Kastamonu Uni., Orman Fakültesi Dergisi, 2017,17 (1): 69-79 Research Article
Kastamonu Univ., Journal of Forestry Faculty
Doi: 10.17475/kastorman.296495

Comparison of Design Gmrt Wind Turbine Plant Effectively with other Power Wind

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Received Date: 09.08.2016 Accepted Date: 23.01.2017

Abstract: In this study, we investigated a special design, advanced wind turbine, which is comprised of Gelibolu Model Wind Turbine (GMRT) and three PTDW (power-treatment-directing-wing) type wings integrated. This model is vertical spindle turbines (DARRIEUS) type power wings. PTDW wings transform the negative wind powers into a positive additional vacuum power and this contribution multiplies the productivity of turbine's power wings by as much as 5 times in proportion to other traditional vertical shaft wind turbines. It show that power balance is effective much more than other models .This model is more suitable for the environment that it is the conclusion gained from the data. Since the turbine's aerodynamic effect zone is wide compared to the scanning area, the total cost of the turbine is less compared to the other wind turbines in terms of per kilowatt cost and full capacity cost. It comprises thanks to the superiority provided by its design. In this study, we used Monte Carlo computer simulation method for the calculations of turbine power and about effective.
Keywords: Darrieus, Gmrt, Monte Carlo simulation, Optimization

GMRT Rüzgar Türbünün Diğer Güç Rüzgar Türbünleriyle ile Efektif Olarak Karşılaştırılması

Özet: Bu çalışmada Gelibolu Model Rüzgâr Türbini (GMRT) ve üç adet PTDW (güç-işleme yönlendirme kanadı) oluşan gelişmiş özel bir türbin tasarım araştırlmıştır. Bu model, dikey türbin türbinlerinin (DARRIEUS) tip güç kanatlarının özel bir parçasıdır. PTDW kanatları negatif rüzgâr enerjilerini pozitif ek bir vakum gücüne dönüştürür ve katkı, türbinlerin güç kanatlarının verimliliğini, diğer geleneksel dikey şaft rüzgâr türbinleriyle orantılı olarak 5 kat artırır. Güç dengesinin diğer modellerden çok daha etkili olduğunu gösteriyor. Çalışmamız gösteriyorki, bu model çevre için daha uygundur. Türbinin aerodinamik etki bölgesi tarama alanına kıyasla geniş olduğundan, türbinin toplam maliyeti, diğer rüzgâr türbinlerine göre kilovat başına maliyet ve tam kapasite maliyeti açısından daha az maliyetlidir. Tasarladığı üstünlük sayesinde oluşur. Bu çalışmada, türbin gücü ve üstün tasarım bakımından simülasyon hesaplamaları Monte Carlo bilgisayar yöntemi kullanılmıştır.
Anahtar Kelimeler: Darrieus, Gmrt, Monte Carlo simülasyonu, Optimizasyon

Introduction

Gmrt is a specially designed and developed wind turbine composed of three "power enrichment routing blade" (gayk) combined with vertical shaft "Darrieus" type power blades. Gayk blades provide an additional vacuum power to wind turbine and increase efficiency of power blades of the turbine up to 5 times of power of equal vertical shaft wind turbines (vswt) (Ackermann 2005; Holttinen et al., 2011; Güleren et al, 2011).Gmrt preserves this performance superiority in comparison with vertical shaft wind turbines automatically by gayk blades' ability to adjust themselves according to each wind directions.Cross - sectional area of gmrt turbine is 1/5 of cross - sectional area of other classical vertical shaft wind turbines (savonius, darrieus) which generate equal power. Importance of this subject can be discussed by comparing gmrt with other types of vertical shaft turbines in terms of scientific details, major superiorities;

i) scanning areas ii) total investment ($ / kw) need per (kw) iii) capacity factor iv) full capacity cost v) cost per kilowatt (kw) vi) repair and maintenance costs vii) availability percentage viii) GMRT turbine power plant field other properties against vertical (vswt) and horizontal (hswt) wind turbines are superior (Luo et al., 2012; European Wind Energy Association Report 2013a,b; Kooijman et al, 2013) . This model can be operated at various wind speeds (initial motion up to 2 m / s and cutting speed) and has a wider operating performance than other models. Table - 1 Advantages of gmrt than other models in same wind field are given. In addition to this, gmrt wind type model has more advantages than other turbines with regards to structural geometry and costs in real MW power turbines and in sea and (off - shore) applications

Structure of GMRT/GAYK

A full - size gmrt model and 120 degree three-dimensional display are given in Figure 1. Structural practice of gayk blades is exemplified in the design. In Figure 1, wind turbine is placed on gayk flange and roller around mass center placed on mdf table (minor radius is 299.94 cm and major radius is 358.02 cm). Hollowed steel rods are placed on the mdf vertically and 3 units of darrieus blades are used in the system. In Figure 1 chord length of gmrt wind turbine is designed as 100 mm, outside diameter of gayk blade radius is designed as approximately 141 cm, inner diameter is designed as approximately 127 cm and blade height is designed as a 301,38cm (Aras, 2003; Butterfield et al., 2005; Güler, 2009; Akdağ and Güler, 2010). Special design of gayk blades effects air flows in such a manner that they are scattered from gmrt cross - sectional area to a wider “Active Area”. In this case, area in “Betz Limit” formula used in identifying wind turbines' performance and its value in denominator are changed significantly. (Şener, 1995; Uslu et al., 2012; Song and Yang, 2015;).

The number giving maximum power that can be generated theoretically from the wind in horizontal axis wind turbines, which is also known as betz limit, is 16 / 27. It is surely beyond doubt that Betz limit theorem is correct; however, denominator value in relevant formula is modified in such a manner that it does not express power of air flows devoted to cross - sectional area of the turbine, but the power of air flows devoted to cross - sectional influence area effected by wide influence area of gmrt turbine. This area is changed in such a manner that it expresses power of airflows of gmrt turbine devoted to gayk blades. This area is formed because it deflects air flows of gmrt turbine devoted to gayk blades and an additional vacuum power providing a very high performance increase to gmrt occurs due to existence of gayk blades. In this case, it occurs due to the existence of gayk blades. In this case gayk blades improve power formulation result by inhibiting negative powers and participate in power formulation of positive vacuum power gmrt turbine and increase its efficiency. In darrieus model, it shows that Figure.2a Simply, power balance in any other type of shaft turbine is (6 kw-4kw=2kw) due to “cross section area” and in Gelibolu model, it shows that figure.2b, effective increase due to wider “active area” (6 kw+4kw=10kw) from cross section area is 5 times more (Tande, 2005; Uslu, 2012).

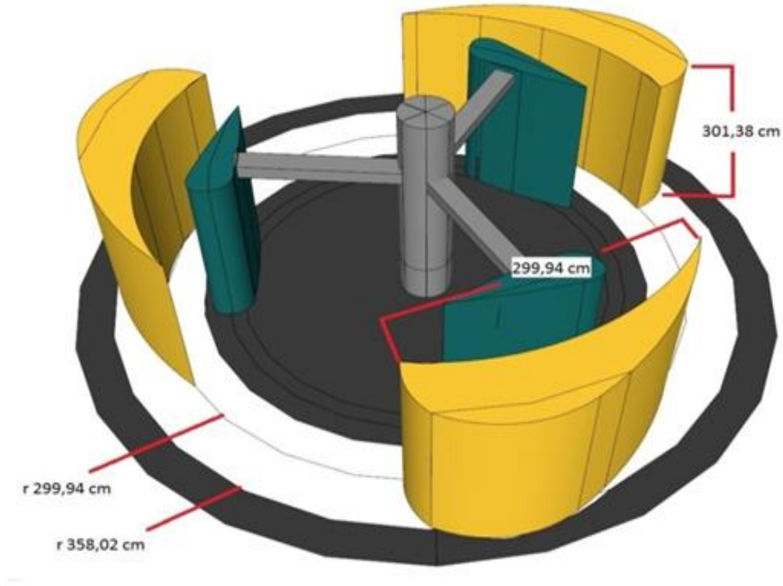

Figure1. GMRT / GAYK of the geometric size

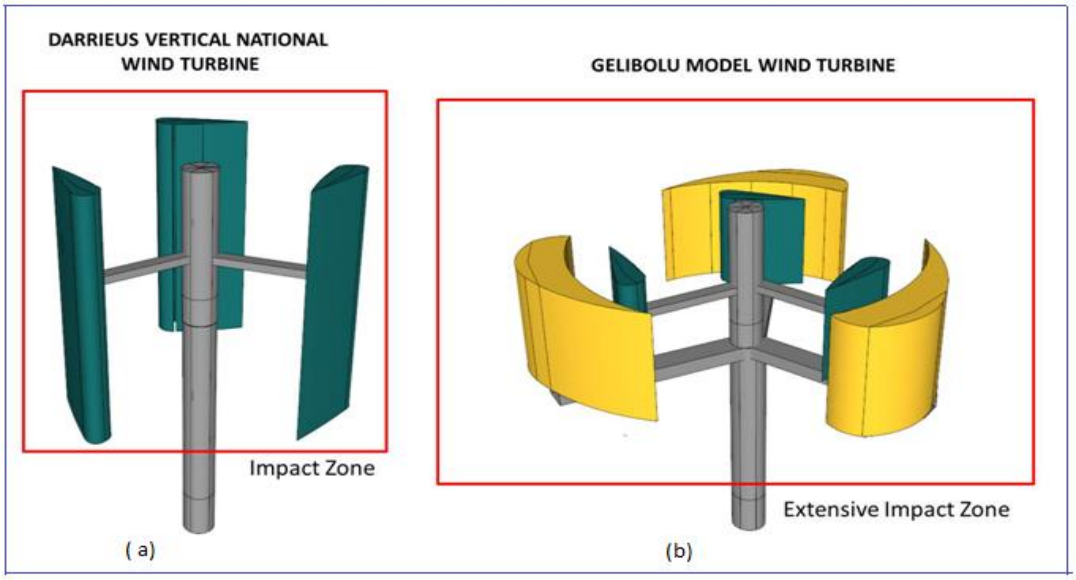

Figure2. Comparison of Gmrt model Darrieusmodels

Engineering advantages of the GMRT turbine

GMRT wind turbine model is 20 % of vswt(vertical shaft wind turbine) in same power in size. Engine routing systems and wheel hub and blade angle adjusting systems in HSWT(horizontal shaft wind turbine) are redundant in GMRT model. However, it needs a power decreasing equipment. Gmrt is suitable for using “multi polar ring generators” (low - speed / narrow, wide diameter) due to its special design. It provides more energy performance than other models annually. Capacity factor is an important performance parameter for both producers and users (Ackermann, 2005; Tande, 2005). In this work, we observe optimal repair strategies for wind turbines operated under stochastic weather conditions. In-situ sensors installed at wind turbines enable beneficial information about the physical states of the system by permitting wind farm operators to make well-versed decisions.

Q=Eout / Emax, Emax=8760 x Pt.

In Figure-3a and 3b are shown that horizontal axis wind wings "domain" and the crosssectionalare (Byon et al., 2010; Sebasitayan et al., 2012).InFigure -3b until 30% is more advantageous to the case (Raghep and Raghep, 2011).

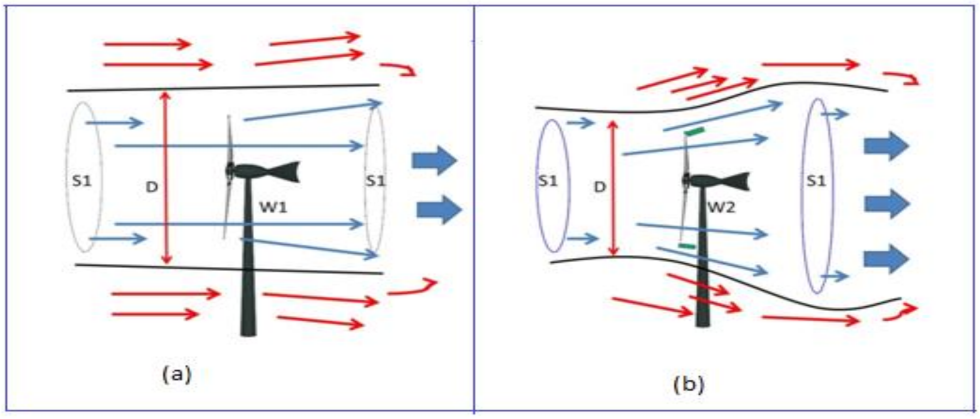

Figure3.Wind turbine blades ofcross-sectional area and the domain.

Table.1 capacity factor and capacity costs of commercial wind turbines

windturbine models	(Q)capacity factor (%)	(T)cıf-completeplantcosts ($/kw)	T/Q(capacity costs) (%)
hswt	27-30	1.050-1.300	4.333-4.815
vswt	20-25	1.300-1.600	5.200-8.000
gmrt (pilot phase	50-65	1.050-900	2.100-1.308
GMRT (series of steps)	50-65	900-700	1.800-1.077

Materials and Methods

Gmrt-Darrieus wind turbines of simulation

Wind turbines, statistical data for the modeling and stochastic studies are supported by a variety of simulation methods (Le Gourieres, 1992; Marmids et al., 2008; Randolph et al., 2008). Monte-carlo simulation study which is a randomly number selection method from at least a probabilistic distribution in a particular trial. Next, the method was adopted for solution to a more difficult and non-statistical problem (Hançerlioğulları, 2006; Randolph et al., 2008; Marmids et al., 2008; Haessig and Multon, 2015). In the study, we applied the reynolds-averaged Navier–Stokes equations with the shear-stress transport (SST) k–ω turbulence model (Menter, 1994; Hansen, et al., 2006; Sarun, 2006) Performance experimental works of gmrt wind turbine is compared with results obtained from measurements carried out in middleeast technical university wind tunnel and turkey general directorate of state meteorology affairs (dmi) at various speeds by darrieus model. The work at dmi is carried out in 2 stages. 1st stage is carried out with 3 units of darrieus type blades which is declared as naca0021. They can be listed as; they were examined i) while blades rotated out of gear, ii) while blades turn alternator rotor, iii) while blades

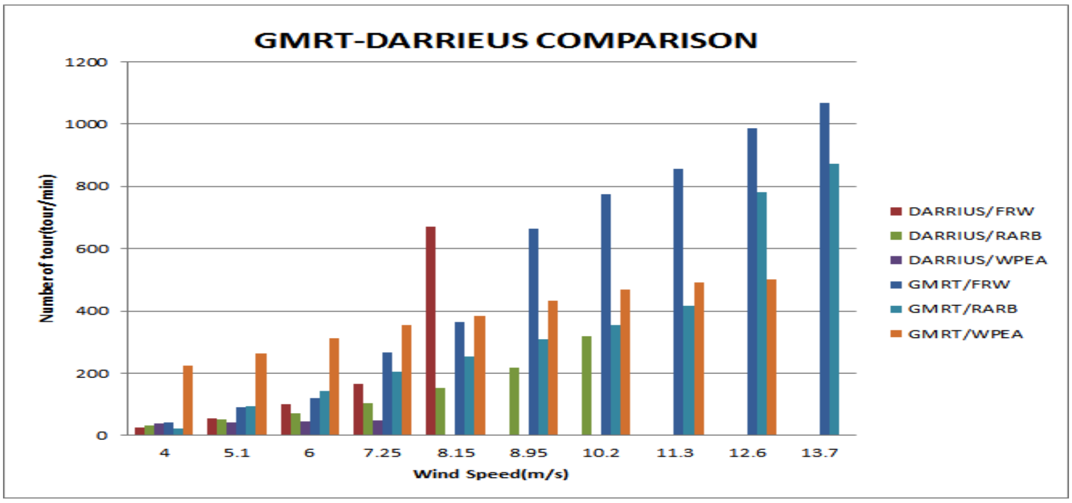

Figure4. Gmrt and Darrius / nace 0021 wind profiles of type

Electricity from alternator. At the 2nd stage of the work, three types of darrieus blades are combined with embedded gmrt type routing blades which can rotate freely. In this study number of tours was measured by electronic tour in figure 4 wind speeds of gmrt type wind turbine and darrieus type wind turbine are compared average tour counts are given in table -2 and table -3 as 1st stage and 2nd stage respectively depending upon their wind speeds. In the experimental analysis works carried out in Middleeast Technical University (METU), bare gmrt experimental power values and gmrt power values on savonius are calculated in figure 5.

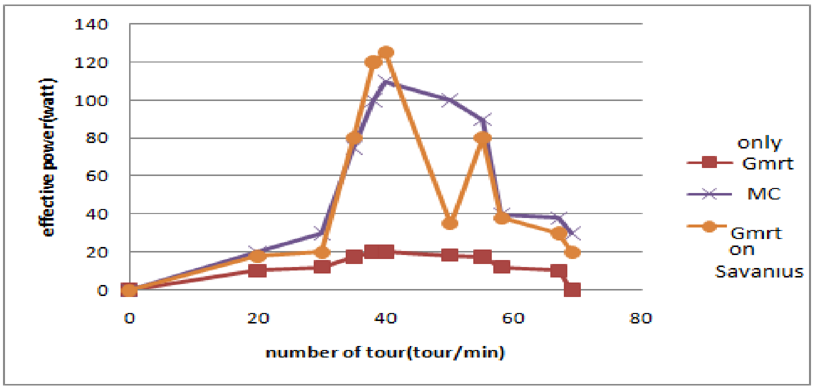

Figure5.Comparing effective power of gmrt and savonius

Table 2. Nace 0021 Darrius-type wind profile analysis

Profile Types	WindSpeed (M/S)	Average Number of Laps (Lap/Min)
Free Rotating Wings (Frw)	8.80	26
	10.3	54
	12.0	101
	13.6	166
	15.2	671
When Returning To The Alternator Rotor Blades (Rarb)	18.3	34
	19.3	53
	20.4	72
	21.8	105
	22.8	152
	23.8	219
	25.6	319
Wings Produce Electricity From The Alternator (wpea)	25.6	40
	27.0	42

Pearson correlation analysing of turbine models

Wind speeds which correspond to average number of tours of GMRT and DARRIEUS types belonging to naca0021 profile are given in figure 6 and figure 7 .Analyzing the tables -2 and 3, we performed Pearson correlation test in order to observe the correlation between the variables; where in this case the variables are turbine models, the profile types, the wind speed and the number of tours. The correlations between turbine models and wind speed, and turbine models and number of tours are significant at the 0.05 level and 0.01 level, respectively. Similarly, there is a significant correlation between profile types and wind speed. However, there is no significant correlation between profile types and number of tours.

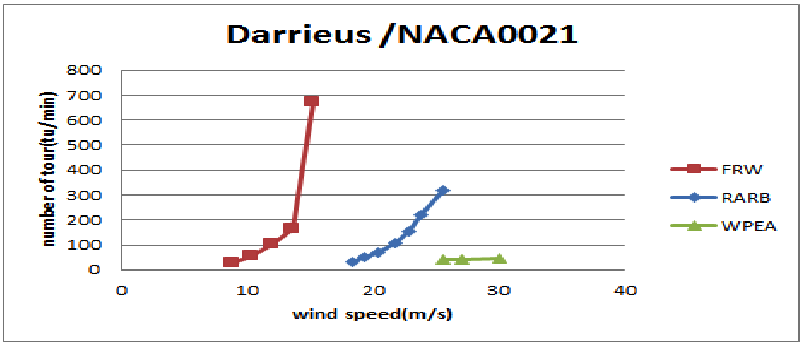

Figure6. Darrieus /Nace 0021 type profile

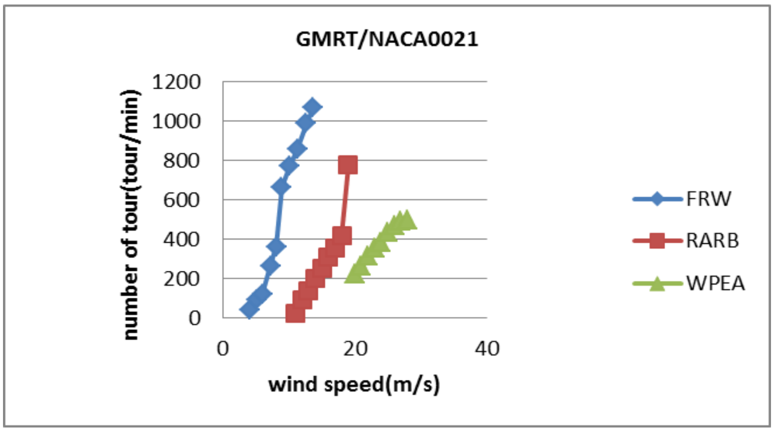

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Figure-7 GMRT/NACA 0021 type profile

We conducted a one-way anova analysis to show the difference between the means of the groups. Here, dependent variable is number of tours, and the factor is turbine model. We obtained the descriptive statistics, the test of homogeneity of variances and anova results, which are shown in tables 4a, 4b and 4c, respectively. The sample size, mean, standard deviation, standard error, minimum, maximum values of turbine models are summarized in Table 4a, it has been also statistically shown that the gmrt model is superior to darrieus in terms of the number of tour. According to levene statistic in table -4b, since the significance level is $p<0.05$, we reject the null hypothesis, which concludes that there is a significant difference between the variances of the groups. As the homogeneity of variances assumption is satisfied, the anova results make sense.For a floating offshore, horizontal axis wind turbine flow characteristics become more complex than those of a fixed off shore wind turbine. Because of the motion of floating platform, which include three translation a component and three rotational components motion as shown in Figure-8,(Rethore, et al., 2014; Wind türbine,rst technology, 2015; Toan and Kim, 2015).

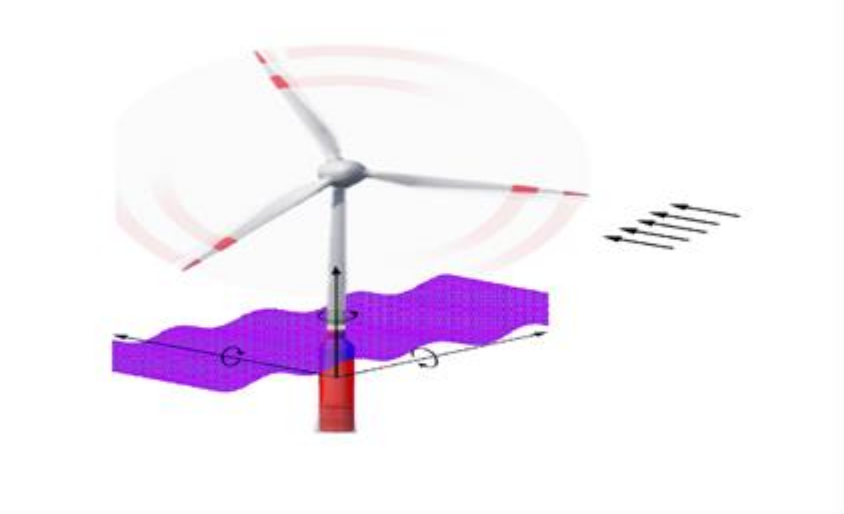

Figure.8 Aerodynamic effects on the rotating blade of tree axis wind

Table3.Gmrt/naca 0021 -typewind profile analysis

Profile Types	WindSpeed(m/s)	AverageNumber of Laps(lap/min)
Free Rotating Wings (frw)	4.00	41
	5.10	92
	6.00	120
	7.25	266
	8.15	364
	8.95	665
	10.2	774
	11.3	857
	12.6	988
	13.7	1069
When returning to the alternator rotor blades (RARB)	11.0	24
	12.0	95
	13.0	142
	14.0	205
	15.0	255
	16.0	310
	17.0	354
	18.0	418
	19.0	780
	20.0	873
Wings Produce Electricity From TheAlternator (WPEA)	20	224
	21	264
	22	314
	23	354
	24	384
	25	433

Table 4a. Descriptive statistics

	N	Mean	Std. Deviation	Std. Error	%95 Confidence Interval For Mean		Min.	Max.
					Lower Bound	Upper Bound		
Darrieus	6	13 4.2500	164 .11480	41 .02870	46 .7994	22 1.7006	2 6.00	6 71.00
GMRT	9	41 8.1034	289 .46753	53 .75277	30 7.9959	52 8.2110	2 4.00	1 069.00
Total	5	31 7.1778	285 .28138	42 .52724	23 1.4698	40 2.8858	2 4.00	1 069.00

Table.4b Test of homogeneity of variances

Levene Statistic	df1	df2	Sig.
6.055	1	43	.018

Table.4c. One-way anova results

	Sum of squares	df	Mean square	f	Sig.
Between groups	830794.888	1	830794.888	12.990	.001
Within groups	2750165.690	43	63957.342	-	-
Total	3580960.578	44	-	-	-

Since the $p<0.05$, we reject the null hypothesis, and conclude that there is a significant difference between the means of the groups. In other words, different turbine models generate different number of tours, and it is statistically significant

TheEffect of GMRT-Gayk combination

Gayk-gmrtcombination makes its increase in power as “time” not as “fraction” in other words percent due to aerodynamic reasons. Chronological weakness of gmrt turbine model is not carrying out following trials for powercomparisons.GAYK/DARRIEUScombination is important. We carried out comparative tur - RPM increase tests with and without variable wind speeds and GAYK (Menter, 1994; Sarun, 2006; Hansen et al., 2016). After establishing an average wind speed and desired rotor size, the next step is to determine the tsr (tip speed ratio).

This is the ratio between the speed of the blade tips and the wind speed (Menter, 1994; Rethore et al, 2014; Windtürbine, rst technology, 2015; Hansen et al., 2016).Thus, we achieved blade tip speed increase tip speed ratio (TSR) up to comparative 1,43. As can be seen from data, savonius - gayk is not a good combination (Byon, 2006). For a healthy calculation in wind theory; all parameters such as wind speed measurements, turbine blade diameter, number of blades, turbine height from ground, blade tip speed ratio and rate of rigidity rate must be known. In this case, by adapting a power equipment and an engineering work which combines all darrieus type turbines on the world and gayk according to this can increase rated power approximately five times aerodynamically. And the investment needed for this is lower in comparison to this advantage. Also, when DARRIUS - GAYK combination is designed and built directly, which we can call it gmrt, it provides a turbine much more efficient, financially advantageous and with higher capacity factor than all wind systems in the literature. With a short aerodynamic comment, we can say that it is not struggle of all powers but their cooperation provides this. In addition to that, we can say that gmrt turbine can utilize airflows passing through a wider cross - sectional areas than its own cross - sectional area directly and indirectly asvacuum (Penedo,2008; Sarun,et al, 2016).

Current level of the literature grounds on shadow cross-section area of turbine. In our study, aerodynamic area created by air flows affecting all turbines, which is called "influence area" and a wider cross - sectional area created by this are not grounded on (Şener, 1995; Tande, 2005).

Conclusion

The world demand for energy is expected to grow by more than two-thirds over the period 2011-2035 (Holttinen et al., 2011) This demand will be met by a combination of non- renewable (coal, fossil fuel, nuclear) and renewable (wind power, hydropower, solar energy, biomass, biofuel, geothermal) energy sources (Erdek et al., 2016). The share of renewable energy sources in total power generation is expected to rise from 20% in 2011 to 31% in 2035, and renewables are expected to eventually surpass gas and coal and become the primary energy source in the world (Toan and Kim, 2015; Erdek et al., 2016). GMRT model is more suitable for the environment and that it is the conclusion drawn from the data. Researches on developing wind power systems must concentrate on increasing aerodynamic and mechanical performances, improving durability and fatigue lives of turbine systems, modeling and simulating wind areas and turbines to be established on sea. A multidisciplinary approach was used in the analysis of the wind turbine. The blade element momentum theory (BEMT) was used in the aerodynamic analysis. GMRT wind type model has more advantages than other turbines with regard to structural geometry and costs in real Mw power turbines and in sea and (off - shore) applications.In GMRT wind turbine optimization the primary objective is to minimize the overall cost of power (COE). In plants with suitable wind, energy generation costs can be reduced to (2 - 2,5 cent / kwh).

By definition coe=cost/aepis the total cost divided by the annual energy production (AEP) typically COE is expressed in Cents/Kwh (Hau, 2008; Penedo,et al, 2008; Windtürbine, RstTechnology, 2015; Rethore et al., 2016).

Acknowledgments

This study is supported by a grant from Tübitak (scientific and technological research council of turkey) as a project of "misag-7(mag-818)".Thegelibolumodel wind turbine has been patented by Turkish patent ınstitute (patent no: 27861). In conclusion, thanks to Yavuz Ali Şener for his works.

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