in density to the air flow we must assume dry as being an ideal gas then apply the ideal gas law equation:

$PPPP*VVVV = nn*RR*TT$ (6)

Where, Pa = pressure, Vg = volume of gas, n = number of kilo moles, R = gas constant, T =

Temperature Kelvin, m = mass. If we consider the density of air as:

$\rho\rho = mmVVVV$ (7)

Then from equations 6 and 7 we can calculate the density of air in the turbine.

$\rho\rho = nnxxPPPPRRxxTT$ (8)

From this we can calculate the density drop in air flow through the duct using equation (8) Density of air at standard temperature and pressure, ρ = 1.293 kg/m3.

3. METHODOLOGY & WORKING PRINCIPLE

In contrast to older designs of ducted turbines, INVELOX separates the location of the shroud and turbine-generator system; the intake is on the top while the turbine-generator is placed at the ground level inside the ducted pipe carrying captured wind towards the turbine. This unique feature allows the engineers to size the intake wind delivery system for any speed increase required without increasing the turbine size. The size of an intake depends on local wind speeds and other environmental conditions.

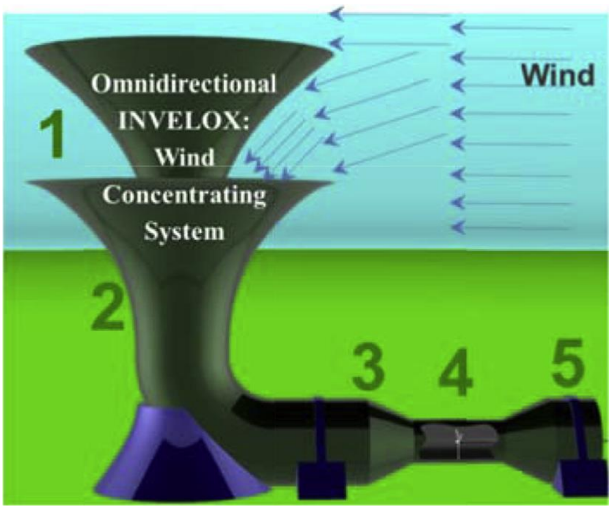

Fig-1: Schematic of the INVELOX wind delivery system with its key components, (1)intake, (2) channeling wind, (3) wind concentrator, (4) Venturi plus wind power conversionsystem, (5) diffuser returning wind to nature

Key features of INVELOX are:

1) The intake and turbine are decoupled. This means the intake size may be adjusted while keeping the turbine as small as necessary depending on the required speed ratio and environmental conditions.

2) The above decoupling of intake and turbine location allows the WTG (Wind Turbine Generator) be mounted at the ground level and thereby reduce O&M.

3) Decoupling of the intake and Venturi, where the turbine is installed, allows designing INVELOX with speed ratio of 6 or higher. This allows operating at high wind speeds and thus generating a lot more power with smaller blades while utilizing a much more efficient generators operating at higher speeds.

4) Smaller blades operating at higher wind speeds results in 85%smaller blades that results in cost savings in material, manufacturing, transportation, and installation.

5) The intake designed to be omnidirectional and thus no need for huge bearing and motors to turn the intake in the direction of wind.

6) INVELOX can be designed with a power rating of 500 W to25 MW. All that matter is how much air is captured.

3.1How the New Technology Works

It is a technology designed to funnel wind energy to ground-based generators. Instead of snatching bits of energy from the wind as it passes through the blades of a rotor, the wind is captured with a funnel and directed through a tapering passageway that naturally accelerates its flow. This stream of kinetic energy then drives a generator that is installed safely and economically at ground level. The wind flow from multiple collection funnels is concentrated in such a way that the resulting power output rises almost exponentially. Bringing the air-flow from the top of the tower to ground level allows us to generate more power with much smaller turbine blades. The tower used is about 50% shorter than traditional wind towers, and uses a ground-based turbine with blades 84% as long. Sheer wind also tested the use of two towers combined to one outlet and two outlets combined to one tower for generating. More wind speed, which will lead to more wind power generation, but they never released any experiment results for these types of combinations.

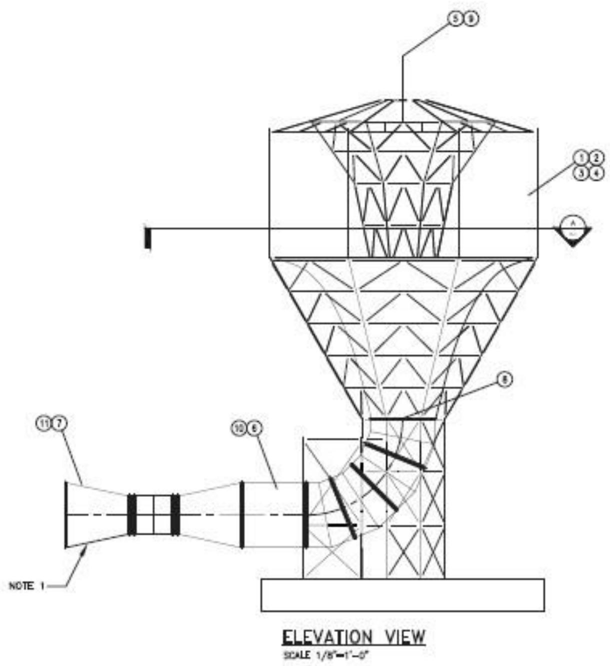

Fig- 2: The Five key parts in the INVELOX wind delivery system.

The five key parts of INVELOX are shown in Figure 4. These key parts are (1) intake, (2) pipe carrying and accelerating wind, (3) boosting wind speed by a Venturi, (4) wind energy conversions system, and (5) a diffuser. The fundamental of the INVELOX system is that it separates the turbine from the intake, very much like traditional hydropower plants that use large dams to build pressure and use wind density and gravity to reach turbines at high kinetic energy levels. The size of the dam is much bigger than the size of the hydro turbine.

3.2Economics of INVELOX

INVELOX is based on hydropower principals. The difference is INVELOX captures the wind kinetic energy, and uses the pressure differentials to increase the kinetic energy available to a turbine, and can do so in nearly any free stream areas with flow greater than 1 m/s. An INVELOX installation will cost nearly 7% to 11% less to construct, and 40% to 45% less for wind power plant operation and maintenance than traditional wind farms.

3.3 Reduction in Noise Impact

It is noted that the damaging frequency range of the traditional turbine is below the hearing frequency of human ear, i.e., below 20 HZ. Low frequency noises and vibrations are harder to measure and noise experts still struggle to deal with these issues. Furthermore, the human organs, such as heart, lungs and brain have resonance frequencies below 20 HZ, and thus the turbine noise can create what is known as “Wind turbine Syndrome.”

4. Conclusions

It was shown that INVELOX can be designed to capture and accelerate air using an omnidirectional intake. The system has low sensitivity with respect to wind direction. A comparison between INVELOX and a traditional wind turbine. It is always difficult to design a meaningful good comparison between two different systems. The INVELOX-turbine system generated significantly more energy than the tower turbine systems with the same turbine size. INVELOX has a strong potential and is worthy of further development. A reason to be skeptical of INVELOX is the fact that in the past-ducted turbines have not made any significant headway in the industry due to questions related to technical implementation and financial viability, even though positive performance was in general demonstrated. One technical issue, for instance, which has been insurmountable to address is the implementation of a mechanism design which will allow for self-alignment of large-scale ducted turbines with the wind direction.

In addition, ducted turbines still need to be placed at a certain height which increases the technical complexity as well as the cost. INVELOX eliminates the need for self-alignment with the wind because its intake is omnidirectional and all rotating parts are on the ground which simplifies the operation and maintenance. It is also reasonable to question whether, once a turbine is placed inside an INVELOX system, the increase in resistance will reduce the output making the promise of superior performance no longer valid. It should be noted, however, that the same is true for traditional open-flow systems. The free stream wind reduces its speed as it approaches the blades due to the induced velocity field by the vortex system shed in the wake of the turbine; this reduction could be up to half or to two-thirds, depending on the environmental and blade profile factors.

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