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AERIAL WIND TURBINE

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Abstract: Wind – an energy source that is available almost everywhere. The force of the wind, harnessed using wind turbine system is admirably suited for power generation. Maximum availability of the wind turbine system is secured through the perfect interaction between the various products and systems. The cost of crude oil is continuously increasing hence the need to find alternative energy sources. One source is harnessing the power of wind which does not harmful for environment. Usually, wind turbines are fixed to the ground and can only reach up to height of125 meters. There are also issues with the consistency of the wind speeds and direction at these heights. Wind turbines installed at these heights do not produce as much power as they could due to the inconsistency of the winds. The goal of this review paper is to enlighten the way to elevate the turbines up to heights of 300 meters and above using a lighter than air structure. At this altitude, the wind speeds are more constant and the direction of the wind does not vary. These two factors can significantly improve the turbines operating efficiency and hence can increase maximum potential. Many steps were involved to reach these goals. To start off, a preliminary design of the structure including the support beams, tether and turbines was created. The summation of the forces from weight and drag associated with the structure were found. These numbers were needed to determine the volume of helium required to overcome the total weight. With the drag forces calculated, the strength of the tether combined with the angle formed between the tether and ground were determined. The turbines are aligned facing backwards so they do not interfere with the tethering system. Wings were added to provide additional lift to reduce the amount of helium needed.

Keywords: Wind turbine, Airship, Drag force, Area of tether, Commercial production

I. INTRODUCTION

If we look back over the last thousand years we can divide the development of mankind into 3 phases:
1. Eotechnic (water and wood complex)
2. Paleotechnic (coal & wood)
3. Neotechnic

This clearly illustrates how important a role does energy & its sources play in our lives. The evolution of mankind merely depends on the method of harnessing the energy. The developed countries have ample amount of energy. They are either energy independent or are going to become so but the rest of the world is facing problem with the same i.e. ENERGY. The cost of oil is increasing and thus the need to find alternative energy sources.

No one can manufacture a lock without a key so as an engineer we should look upon the problems as a solution itself .So the first problem comes in our mind is solution of energy problem. Many of the researches are going on the specific topic of energy generation and alteration. One of the energy extraction segment is wind energy which is used by wind turbine. Land based wind turbines are not used to their fullest potential due to the inconsistency of wind near the earth's surface. The goal was to determine if a structure could be designed and built to harness wind energy at high altitudes. Using a non-rigid airship, a design was created to lift wind turbines up to a desired height while still achieving a moderate power output. Most of the designs for wind power turbine have a specific feature that they are anchored to the ground via a huge tower. Problems with these designs are that the inconsistency of the wind causes most of these devices to be idle a majority of the time, with 30 % efficiency at most Another problem encountered by the developing nations or developed nation is that, in developed nations the energy is sufficiently produced hence CO2 and as global warming is currently ongoing major issue, these countries have to restrict their excretion of these greenhouse gases mostly produced by their power plants. In contrary indeveloping nations the power is either insufficiently generated or the distribution system is not proper so there is a need to harness such kind of resources mentioned above.

II. HISTORY

5000 B.C. the use of wind power starts with the sailor's invention. And with the aid of that wind mills were inaugurated in Persia 1100 years ago. They were being used for grain grinding mills and water pumps. Till 1870, blades were made of wood but after that steel blades were introduced. And in 1888 first electricity generated wind mill is introduced .It produced 12 kilowatts with a 17 meter rotor diameter. Some modifications in design yield the production up to 25 kW per windmill. Further, the United States government took an interest in wind energy after the "Arab oil crisis" of 1973. While this was not a major evolutionary success, it only does represent the beginning of the United States government realizing the weaknesses of oil based conventional energy and looking towards more renewable energy sources. For the next twenty years i.e. till 1995 much developmental research and testing was completed to solve many of the issues with windmill designs. Future designs will be far more

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efficient and able to produce energy in the magnitude of megawatts rather than kilowatts. However, as with most things, more can be done to increase the efficiency and power output of this renewable resource.

III.FACTS AND DATA

The modern design consists of up to 3 Megawatt turbine with two or more blades. The rotor diameter is up to 100 meters. Most turbine designs have three blades but it is said that the 2 blade design will become the norm for offshore wind farms. The blades are shaped aerodynamic in order to create lift from air moving over the blade. Generally blades are made of a composite material structure. The best type is the wood laminates which prove to be the strongest and lightest. Most modern wind turbine towers are conical tubular steel towers. They can range in height from 30 to 85 meters depending on the tower costs per meter, how much the wind locally varies with height above ground level, and the price the turbine owner gets for an additional kilowatt hour of electricity. They are manufactured in sections of 20-30 meters and are bolted together on site. The conical design is used to increase their strength while also saving materials at the same time. The market for wind energy is expanding every day and many different companies are becoming involved or have been since the start. Companies all over the world are supplying wind energy to the residential market as well as building wind farms with hundreds of wind turbines for commercial use.

According to the World Wind Energy Association, in 2008 the top five countries in terms of installed capacity are

- US (25.17 GW),
- Germany (23.9 GW),
- Spain (16.74 GW),
- China (12.2 GW)
- India (9.587 GW).

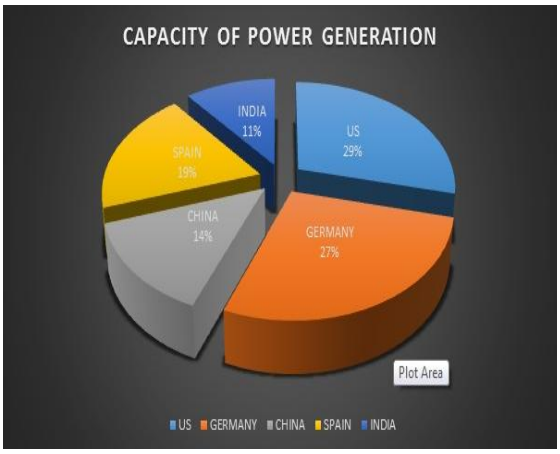

Fig: 3.1 Capacity of Power Generation

IV.COMMERCIAL SUCCESS

These are several big brand names in the turbine business industry:

1. Vestas (Denmark),
2. GE (US),
3. Gamesa (Spain),
4. Enercon (Germany),
5. Suzlon (India),
6. Siemens (Germany),
7. REpower (Germany).

Each of these companies has developed a wide range of turbines for varying power levels and different locations with assorted wind conditions.

- Vestas, a German company has wind turbines all across the world. They design 4 types of turbines that output power at a range from 850 kW to 3 MW. Their largest, 3 MW, turbine has a diameter of 90m with a weight of 41 tons which includes only the hub and rotor. Vestas has wind turbines in Europe, Denmark, the USA and China
- GE has been developing turbines for years now and has several models. Currently, GE has a 1.5 MW, 2.5 MW and a 3.6 MW turbine available to the market. The most advanced one is their 3.6 MW version that they have available for offshore installations. It has a rotor diameter of 111m and is rated at wind speeds of 14 m/s
- Gamesa is based in Spain and has turbines ranging from 850 kW to 2 MW. They have turbines designed for different wind speeds such as low, medium and high. The weights of their turbines rotor and blade combinations range from 10 tons up to 36 tons each.
- Enercon, out of Germany, has the largest turbines on the market today. Their turbines are able to create power of over 6 MW each. These structures have a rotor diameter of 126 meters and are rated at 6 MW but have the potential to reach upwards of 7 MW. Enercon also has smaller scaled turbines ranging from 330 kW to 2 MW. They have close to 7,000 wind turbines in Germany and around 15,000 installed around the globe
- Suzlon, Siemens and REpower are all competing companies as well, with turbines starting at less than 1 MW. REpower was the leader for a while with their 5 MW turbine The power output is related to the size of the turbine which also has a large impact on the weight of the product. The weight factor is important when choosing which type of turbine. The capacity is how much energy a single turbine can create. It ranges from 850 kW to 3.6 MW. The blade length is the span of a single blade and the hub height is the height of the tower which it is supported by. The total height is the distance from the ground to the tip of a vertical blade. The swept area is found by using the blade length as the radius and finding its circular area. This area is important for determining the total power output of the turbine. The area also affects how far each turbine must be placed away from one another. The last three columns show the different speeds of the spinning turbines and the ideal wind speed for the individual turbines.

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SIZE SPECIFICATIONS

model by blades	capacity	blade length	hub ht tip speed	total ht	area swept	rpm range speed	max blade	Rated wind
GE 1.5s	1.5 MW	35.25 m	64.7m	99.95m	3904m2	11.1-22.2	183 mph	12 m/s
GE 1.5sl	1.5 MW	38.5 m	80 m	118.5 m	4,657 m2	10.1-20.4	184 mph	11.8m/s
GE 2.5xl	2.5 MW	50 m	100 m	150 m	7,854 m2	NA	NA	12.5m/s
GE 3.6sl	3.6 MW	55.5 m	48.5 m	134 m	9,677 m2	8.5-15.3	199 mph	14 m/s
Vestas V52	850 kW	26m	44 m	70 m	2,124m2	14-31.4	128 mph	16 m/s
Vestas V82	1.65 MW	41 m	70 m	111 m	5,281 m2	12-14.4	138 mph	13m/s
Vestas V90	1.8 MW	45 m	80 m	125 m	6,362 m2	8.8-14.9	157 mph	11 m/s
Vestas V100	2.75 MW	50 m	80 m	130 m	7,854 m2	7.2-15.3	179 mph	15 m/s
Vestas V90	3.0 MW	45 m	80 m	125 m	6,362 m2	9.0-19	200 mph	15 m/s
Gamesa G87	2.0 MW	43.5 m	78 m	121.5 m	5,945 m2	9.0-19	194 mph	13.5 m/s
Siemens	1.3 MW	31 m	68 m	99 m	3,019 m2	13-19	138 mph	14 m/s
Siemens	2.3 MW	41.2 m	80 m	121.2 m	5,333 m2	11.0-17	164 mph	15 m/s
Suzlon 950	0.95 MW	32 m	65 m	97 m	3,217 m2	13.9-20.8	156 mph	11 m/s
Suzlon S64	1.25 MW	32 m	73 m	105 m	3,217 m2	13.9-20.8	156 mph	12 m/s
Suzlon S88	2.1 MW	44 m	80 m	124 m	6,082 m2	NA	NA	14 m/s
Clipper Liberty	2.5 MW	44.5 m	80 m	124.5 m	6,221 m2	9.7-15.5	163 mph	11.5 m/s
Repwer MM92	2.0 MW	46.25 m	100 m	146.25m	6,720 m2	7.8-15	163 mph	11.2 m/s

Table4.1 Size Specification of Turbine

V. SPECIFICATION COMPARISON OF AERIAL WIND TURBINE

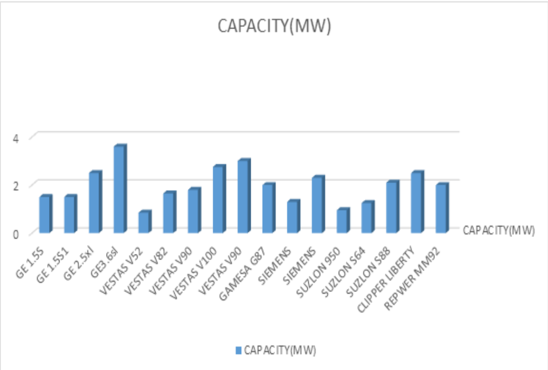

Chart 5.1 Capacity in MW

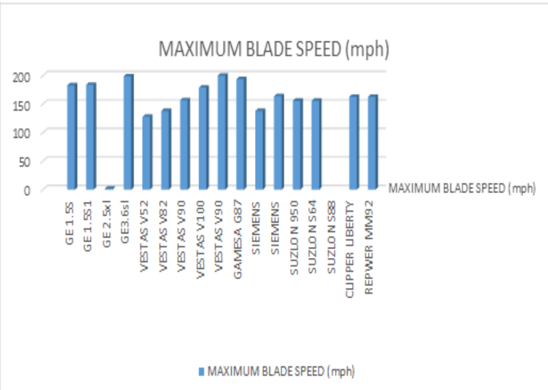

Chart 5.2 Maximum Blade Speed (mph)

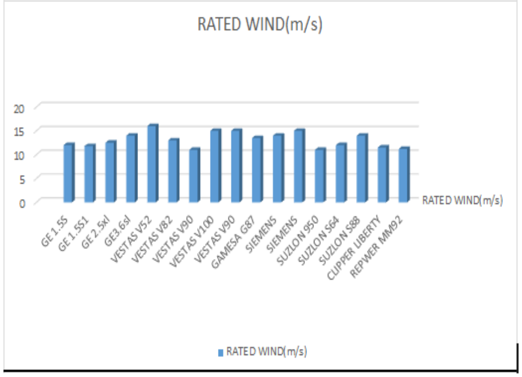

Chart 5.3 Rated Wind (m/s)

VI. PATENTS SEARCHES OF AERIAL WIND TURBINE

Few patent searches that yield the idea are mentioned below. The present state of aerial wind turbine design is one in which designers have thought of many designs ranging from the simplest form of a kite/airfoil attached to a rope to the most radical proposals.

1. US patent number 4,073,516 was one in which there are a lot of general ideas and little specifics. "Wind-Driven Power Plant" was issued a patent in June of 1975. Its design called for a power plant having a rotor assembly with at least one rotor connected to a generator. A gas-filled hollow body keeps the whole system in the air. The designer called for the whole system to be either anchored to the ground or be suspended in the air with a floating body. It would have some sort of means for aligning the rotors with the wind direction. There is also at least one pair of coaxially supported counter rotating rotors that compensate for the spinning of the turbine. This causes rotors to always become aligned into the prevailing winds.

2. US patent 4,491,739 entitled "Airship-Floated Wind Turbine." was pretty much different. The goal for this patent was to create a wind turbine with a diameter reaching 1,000 feet. In which operational height is several thousand feet. In this design, the airship holds up a large ring which supports the outer ends of the turbine blades that extend inward from the ring to the airship. A bearing assembly was created that allows the airship to rotate without twisting the tether line. The ring around the airship is basically a large "space frame" structure that holds all the turbine blades on the outer edges. This greatly reduces the weight of the whole structure.

3. US patent 4,450,364 with the title of "Lighter than Air Wind Energy Conversion System Utilizing a Rotating Envelope." This is a system where the main rotors spin independently of the gas-filled structures. It is self-orienting and includes aerodynamic damping of orientation motions. However, it still requires large heavy rotor blades. The rotor blades are designed to be rotated by the wind in a plane perpendicular to the longitudinal axis of the structure. There is also a non-rotating tail for

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orienting the structure while also providing some additional lift. Generators are positioned on the rotor blades in order to generate the electricity. The complete system is tethered to the ground by at least one tethering cable and one electrical cable.

4. US patent 6,523,781 titled "Axial Load Linear Wind-Turbine." This design can be used at any height ranging from 300 feet to 3,000 feet. It is meant to capture the wind in the axial direction, perpendicular to the airfoil's flight direction. Most of the expensive and heavy components are on the ground and only the airfoils are in the air. The system consists of three airfoil kites in tandem connected to a ground anchor. The kite operates at high speeds with the airfoil moving mostly perpendicular to the wind stream. This patent greatly reduces one of the major problems in terms of receiving the energy from the turbines in the air.

5. US patent 7,129,596 entitled "Hovering Wind Turbine." This a fairly simple design in which the turbine is one that would be seen on a residential unit. The blades lie on the surface of an imaginary horizontal cylinder with their pitch angle changing as a result of the rotational angle. This allows the turbine to gather wind energy mainly in the upwind and downwind areas of the cylindrical path. It also uses a fraction of the gathered energy to create lift by deflecting air downwards, mostly in the upper and lower areas of the cylindrical path.

VII. SWITCHING REASONS

There are so many reasons which enable the reason to find out the alternative energy resources. When it comes to harnessing power from the wind, there are some problems with finding a consistent wind. This greatly affects how efficient a wind turbine can be. From Betz's linear momentum theory, the maximum energy that can be extracted is up to 60 percent while most designs nowadays get around only up to 40 percent. A speed of 12 m/s is needed to get this maximum efficiency but in cities like New Delhi (India) the air flows with average speed of 2-3 m/s. Any speeds higher than 8m/s will decrease efficiency and could potentially damage the turbine. Another way of increasing the efficiency of the turbine is to allow the rotor to change its rate of rotation as the wind speed changes. This is known as variable speed operation where the generators allow for variable rates of rotation. However, most designs are still of the fixed speed operation where all the components are much cheaper.

There are numerous factors which affect the size and design of an aerial wind turbine. Almost all the factors can be placed in two groups:

1. Time-dependent
2. Frequency-dependent.

More factors which are responsible

- Forces from the wind
- The unwanted vibrations of rotational frequency
- The fatigue effects of the constant rise
- Fall of the blades

All influence the design process. With power output goals in mind, the power capture is proportional to the swept rotor area. This will only increase to a certain range where the component size and machine cost outweighs the effectiveness. Conversely this "range" has greatly increased over the years as manufacturing and operational understanding is gained over time.

To reduce carbon dioxide emissions is a major promising advantage of alternative energy proposals. From the US average fuel mix, about 1.5 pounds of CO2 are emitted for every kilowatt hour that is generated. In 2006, electricity consumption accounted for more than 2.3 billion tons of CO2. This accounted for 39.5 percent of the total emissions from human resources.

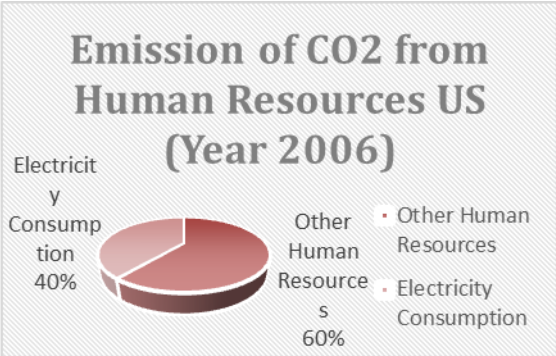

Chart 7.1 Emission of CO2 from Human Resources (US report year 2006)

According to the US Department of Energy, Coal-fired plants alone released over 91.9 billion tons, which is one-third of the US total.

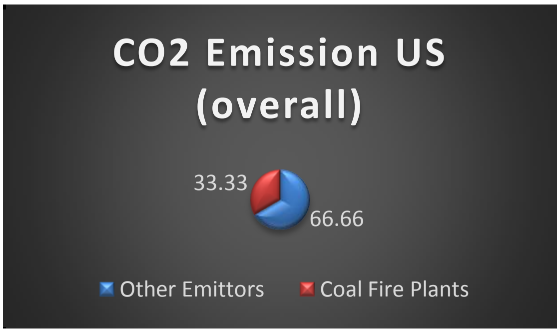

Chart7.2 CO2 Emission US (overall)

The US Department of Energy also projects that CO2 emissions from power generation will increase 19 percent between 2007 and 2030. This is due to new or expanded coal plants.

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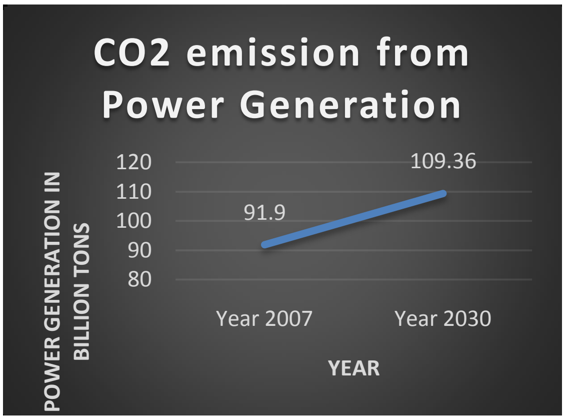

Chart7.3 CO2 emission from Power Generation

A single 750-kW wind turbine produces roughly 2 million kilowatt hours ofpounds CO2 = 3 million lbs CO2 = 1500 tons of CO 2 per year A forest absorbs about 3 tons of CO2 per acre of trees per year. Therefore, a single 750 kW turbine prevents the same CO2 emitted each year as could be absorbed by 500 acres of forest.

Chart7.4 Balance between Forest and Aerial Wind Turbine

VI. AIR SHIPS

A significant idea to deploy a wind turbine system in flight is to incorporate lighter-than-air structure. The main concern is the size and shape of the airship. If the airship is much larger than any other airship ever made, then using lighter-than-air technology alone is a far-fetched pursuit. Other issues more quickly resolved are the type of medium used (helium, hydrogen, etc.) and the structure of the airship.

For practical feasibility, the gas inside the airship needs to be lighter than the surrounding air.one idea can be using heat as air can become lighter as heat supplied to it. Temperature is inversely proportional to density i.e. the higher the temperature, the lighter the gas. However, hot air balloons require constant heat and a large volume of space, ruling out the possibility of using hot air. This leaves two possibilities: hydrogen and helium.

The prominent advantage of hydrogen is that it is can be generated by splitting water molecules using electricity, sunlight, or radio waves. The electricity can be generated from the wind turbines automatically when needed, and the hydrogen can be sent upward by tubes inside or along the cables that attach the ground station to the aerial wind turbine. Plus, hydrogen is less dense than helium. However, another problem encountered is that it is explosive and requires fire protection measures for the airship. The two advantages of using the rare and expensive helium gas are that it is not flammable and does not leak as much as hydrogen. Though the airship will be flying high, susceptible to lightning strikes, pursuing a design that prevents lightning and leaks from igniting the airship would be a feasible concept.

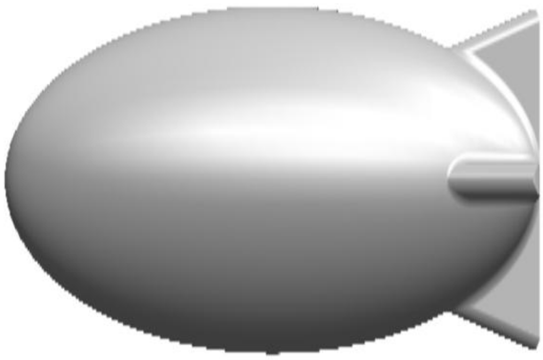

Fig: 9.1 Envelope

TYPES OF AIRSHIPS

There are three types of airships:

1. Rigid
2. Semi-rigid
3. Non-rigid.

Rigid airships such as the Hindenburg require an external shell to retain the shape of the airship. This airship requires a lot of heavy material that increases the weight of the airship. Semi-rigid airships have a frame around the envelope (the encasing of the medium) that is sometimes flexible. However, semi-rigid airships seem to be obsolete, minus the one and only Zeppilin NT. Non-rigid airships rely on an over-pressure to retain the shape of the envelope and are the most popular type of airships today. In fact, there is very little difference between semi-rigid and non-rigid airships of today. It could save on material costs to use an airship that does not rely on a frame. It results in significant weight reduction and therefore makes sense to use a non-rigid airship if possible.

VII. CONSIDERATIONS FORDESIGN PROTOTYPE

The methodology is based upon the basic principle of shaft design which has to bear the weight of turbines. And the balloon which consisting helium gas the size of the balloon should be such sufficient that it uplift the total weight of turbine and designing of cable for facilitating the strength on high altitude as we know high speed of wind require a wire with high young’s modulus and specifically balloon require an aerodynamic design.

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In order to reach the altitudes needed, a blimp with 200,000 cubic feet of hydrogen was used. The main factors which lead to a blimp of such size are:

- Weights of the turbines,
- The drag exerted on the swept area of a spinning rotor and the
- Combined drag and weight of the Tether

For the material used and the overall structure of the blimp, it was actually very similar to the Goodyear blimp that we see today. The blimp is a non-rigid airship without an internal supporting framework. The envelope is made out of a polyester composite fabric much like the fabric used for modern space suits. The higher pressure of the lifting gas inside the envelope and the strength of the envelope is what maintain the shape of the blimp.

Two Vestas 850 kilowatt turbines are attached under the blimp using steel supports. The supports are connected to the blimp using two catenary curtains and suspension cables inside the blimp, each located along the length of the airship. The curtains are made from folded fabric and are stitched into the envelope. The suspension cables then attach to the supports much like the gondola underneath the Goodyear blimp. Steel supports are attached between the two nacelles of the turbines to provide a more rigid structure. The turbines are set up to spin in opposing directions in order to counteract the forces involved with the spinning of the blades.

With an operating height of 300m, a material for the tether needed to have a high tensile strength and be a light as possible. Steel was first tried as the material for the tether but it was too heavy and not strong enough. After using calculations for the drag forces, the diameter of the steel tether came out to be 18 cm and this was considered to be too large. The selected tether is made out of a carbon epoxy composite with a tensile strength of 1100 MPa. By using the carbon composite, the diameter became 12cm which is more workable. This comes out to have a cross-sectional area of 256 cm2. The greatest challenge presented to the analysis was to calculate the amount of hydrogen that the airship must contain in order to stay afloat. All weights must be accounted for: the supports, the turbines, the envelope material, tethers, power lines, support cables, and possibly a wing. This analysis combined the sciences of fluid dynamics, stress analysis, heat transfer, electrical engineering, and elements of machine design to provide a basis for which a company could see that a design was possible, a proof of concept.
Further setup consisted of determining what safety factor to use, what lighter-than-air medium to fill the airship, and what proportions to assume for the airship envelope. Most safety factors tend to be around 2 or 2.5, but since this is a revolutionary idea, it made sense to go with a higher, more conservative safety factor of 3. The medium chosen was decided much earlier on to be hydrogen, due to its cost-effectiveness as well as the safety of the envelope being far from any type of spark. A proportion of 1:4 (height or depth by length) was the approximate ratio of many small blimp-like balloons that could serve as a test model for our design.

Surface Area:
The envelope was assumed to have the same thickness and material as the Goodyear blimp. The surface area should be chosen according to the conditions available in the vicinity. Large surface area is usually avoided as it require heavy material requirement.

Hanging Supports:
The next vital step is to design hanging support system. The hanging supports consist of two rods extending from the centroid of the envelope (possibly using a netting or other canopy-type support to connect to the envelope) to the nacelles of the turbines. Because the width of the envelope is smaller than the sum of the radii of the blades plus a clearance (dclrnc at 10m), this results in the two hanging supports being at obtuse angles from the envelope. This will be an additional feature to the modified aerial wind turbine

Power Lines:
Power lines designing is an important concern as we need to find out how much amount of electricity is going to be generated from the source station, accordingly the heat releasing from wire as they heat up due to resistance of conducting material and critical thickness of the wire subsequently. The thickness of the power lines running up and down the tether must be considered. Because the resistance in a power line is relative to the current squared (I2) and current directly proportional to the voltage, when the voltage increases, the resistance significantly decreases. However, when the voltage is too high, it may spark or lose charge through the corona effect (electron release into space when high charge is present on small point conductors). Thus, the range in voltage for high tension power lines was researched and found to be in the range of 3kV to 1MV. To be in that range, but cautious, 300kV was eventually chosen to be the voltage in the power lines.

Drag Force:
As the initial concept clearly indicates that when these turbines will placed on high altitudes they would feel significant drag force. The fundamental fluid mechanics laws clearly states that there will be high velocity as the altitudes increases and in contrary there is low velocity as we reach near the earth surface due to no slip condition between earth and flowing wind. The “no slip” condition is a practical assumption that fluid velocity moving across a surface will approach zero as it nears the surface. Therefore, wind velocity is small at the ground and much larger the further away.

Area of Tether:
The tether has to be strong enough as it holds the structure in peak time when wind flows at very high speed. This means that a tether that can support the drag forces as well as the upward forces of the wing must be attained. To do this, the drag force must be counteracted by another force. This another force must be attained by using mathematical inductions for proper designing.

Wing:
Lift needed to be provided beyond that of the airship part of the structure or else the angle of the tether from the ground would be much too small, resulting in the turbine blades interfering with the ground. The calculations assume a wing to be an elliptical shape with 4% height of width and thickness of aluminium.

Horizontal Beam:
The horizontal beam connecting the two nacelles undergoes compressive stresses from the weight of the turbines hanging from the supports connected to the nacelles. Also, the beam undergoes torsion from the spinning turbine blades. The torque is a function of power over rotational speed.so it must be properly designed to sustain both the stresses.

Support Cables/Rods:
There will be some cables and rods to sustain various forces in the aerial wind turbines.

Maximum Fatigue Load on Supports:
Because the hanging beams undergo recoil when the wind stops suddenly from a gust of wind, the supports were designed with a larger moment area of inertia. The beams are rigid, hollow rectangular beams with the long direction facing the wind.

Calculating Mass:
Each and every material used carried its own mass, and this is calculated by multiplying volume and density. Two types of overall masses were determined: if only steel was used for cables and structures and if aluminium was used for structures and carbon epoxy was used for the tethers and cables. Most of the mass consist from mass of the hub and rotors.

VIII. ISSUES AND RESOLUTION

- One major issue for keeping this structure in the air would involve replacing the hydrogen that leaks out of the balloon. Both hydrogen and helium leak out of the thin materials because they are very small molecules and find their way out of nearly any barrier. By determining the rate at which the gas seeps out, you could then come up with a method to refill the blimp with new helium/hydrogen. It can be employed with a sensor system which indicate the low level of hydrogen in the system. Another method could involve tubes in the tethering system that can feed the envelope when needed.

- Another major concern is drag force. From the immense drag on the turbine blades, the structure will be blown so far backwards that it will be rendered useless. Thus, more lift must be generated in high winds. The solution is either more hydrogen or the addition of a wing to provide lift.

- Next problem encounter is the platform area (underside of the wing area) which will be quite immense. However, the boundary layer around a wing's cross-section is generally quite thin in comparison to the dimensions of the cross-section. Therefore the wings can be layered between the supports much like a bi or tri plane. This will provide significant lift when the wind is strong, conserve space, and keep the bending stresses to a minimum.

- Material selection is an additional aspect that should be taken into deep observation. Whenever you have something this huge in the air, it is important to reduce the weight wherever possible while also increasing its strength. Steel has very important fatigue properties. It has a fatigue limit in which it will theoretically never fail under certain repetitive load size. The high the grade of steel used, the less likely it is to fail and a lesser amount of material can be used to support the structure.

IX. FUTURE SCOPE

These would not only help to serve developed nations as well they will be able to serve developing countries like India in the manner mentioned below:

- They will prove their best suitability to remote areas where transmission cost more than generation.

- They will become the indigenous source of energy generation for high dense cities where wind blows with significant low speed near the earth surface as the reason mentioned in above paper

- As this would be emission free energy generation so it would be beneficial for countries like US where excretion of high amount of greenhouse gases is major concern.

- Fuel (air) is free so almost every country (according to their geographic condition) can harness the resource as free of cost.

After so many researches in this specific study many conclusions were made and ideas for future work came about. From the analysis, the major finding is that at the present time this project is feasible but will be challenging to complete. One reason for this conclusion is the size and weight of the turbines. The weight of the turbines and the drag forces cause the blimp to be massive in size. This project can be undertaken but in the future there are specific challenges that should be solved in order to have an upgraded prototype.

The future of aerial wind turbines is exceptionally promising with the hope that emerging researches and technology will reduce the weight and size of wind turbines while maintaining the same power capacity. But it would be better if the overall size of the structure could be smaller in the future.

These turbines are used to give energies to those areas where the wind flows at high speed but on high altitudes specially where there is high population density and high power crisis as there is no such power generation in the city. For an example New Delhi. The political capital of India having 1500square kilometre area and population density is above 11k per kilometre square so the land is not enough for power generation and there is no in-built electricity plant in the city so these turbine gave the citizens The Elysium of 24*365 power supply

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