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TO REDUCE WEIGHT AND TO IMPROVE EFFICIENCY OF VERTICAL AXIS WIND TURBINE

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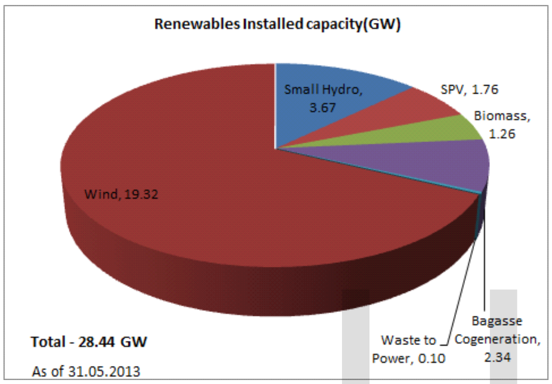
Abstract—**Abstract -**Due to development of all the country now a day's all the country requires good energy source. As there is increase in demand for energy usage day by day we require good energy source which is renewable. Moving across the emerging trends of renewable energy sources, wind energy has attracted more attention because it is considered as a renewable resource and is easily available. Wind energy is an important renewable energy source due to maturity of technology, good infrastructure and relative low cost competitiveness. Due to growing interest in wind energy harvesting offshore as well as in the urban environment, vertical axis wind turbines (VAWTs) have recently received renewed interest. Vertical axis wind turbine uses a radically new approach to capturing wind energy.the device capture the energy of wind and converts into mechanical form. Their omni-directional capability makes them a very interesting option for use with the frequently varying wind directions typically encountered in the built environment while their scalability and low installation costs make them highly suitable for offshore wind farms. However, they require further performance optimization to become competitive with horizontal axis wind turbines as they currently have a lower power coefficient. The angle of attack is a potential parameter to enhance the performance of VAWTs. The current study investigates the variations in the experienced angle of attack and weight optimisation of turbine.

Keywords—wind turbines,VAWT,PLA,wind turbine blades,renewable energy

1.INTRODUCTION

A vertical-axis wind turbine (VAWT) is a type of windturbine where the main rotor shaft is set transverse to the wind (but not necessarily vertically) while the main components are located at the base of the turbine. This arrangement allows the generator and gearbox to be located close to the ground, facilitating service and repair. VAWTs do not need to be pointed into the wind, which removes the need for wind-sensing and orientation mechanisms. Major drawbacks for the early designs included the significant torque variation or "ripple" during each revolution, and the large bending moments on the blades. Later designs addressed the torque ripple issue by sweeping the blades helically. A vertical axis wind turbine has its axis perpendicular to the wind streamlines and vertical to the ground. A more general term that includes this option is "transverse axis wind turbine" or "cross-flow wind turbine." Today, India is stepping towards becoming a global super power. This implies that, it is leading the list of developing countries in terms of economic development. Hence its energy requirement is going to increase manifold in the coming decades. To meet its energy requirement, coal cannot be the primary source of energy. This is because coal is depleting very fast. It is estimated that within few decades coal will get exhausted. The next clean choice of energy is solar power, but due to its lower concentration per unit area, it is very costly.India ranked fourth in the world for amount of power produced by harnessing wind energy. Fig 1.1 shows pie chart for share of renewable installed capacity in india.

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment. This popularity has been bolstered by cutting edge research and ground-breaking technology that has been introduced so far to aid in the effective tapping of these natural resources and it is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the latter part of the 21st century. Facts from the World Wind Energy Association estimates that by 2010, 160GW of wind power capacity is expected to be installed worldwide which implies an anticipated net growth rate of more than 21% per year.



1.1.Wind Power In India

Wind power generation in India has increased in recent years. The country's total installed wind power capacity reached 37.699 GW as of 29 february 2020.

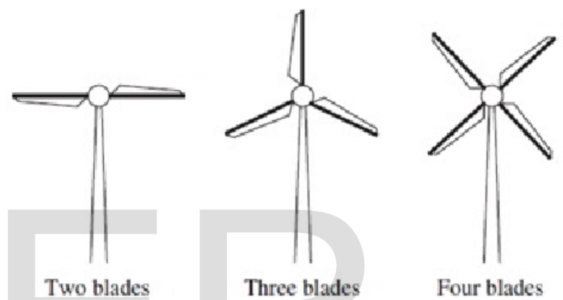
The Indian government had an initial target of 54.7 GW capacity for 2022 against 60 GW set by the government.

1.2. Types Of Wind Turbine

Wind turbine are mainly divided into two i.e, horizontal Axis and vertical axis wind turbine.

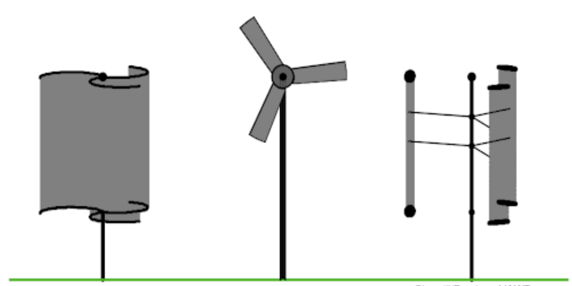
1.2.1.Horizontal Axis Wind Turbine

This is the most common wind turbine design. In addition to being parallel to the ground, the axis of blade rotation is parallel to the wind flow. Some machines are designed to operate in an upwind mode, with the blades upwind of the tower. In this case, a tail vane is usually used to keep the blades facing into the wind. Other designs operate in a downwind mode so that the wind passes the tower before striking the blades. Without a tail vane, the machine rotor naturally tracks the wind in a downwind mode. Some very large wind turbines use a motor-driven mechanism that turns the machine in response to a wind direction sensor mounted on the tower.



1.2.2 . Vertical Axis Wind Turbine

Although vertical axis wind turbines, below figures have existed for centuries, they are not as common as their horizontal counterparts. The main reason for this is that they do not take advantage of the higher wind speeds at higher elevations above the ground aswell as horizontal axis turbines. The basic vertical axis designs are the Darrieus, which has curved blades, the Giromill, which has straight blades, and the Savonius, which uses scoops to catch the wind.



2 **Litrature review:**

1.Nallapanenimanojkumar et.al This presents aerodynamic modelling, fabrication and the performance evaluation of vertical axis wind turbine (VAWT). Aerodynamic modelling of VAWT is designed using software tools by considering NACA0012 airfoil whose chord length is 0.12m. Aluminum material based light weight 3 bladed practical prototype model of VAWT having rotor diameter and rotor height as 0.36 m and 0.40 m respectively is fabricated. This practical prototype model is tested in subsonic wind tunnel to annalyze the performance parameters like power in the wind, mechanical power at turbine shaft, tip speed ratio (TSR) and power coefficient. The rotor is tested under different wind speeds ranging from 4.38 m/s to 22.38 m/s, test results shows the reliable and efficient performance. The Wind is generated due to pressure difference of atmosphere. Because of the atmospheric pressure difference, air particles move high-pressure end to lower pressure end. During the air flowing, air molecules are subjected to Coriolis effect except exactly on the equator. The winds are often referred to according to the direction from which the wind blows and its force. There is a rapid growth in wind power development globally. This utilization of the wind for electricity generation is expanding quickly, due to large technological improvements, industry maturation and increasing concerns with greenhouse emissions associated with fossil fuel burning. Given the enormous wind resources, only a small portion of the usable wind potential is being utilized presently. Government and electrical industry regulations, as well as government incentives, have a large role in how quickly wind power will be adopted.

The purpose of this paper the Vortex-Induced Vibration (VIV), which occurs since many fields of engineering, has been studied extensively, especially in the past fifty years, due to its significant implications in different engineering applications including offshore structures, cooling towers, bridges, heat exchangers and electrical transmission lines. VIV of an elastically mounted circular cylinder in fluid flow has been studied experimentally and numerically in the literature and have been covered in several overviews such as and more recently.

2.Junkun Ma et.al This paper presents a study of the effects of airfoil pitch control on the fluid dynamics and efficiency of a Vertical Axis Wind Turbine (VAWT) with airfoil that pivots freely with respect to its supporting arm attached to the main shaft of the VAWT. The steady-state velocity and pressure fields for different airfoil pivoting angles at a series of VAWT rotation angles are obtained. Net force on the airfoil at a given position, which is directly related to the efficiency of the VAWT, is also derived based on the pressure field and the airfoil geometry. As a comparison, wind speeds representing both laminar and chaotic air flows are considered. The results show that an optimal airfoil pivoting angle resulting in maximum net force exists at any given VAWT rotation angle. It is also shown that the maximum net force at a given VAWT rotation angle increases non-linearly as the wind speed increases.be unidirectional in this study. The symmetry shown in the results is likely due to the fact that NACA0012 airfoil does have a symmetric contour with respect to its chord. Other NACA airfoil with non-symmetric contour shall be compared. The purpose of this study is to investigate the fluid flow around a three-bladed VAWT and analyse the effect an upstream deflector effect has on the turbine efficiency.

3.YaminiSarthi et.al This paper present the effect of blade profile, number of blade, surface roughness of blade, aspect ratio and Reynolds number on the performance of vertical axis wind turbine. A numerical analysis, adopting the multiple stream tube (MST) method, is carried out to evaluate the performance depending on the parameters. The numerical result shows that the variation of blade profile directly affected the influence power production. An enhancement of the power production is observed with increasing the Reynolds number on the whole tested blade speed ratio range. Aspect ratio of wind turbine is the ratio between blade length and rotor radius. Since the aspect ratio variations of a vertical-axis wind turbine cause Reynolds number variations, any changes in the power coefficient can also be studied to derive how aspect ratio variations affect turbine performance. It is shown experimentally that the surface roughness on the turbine blade has a significant effect on the performance of turbine.The design intended that the turbine should have low cut-in wind speed, lightweight, and can be easily moveable. The drag based machine should be capable of harnessing energy from the non-directional wind at low cut-in speed, which makes it a better choice for many urban applications. Fig. 1 shows a view of the proposed turbine blades and support system. The blades were attached to the hub with the help of three steel bars, and each bar is welded to the center to provide stability to the design

4 Z. M. Zain et.al This paper proposes the new patented invention of the vane-type wind turbine which uses wind energy more efficiently and is only dependent on the acting area of the vanes. The vane wind turbine was designed to increase the output of a wind turbine that uses kinetic energy of the wind. Due to its high efficiency, simple construction and technology, the vane wind turbine can be used universally, apart from the fact that it is made from cheap materials. The new design of the vane-type wind turbine has quite small sizes than the propeller type one of same output power. The Darrieus turbine blade generates maximum torque at two points on its cycle. This lead to a sinusoidal power cycle that creates resonant modes that can cause the blades to break. Some designs of the blades canted into a helix that spreads the torque evenly over the entire revolution, thus preventing destructive pulsations. Another problem of the mass of the rotating mechanism is at the periphery that leads to very high centrifugal stresses on the blades which must be stronger and heavier than otherwise to withstand them. These turbines are one of the simplest self-starting vertical-axis turbines. Aerodynamically, they are drag-type devices, consisting of two or three scoops. Turbines use the cavity shape of the blades that allows the pressure wind to rotate turbines with low speed and creates high bending moment on the shaft of the turbine due to big area of the curved elements. The Savonius wind turbines are useful in the medium and small-scale installation.

3.Objectives

- main objective is to harness the wind energy with wind velocity as low as 2 m/s and as high as 40 m/s
- .Replace steel with PLA

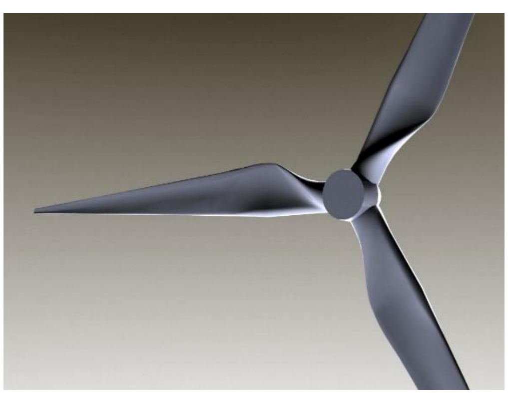
4**. Components**

4.1. Dynamo:

A dynamo is an electric generator that creates direct current using a commutator. Dynamos were the first electrical generators capable of delivering power for industry, and the foundation upon which many other later electric-power conversion devices were based, including the electric motor, the alternating-current alternator, and the rotary converter. Today, the simpler alternator dominates large scale power generation, for efficiency, reliability and cost reasons. A dynamo has the disadvantages of a mechanical commutator. Also, converting alternating to direct current using power rectification devices (such as vacuum tubes or more recently via solid state technology) is effective and usually economical.

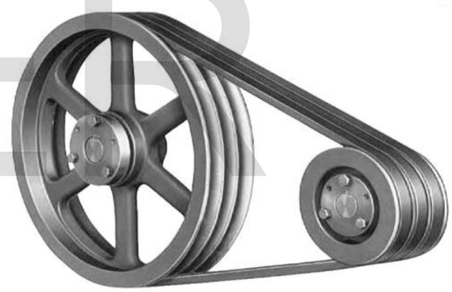
4.2. Turbine blades:

A turbine blade is the individual component which makes up the turbine section of a gas turbine or steam turbine. The blades are responsible for extracting energy from the high temperature, high pressure gas produced by the combustor. The turbine blades are often the limiting component of gas turbines. To survive in this difficult environment, turbine blades often use exotic materials like super alloys and many different methods of cooling that can be categorized as internal and external cooling, and thermal barrier coatings. Blade fatigue is a major source of failure in steam turbines and gas turbines. Fatigue is caused by the stress induced by vibration and resonance within the operating range of machinery. To protect blades from these high dynamic stresses, friction dampers are used. Blades of wind turbines and water turbines are designed to operate in different conditions, which typically involve lower rotational speeds and temperatures.



4.3. Belt &pulley:

A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt, or transfer of power between the shaft and cable or belt. In the case of a pulley supported by a frame or shell that does not transfer power to a shaft, but is used to guide the cable or exert a force, the supporting shell is called a block, and the pulley may be called a sheave. A pulley may have a groove or grooves between flanges around its circumference to locate the cable or belt. The drive element of a pulley system can be a rope, cable, belt, or chain. Hero of Alexandria identified the pulley as one of six simple machines used to lift weights. Pulleys are assembled to form a block and tackle in order to provide mechanical advantage to apply large forces. Pulleys are also assembled as part of belt and chain drives in order to transmit power from one rotating shaft to another.



5. Accessories Used

5.1Anemometer

It is the device used for measuring wind speed. The termed is derived from Greek word anemos which means wind. One of the forms of mechanical velocity anemometer is the vane anemometer.

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5.2. Tachometer

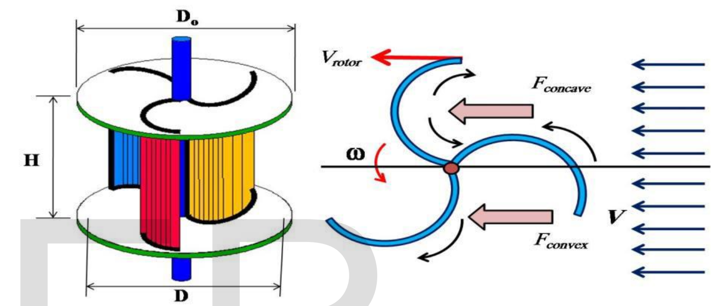
It is an instrument measuring the rotational speed of shaft or disk as in a turbine or a machine. The device usually displays the revolution per minute on a digital display. The word has been derived from Greek word tachos meaning speed.

6.Working

Savinious turbines are one of the simplest turbines.Aerodynamically,they are drag type devices consisting of two or three blades. The savonius wind turbine works due to the difference in the forces exert on each blade.The lower blade (the concave half to the wind direction) caught the air wind and forces the blade to rotate around its central vertical shaft. Whereas, the upper blade (the convex half to wind direction) hits the blade and causes the air wind to be deflected sideway around it.

Because of the blades curvature, the blades experience less drag force (*Fconvex*) when moving against the wind than the blades when moving with the wind (*Fconcave*). Hence, the half cylinder with concave side facing the wind will experience more drag force than the other cylinder, thus forcing the rotor to rotate. The differential drag causes the Savonius turbine to spin. For this reason, Savonius turbines extract much less of the wind's power than other similarly sized lift type turbines because much of the power that might be captured has used up pushing the convex half, so savonius wind turbine has a lower efficiency.

The three blade savonius wind turbine is constructed from three half cylinders, they are arranged at (120 degree) relative to each other as shown in figure



Advantages

- Less vibration
- Produce electric energy at low wind speed
- Vawt are shorter than hawt

Disadvantages

- Not efficient as hawt
- Requires power and starting motor to start darrieus wind turbine

7. Calculations

7.1. Design of shaft (Aluminium)

m=1.06kg, $s_{ut} = 310\ \text{N/mm}^2,\ s_{yt} = 276\ \text{N/mm}^2,$

l=300mm

- **Compressive stress**

$$\sigma_c = \frac{3mg}{\frac{\pi}{4} * d^2} = \frac{3 * 1.06 * 9.81}{\frac{\pi}{4} * d^2} = \frac{39.7197}{d^2} N/mm^2$$

$$\tau = \frac{T}{J} * r = \frac{3mgl}{\frac{\pi}{32} * d^4} * \frac{d}{2}$$

$$\tau = \frac{48mgl}{\pi d^3} = \frac{48*1.06*9.81*300}{\pi d^3} = \frac{4766306714}{d^3} \ N/mm^2$$

- Principle Stress Theory

$$\sigma_c = \left(\frac{-\sigma_c}{2}\right) + \sqrt{\left(\frac{-\sigma_c}{2}\right)^2 + \tau^2}$$

$$= \frac{-19.8598}{d^2} + \sqrt{\frac{394.4136}{d^4} + \frac{227108255*10^{-6}}{d^6}}$$

$$\sigma_{t_{all}} = \frac{S_{ut}}{fos} = \frac{310}{3} = 103.33 N/mm^2$$

σtall = σ1

$$1033.33 = \frac{-1908598}{d^2} + \sqrt{\frac{394.4136}{d^4} + \frac{227108255*10^6}{d^6}}$$

d=7.7182mm

we know,

$$\tau_{max} = \sqrt{\left(\frac{-\sigma_c}{2}\right)^2 + \tau^2}$$

$$\tau_{max} = \sqrt{\frac{394.4136}{d^4} + \frac{2271.8255 * 10^6}{d^6}}$$

$$\tau_{all} = \frac{0.5s_{yt}}{fos} = \frac{0.5*276}{3}$$

$$46 = \sqrt{\frac{394.4136}{d^4} + \frac{2271.8255*10^6}{d^6}}$$

d=6.65mm

we choose shaft dia from above two dia.

D=7.7182mm

7.2 Diameter of the turbine, D

The relationship between required power output and design velocity was utilized to evaluate diameter of turbine.

$$P = \frac{1}{2} * \rho * V^3 * D^2$$

Where, ρ = 1.23kg/m^3 Cp=0.48

P=50w V=8m/s

Now, $P = \frac{1}{2} * \rho * V^3 * D^2$

$50 = 0.5*0.48*1.23*8^3 * D^2$

D=0.5751m

7.3Design of blade

Span length of the blade,b-The length of blade is taken as half of dia of turbine b=0.6/2=0.3m

Aspect ratio,AR-Aspect ratio is the ratio of span length, with chord length, c of the blade.

AR= b/c

$$5 = \frac{0.3}{c} = 0.06m$$

Chord length of the blade, c -Using the above described relation of AR, the chord length of the wind turbine blade is taken as

C=0.06m

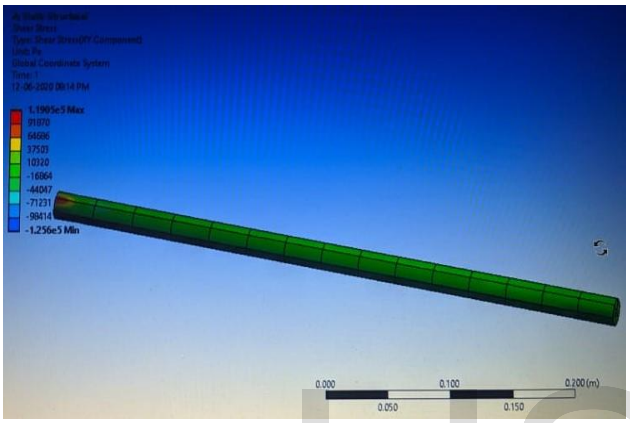
Area of aerofoil blade

For solid

$$A = \int_0^c \frac{y}{c} - \left(-\frac{y}{c}\right) dx$$

From this total deformation analysis, we conclude that deformation is maximum at the left of the shaft and it shows by red, orange and yellowcolour respectively. Conversely, total deformation is minimum at right of shaft and it grows till end ofshaft.

9.2.Shearstrees on shaft



10.Methodology

- Size of the turbine required for that power generation
- Designing of the turbine rotor on the basis of calculation.
- Consideration of other part such as bearing, shaft, base, disk, etc. on the basis of rotor size
- CAD model of the Vertical axis wind turbine.
- Analysis of the designed model
- Fabrication of the VAWT
- Testing it in different wind condition.
- Results

11.Conclusion and Future Scope:-

Conclusion- So as per work plan we had done literature survey,design and calculation of shaft, nlade,etc. Then next we had done CAD modelling of parts and assembly and ansys-simulation.On the basis of simulation reslt we started fabrication.

Future scope

- To ensure future growth of the U.S. wind industry, the Energy Department's Wind Program works with industry partners to improve the reliability
- Improving the mechanical structure.
- To reduce the cost.

11. Expected Result:-

Actually, results of our project depends upon the testing conditions and various environmental factors. Movement of the turbine depends upon the velocity of wind at Particular time and place. So, as per that generation capacity changes.

Acknowledgment

It is our privilege to acknowledge with deep sense of gratitude to our project guide**, Prof.A.J. Jamdar**for their valuable suggestions and guidance throughout our study and timely help given to us in the completion of this project.

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Refrences

1] R.Usubamtov,A.Y.Qasim and Z.M.Zain school of Manufacturing Engneering,University Malaysia Perlis,KampusTetap,UluPauh Arau,02600 Perlis,Malaysia

2]A. A. Safe, SaadKashem, M. Moniruzzaman, and M. T. Islam, "Design fabrication and analysis of twisted blade vertical axis wind turbine (VAWT) and a simple alternator for VAWT," in Proc. the 9th International Forum on Strategic Technology (IFOST), pp. 304308, Cox's Bazar, Bangladesh, October 21-23, 2014.

3] PranitNagare, RammohanShettigar, Arnav Nair, Pratibha Kale, and PrasannaNambiar, "Vertical axis wind turbine," in Proc. 2015 International Confernece on Technologies for Sustainable Development (ICTSD-2015), pp. 1-6, Mumbai, India, Feb 04-06, 2015.

.4] Travis J. Carrigan, Brian H. Dennis, Zhen X. Han, and Bo P. Wang, "Aerodynamic Shape Optimization of a Vertical-Axis Wind Turbine Using Differential Evolution," ISRN Renewable Energy, vol. 2012, Article ID 528418, 16 pages, 2012.

5] Antoine Vergaerde, Tim De Troyer, LievenStandaert, Joanna Kluczewska-Bordier, Denis Pitance, Alexandre Immas, Fr_ed_ericSilvert, Mark C. Runacres, "Experimental validation of the power enhancement of a pair of vertical-axis wind turbines", Renewable Energy 146 (2020) 181e187

6] . S.M.H. Karimian, AbolfazlAbdolahifar, "Performance Investigation of a New Darrieus Vertical Axis Wind Turbine", Journal Pre-proof

7] Composite Material For Wind Turbine Blade-by PovlBrøndsted, Hans Lilholt, and AageLystrup, Materials Research Department, Risoe National Laboratory, DK 4000 Roskilde, Annu. Rev. Mater. Res. 2005. 35:505–38.

8] Xiaona Ji, and JorgSchliiter, "Design and analysis of small scale vertical axis wind turbine," in Proc. IET Conference on Renewable Power Generation (RPG-2011), pp. 1-5, Edinburgh, September 06-08, 2011.