A fuzzy logic controller for stability voltage and maximum energy extraction for fixed speed wind power generation systems

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Abstract

This paper introduces two advantages of a fuzzy logic controller for the first is stability voltage and the second is maximum energy extraction for fixed speed wind power generation systems. Maximum energy extraction is determined by thetip speedratio (TSR) and the power factor of a wind turbine in order to capture the maximum efficiency and control the speed of turbine in order to control voltage stability.While the TSRand power factor were taken as output variables we propose control the tip speed of generator in surrounding the value of maximum TSR. The proposedmodel produced fuzzy logic controller can keep the voltage stability at maximum TSR and nearest. The results indicate that we can do two task (power max extraction and stability voltage) in one design.

Keywords :Wind turbines , Tip speed ratio, energy extract, fuzzy logic stability control

1. Introduction.

Wind energy has four points of wind parameters corresponding to wind turbine with velocity and shape of shears basically; stall, fatigue, tip speed ratio, turbulence intensity and pitch, Fatigue load is forces on very turbulence wind, Stall is coefficient lift critically attack degree usually depend on velocity and shape of aerofoil Turbulence intensityis depend on velocity and Reynolds number, Pitch is a variable pitch turbine is one in which the rotor blade pitch angle is continuously adjusted by an internal hub mechanism to provide constant speed output over a wide range of wind speeds. It is a precision solution to overspeed control.Tip speed ratio is why it's important in wind turbines. The tip speed ratio is simply a number from 0 - (theoretically a huge number, but usually 8 - 10) which tells you how fast the blades are moving in relation to the wind speed. For example, if we have blades whose tips are moving at 80MPH and a wind speed of 10MPH that would give us a tip speed of 8 (which is what the windmax blades give).In wind generators a higher tip speed ratio is better and here is why. We normally have 3 blades which are travelling through the air. A low TSR means that the blades aren't moving very fast and there is quite a bit of air that passes through the wind generator without even touching the blades. With a higher TSR the blades are moving faster which means that they 'touch' more wind during each rotation. This means that they are able to extract more energy from the wind which means they are more efficient. The wind generator blades we use have a TSR of 8 and an efficiency of about 49% (maximum efficiency is around 60%).There is a downside to having that increased efficiency though a higher TSR means that the blades are rotating faster which means that your wind generator will produce more noise. When trying to figure out what TSR you should use for your wind generator make sure to think about noise? When the wind really gusts you'll hear some chopping. From fifth wind parameters, we can divide into two groups. The first group i.e. turbulence intensity and fatigue load causes drag forces. These are more say to the structure strengthens of wind turbine. And the second group is stall, tip speed ratio, and pitch say how to catch energy efficiently. We start with stall analysis. Shape of blade will determine coefficient of lift, in the one shape we get correlation between degrees of attack with coefficient lift

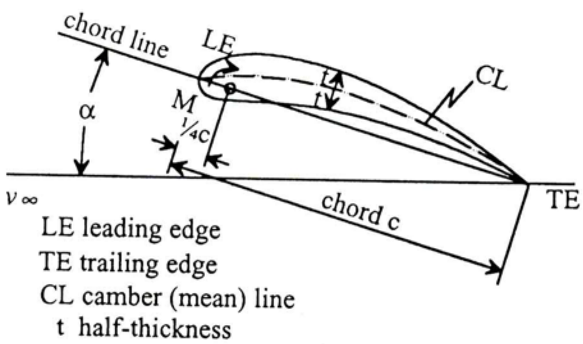

Figure 1

Lift is L, dragis D be formula in:

$L = \frac{1}{2} \rho v^2 A C_L$

$D = \frac{1}{2} \rho v^2 A C_D$

Where : A= wing area

B= span

Moment of pitch can be calculated

$M = \frac{1}{2} \rho v^2 A c\, C_M$

Now we can see on figure 2 the stall

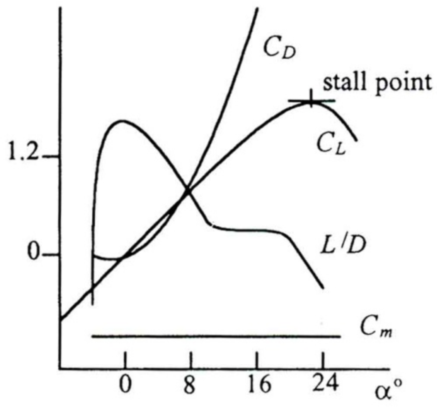

Figure 5 stall point

And figure 2 show the aspect of ratio

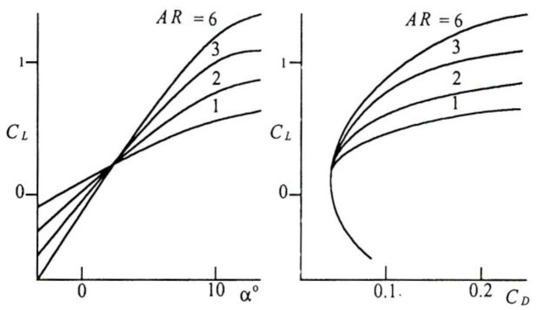

Figure 3 aspect ratio

Figure 3 aspect of ratio

Analysis of flow on blades depend on blade solidity σ, defined chord pitch ratio, c/s. forhigh solidity blade connect low solidity cause blade isolated. Show in figure7, flow A stationary cascade vvelocity (absolute)v_f,$v_w$axial and tangential components of velocity$v_r$velocity (relative) α, θ angle between the direction of the absolute and relative velocity, respectively, and the *tangential* direction F_a, $F_t$axial and tangential components of the force on a blade ξ stagger anglesubscripts:1-2, 3-4 refer to stationary (fixed) cascades (stator, guide vanes)2-3referto moving (rotor) cascade Coefficient C_p, defined

$$Cp = \frac{(p - p_\infty)}{\frac{1}{2}\rho v_\infty^2}$$

where p_∞, v_∞ refer to undisturbed (approach velocity). distance x from chord line, show chord length c. Lift force is net pressure force on surface wing, power component perpendicular free stream. Relative to free stream, and coefficient lift

then C_L = (mean C_p) cosα.Pressure coeffficient x/c, dan mean value can be calculated with area internal curve. The value approximate 0.98 see figure 7 Value C_L = 0,98cos 8 = 0,97.

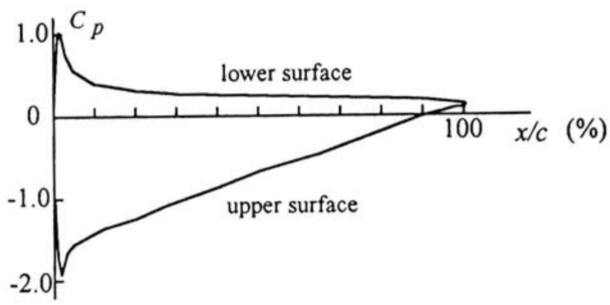

Figure 4 coefficient of lift

Note; atlower surface Cp> 0, the pressure is higher than free stream through hole length. At upper surface Cp< 0, and the pressure is higher than free stream and 10% from chord length no stream. NACA 4415 aerofoil is composition geometri. First Integer showline of ordinatemean maximum (measure from chord line) in % chord. Second Integer show distance from leading edge to location maximum chamber, at one to tenchord. Two last integer show section of thickness in % chord. From stall lesson we goes to tip speed ratio is the conclusion of stall as show later

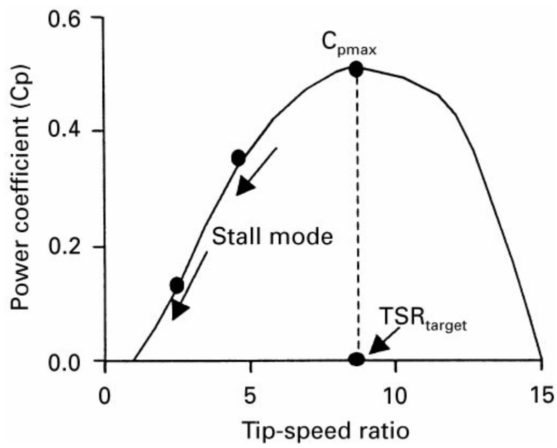

Figure 5 tip speed ratio

$\lambda = \frac{\omega_t R}{u}$ Performance of a 3 kW wind turbine generator with variable pitch control systemBaku M. Nagai 1, KazumasaAmeku, JitendroNath Roy

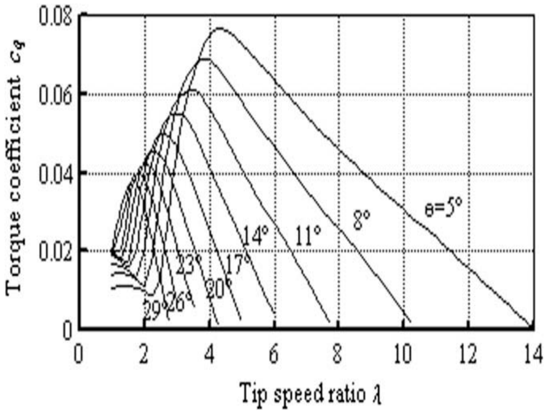

Figure 6 tip speed ratio on pitch angle

From two figures we know about efficiency energy with control of tip speed ratio and angle pitch we have two equation y=0.13x – $0.0083x^2$ figure 8 and y=0.008x + 0.112 from figure 9 with solver solution from Microsoft excel get the value tip speed ratio is 8.313.

2. ANFIS model application

Intelligent ANFIS control on modeling and analysis of no complex data. Second,it appropriate for incorporating the qualitative aspects ofhuman experiences within its mapping rules. Artificial neural networks(ANNs) have used to identify models for complexsystems. For the same purpose, ANNs and FL are combined, and arereferred to as ANFIS, which takes advantage of the learning capabilitiesof ANNs and modeling superiority of FL (Cam &Yildiz,2006 to acquire optimal outputdata in the study. The algorithm consists of the least-squares methodand the back-propagation algorithm. The first method was usedto optimize the consequent parameters, while the second methodin relation to fuzzy sets was employed to arrange the premiseparameters (Ubeyli&Guler, 2005).In the model application, the type of profile, the end losses, the profile type losses for the type of profilesconsidered were taken as input variables, tsr

3. Results and discussion

and general 8.5. we have table 1 for the value of TSR

Table 1

no	type	TSR value
1	Anfis	8.54
2	Conventional	8.5
3	Solver	8.313

4. Design of Fuzzy logic controller

Table 1 show the maximum extraction energy and this paper propose the voltage controller to work on TSR value 8.313 until 8.54.

5. Conclusion

In this study, we can propose two advantage first maximum energy extraction and second voltage stability based on the validation with solver of Microsoft excel the performance of ANFIS and ANN methods forpredicting tip speed ratio and power factor in wind turbines wereinvestigated. Two ANFIS models were developed to predict TSR andpower factor. For this purpose, the data set of blade profile types(LS-1 and NACA 4415) was used as training and checking data.Then the data set was used as testing data to evaluate the ANFISmodels and also ANN method. Results indicate that the errors ofANFIS models in predicting tip speed ratio and power factor areless than those of the ANN method. All ANN and ANFISdeveloped and evaluated in this study had a maximum mean percenterror of ±4.32% (with ±0.5% for majority of data points).The proposed approach is illustrated in the paper by using selectedblade profile types of wind turbine (LS-1 and NACA 4415).

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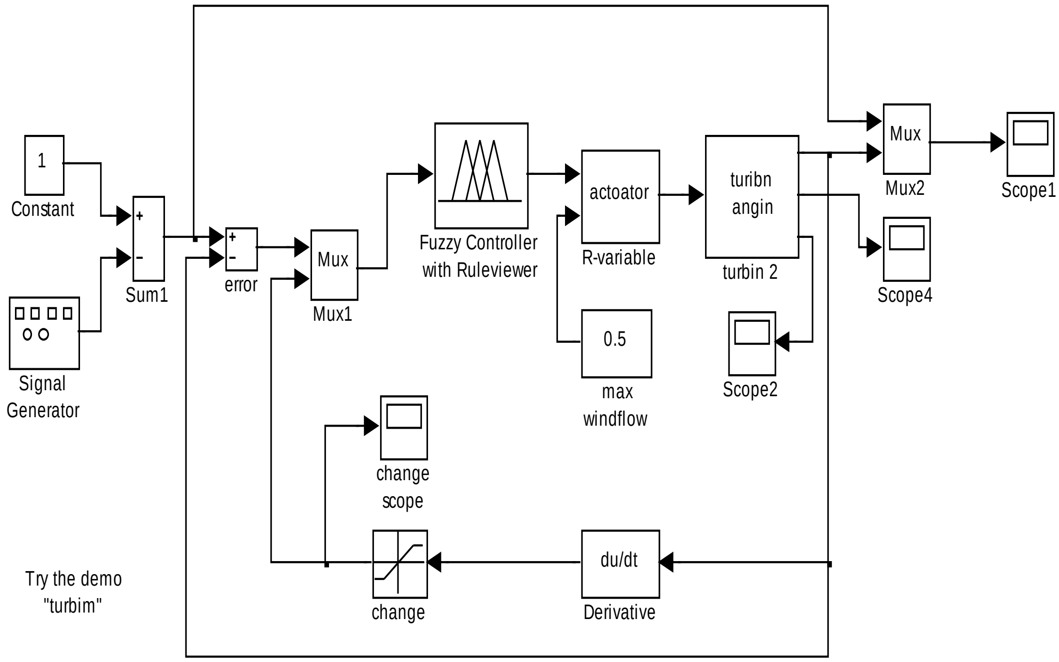
Apendix

Fuzzy logic design under simulink figure


1
Constant
Signal
Generator
Sum1
error
Mux
Mux1
Fuzzy Controller
with Ruleviewer
actoator
R-variable
0.5
max
windflow
turibn
angin
turbin 2
Scope2
Mux
Mux2
Scope1
Scope4
change
scope
change
du/dt
Derivative
Try the demo
"turbim"