Fuzzy LogicController for Doubly Fed Induction Genertor(DFIG)With Wind Turbine A review

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***Abstract*—as requirement of power resources are increasing, demand of non-conventional resources is also increased. In this field, solar and wind are the main resources to generate power. In this paper review of such techniques is carried out which are used in wind energy generation. Various generators used with different control techniques to manage stability and to improve output parameters along with efficiency. Doubly fed induction generator (DFIG) taken as base for this paper and fuzzy logic controller (FLC) for the controlling part of converters in grid side converter (GSC) and rotor side converter (RSC) of generator. Active and reactive power are the main parameters to be considered and many researchers worked to improve these parameters which is reviewed and concluded that there is a scope of improvement in parameters by analyzing these parameters and this technique is used with any type of generator due to its flexibility and noncomplex modelling.**

***Keywords*—doubly fed induction generator (DFIG), Fuzzy logic controller (FLC), grid side converter (GSC), rotor side converter (RSC)**

I. Introduction

Now a day's electrical power is a part of everyone's life. As the demand of power increasing, the requirement to generate power is also increasing. In this regards the future forecasting of power generation sources analysis gives that there is lack of conventional sources so power generation will have to switch towards non-conventional sources as Wind, Solar, Fuel Cell, Biogas, Geothermal etc. the most available sources among these are solar and wind. Both of these power plants need a specific requirement of location where the plant have to setup.
Major disadvantage of these resources are their low efficiency generation equipment. This is due to economic reasons, that if efficiency will be increases then total power plant equipment will be more costly than the total generation. This field, researchers are searching and experimenting on the ways to search those techniques that can increase efficiency and decrease total cost of plant.

In this paper, such energy source (Wind) is considered for research and analysis. Total power generated from wind in this world is 12 % (approx. 486.8 GW) where as in India its 9.1% (approx. 28,700 MW) of total power generation up to 2016[1].

In Fig.1 the data showing the present situation of installed units in India up to 2016.

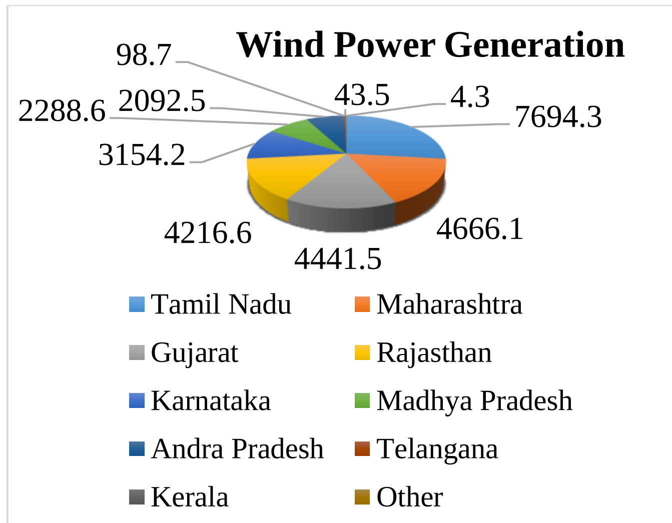

Fig.1 Installed units of wind power in different states of India in MW

It shows that the maximum units is installed in Tamil Nadu (7694.3 MW) and achieved target of 32287.27 MW up to April 2017[2]

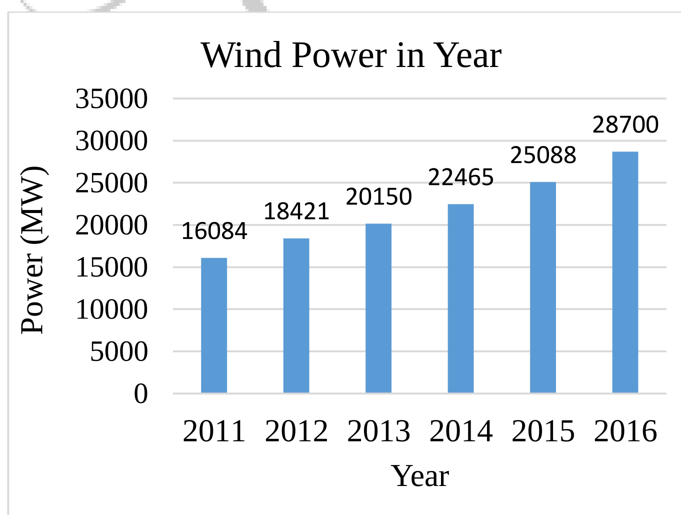

Fig. 2Data of India cumulative installed wind capacity

As shown in Fig.2 the growth of wind power in year 2001 to 2016 in India. The number of units of wind power is gradually increasing all over India due to its many benefits mentioned in next point. The main thing is its pollution less generation and it is renewable source of energy. Data shows the increasing interests of installing number of units of wind power all over India. [2]

II. DOUBLY FED INDUCTION GENERATOR (DFIG)

A doubly fed induction generator (DFIG) coupled to the grid through power electronic converters. It is connected between the rotor windings of DFIG and the grid. In the stator, winding of DFIG large oscillatory current is flowing when a voltage drop occurs at the terminals. Because of magnetic coupling between rotor winding and stator winding, these currents will flow through the converter and high current can cause its thermal breakdown. A set of resistors is used to short circuit the rotor winding when fault occurs in DFIG. This short circuit current will flow through this crow bar in its place of the converter.

In a doubly-fed induction generator based wind generation system, the DFIG's stator output active and reactive power is controlled through RSC, whereas the GSC controls the common dc-link voltage. In this paper, we analyse the behaviour of a crow bar protected DFIG. Based upon this, approximate equations are derived to determine the short circuit current contribution of the wind turbine. To construct a variable speed constant frequency system, an induction generator is considered attractive due to its flexible rotor speed characteristic with respect to the constant stator frequency.

One of the solutions is to expand the speed range and reduce the slip power losses simultaneously. DFIG is to doubly excite the stator and rotor windings. The power converters generate the majority of the slip power in the rotor circuit.

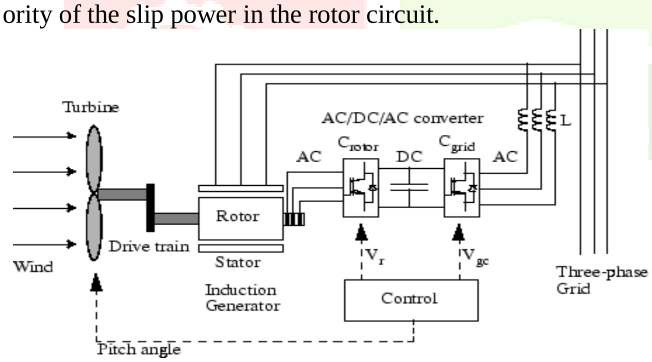

Fig.3 DFIG model with wind base turbine and convertors

M ramirez-gonzalez presents the new technique of power oscillation damping controllers (PODCs) in wind turbines by implementing fuzzy controller in it. For iterative work used Bat optimization algorithm (BOA) with two-step process. In first process, the system is taken no lead and lag and in another process with led and lag system is represented as comparison of proposed technique. In the whole system this technique uses Eigen value for analysis to show effectiveness in inter damp oscillation reduction of wind farms with DFIG [3].Ashoury-Zadeh proposed controller for wind turbine with DFIG. First implementing Fuzzy controller to the system then implemented GA algorithm on outputs for optimization to improve transient response. The two controllers associated with the speed controller of wind so the wind variation can be controlled in output results so the output frequency will also influenced in better way. This technique improves the overall performance of the system under unbalanced condition of wind speed and frequency variation [4].

S. KrishnamaRaju represented two types of fuzzy controllers i.e. type-1 and type -2 for wind turbines with DFIG. This is proposed for the system having variable wind speed, fluctuations, disturbance and faults in grid system. The analysis gives satisfactory results for such a level. These two type of system is for non-linear and uncertainty in the system respectively. It shows that this technique can be implemented in any case of variation in stability so that it improves at certain level to gain average results as compared with conventional techniques[5].B. han, l. Zhoupresentfuzzy logic controller in unbalanced structured loading system of wind turbine to control power. This technique is used for blade individual pitch control methodologies (IPC). For the controlling of unbalanced blade movements, torque three different type of FLC are proposed. For simplicity and effectiveness of the system combination of IPC and FLC is simulated successfully. It shows improvements in life cycle of system also [6].J zou, cpeng presented a fuzzy clustering algorithm for the analysis of active power in wind system with DFIG. For clustering process five benchmarks are used. Then FCM implemented for wind clustering. The parameters of DFIG are computed and a dynamic method is modelled. The result analysis gives the effective active power dynamic response in this equivalent system design. This technique is simplified as the complexity of analysis is resolved [7].

S M Muyeene proposedcontroller for wind turbines associated with permanent magnet synchronous generator (PMSG) during variable wind speed. This controller works for controlling grid side inverters in wide range of operation for the analysis of dynamic as well as transient responses of turbine. This technique can be used with all type of wind turbine generators those are connected to grid [8].L. Wang presented a hybrid controller for two parallel connected wind farms implementing static VAR compensator (SVC), PID damping controller and an adaptive-network-based fuzzy inference system (ANFIS) controller. These controllers are responding to supply reactive power, provide mechanical mode to exciter mode of synchronous generator and balancing transient faults respectively. The combination of SVC-PID and SVC-ANFIS with their performance during damping represented that SVC with ANFIS have better results than other controller during unbalanced disturbances in the system [9].

E kamal proposed a controller with fuzzy logic for non linear system containing variable parameters like wind speed and implemented it with wind turbine and doubly-fed induction generator (DFIG). The designing of proposed controller is based on the concept ofparallel distributed compensation (PDC). It is represented in output results that the controller enhanced the power quality and improved the stability of the overall system to improve system performance [10].*A. Giannakis* presented a fuzzy logic controller for DC/DC converter used in 2MW DFIG with Wind turbine. This controller is capable for maintaining stability, compensate DC voltage ripples and capable to recover the mechanical torque oscillations on turbine. The simulation results are compared with the conventional methods and results in improved output of voltage and current. This system can be used in unbalanced condition of load and faults that will be regain its stability [11].

A.Dida proposed a MRAS (model reference adaptive system) based on fuzzy logic control for DFIG with wind turbine for the estimation of blade rotation and wind speed variation control. The process coves in two steps in which generator speed is measured and then rotor speed observer, and wind speed estimator are applied to reduce overall cost of system. An improved Tip Speed Ratio (TSR) technique is used as the wind speed is variable in nature. That is used to approximation of electromagnetic torque of reference and the estimated mechanical power of the wind turbine. Sensor less controller is better to use when sudden fluctuation occurs in the system. By using this technique sensors of rotational and wind speed can be removed so overall cost also reduced [12].

S.Ghudelbourk has been presented a fuzzy logic controller for DFIG of wind turbine for auto setting the dynamic parameters which affects the total harmonica of the system by replacing it by matrix converter. FLC improves the performance of these converters and eliminates the impact of THD. This proposed system is work separately for active and reactive power management. Improvement of reactive power generated during distribution network also improved by considering these converter with fuzzy logic converter [13].

A.Dida proposed control system has been applied to a WTS (wind turbine system) driving a 1.5MW DFIG. An intelligent fuzzy inference system has been used to control the speed as MPPT system by using the optimal TSR and the stator power of DFIG. The dynamic response for a brusque wind speed change is carried out and compared to the TSR-PI and the OT responses. The results show the superiority of the TSR-fuzzy strategy. It is shown that by using the proposed controller, faster dynamic response with no overshoot, shorter settling time and no steady-state error are achieved. Also, the higher number of levels given by the five-level converters provides the advantages of a higher power rating and lower output harmonic if we can accept the complexity in materiel and modulation strategies [14].

H.Nguyen-Thanh presents a controller using PID with fuzzy controller (PID-FLC) under unbalanced condition of wind turbine operated DFIG system. This proposed technique improves the rotor current while distortions occur in grid voltage using Torque Stability Controller (TSC). Overall control of active and reactive power in system through this technique is represented. Author concluded that the responses of TSC-PID-FLC have fast response during transient fault conditions that unbalanced the system and voltage sag and swell observed [15].

R.Bhavani have been presented a fuzzy logic controller with unified power quality converter (UPQC) in a grid connected DFIG as in wind turbine. This proposed method decreases the overall voltage sag and improves the performance of system and enhanced the efficiency on converter by decreasing total harmonic distortions. Total active and reactive power is also maintained and covered in stable condition [16].

S. Sharma says under conditions of unbalanced network presents a new control method for doubly fed induction generator (DFIG) works. Under unbalanced supply voltage, common DC-link voltage is controlled by grid side converter (GSC). A new fuzzy logic controller is proposed to coordinated control strategy for the RSC and GSC, implementation is complicated but Fuzzy Logic Controller exhibits the best steady state accuracy and robustness to load disturbance and parameters. The RSC is controlled to eliminate the electromagnetic torque oscillation. Fuzzy-logic controller is used as its implementation is according to user defined rules [17]

S.Beheshtaein proposeda new technique in which fuzzy logic (FLC) is adaptive with particle swarm optimization (PSO) in DFIG with wind turbine system. PSO is used to optimize the selection of rule from FLC membership function, this can faster the performance of the system to detect fault voltage and current and regain the stability. For implementation of this technique, 12 and 50 MW system are considered in normal condition and faulty condition. Parameters considered for the performance analysis of overall system in presence of proposed method and in absence of it are settling time and mean absolute deviation indices [18].M.P.de Santana presents a fuzzy logic controller works on the concept of active power filters. To reduce the odd harmonics i.e. 5th and 7th in the DFIG with wind turbine system. it uses the conventional principle of resonant control in which the frequency is tuned to 6th value of synchronous frequency. The main advantage of this method is that it works on 5th and 7th harmonics in same time. The rotor current will be delivered in opposite direct so that it reduces the effect of harmonic contents. This method reduces the need of filter to measure harmonic contents. This is compared with vector control system and results shows that it works eight times more efficiently than those methods [19].

M.Doumi proposed a new technique in which fuzzy logic controller is designed with sliding mode controller implemented in DFIG with Wind turbine. This model shows the effective results in decoupling, robustness and dynamic performance of the system in different conditions as during unbalance, sag, swell, active and reactive power control. This is compared with conventional PID controller for performance analysis and given better results [20].S.Louarem proposeda hybrid controller with PI and Fuzzy logic Controller implemented in DFIG system with wind turbine. Variable wind speed is considered for analysis and during this the variable active and reactive power is controlled as per required outputs. Conventional PI controller is further advanced by implementing concept of FLC in reducing analysis and output results. By analysis it is obtained that, the reference maximum power and the power factor are received approx. unity, which is best in nature [21].

R. Cheikh proposednewtechnique in DFIG inSavonuis vertical axis wind turbine (VAWT) by implementing FLC in it. Control of grid side and rotor side converter by decoupling control is presented to increase the efficiency of converters output. This is based of maximum power point tracking scheme to obtain maximum power from wind in variable wind speed conditions [22],N. Sa-ngawong have given fuzzy logic controller for DFIG to control frequency. This method controls the fluctuation in load that varies the frequency of wind turbine driven DFIG rotor and controls the active power generation at rotor side converters. It is proposed that under random load demands and variable wind speed conditions this is adaptive to have efficiency and effective power gain in DFIG system [23].

K.Belmokhtar proposed fuzzy logic controller for DFIG with wind turbine. Variable wind reflects in variable speed of wind shaft so that is managed by FLC. This method has many advantages over conventional techniques that it does not require memory space and any mechanical device to function. Pitch control in this wind system is essential calculated and controlled by FLC at variable wind speed [24].

Many researchers are working for maximum power point tracking methods in wind resources. In this paper specific methods are reviewed.

III. CONCLUSION

Doubly Fed Induction Generator is attached with wind turbine to generate electrical power. As discusses in this paper, the main disadvantage over this method is its converters have to control so that maximum efficiency can be achieve.

Focus of this paper attracts that while using DFIG, GSC and RSC have to control its frequency, active, reactive power, damping and transients. For this purpose, authors proposed many techniques and out of which most effective is Fuzzy logic Controller. This improves overall power gain and archives stability of the system. For damping control in[3,12,23,24], transient control[4,8,9,19], in unbalances conditions[5,6,10,11], other proposed controllers for active and reactive power improvements.

This paper have outcomes for the various parameters that FLC is effetely works in any type of disorder and conditions and improves the efficiency of gain power and achieving fully controlled required outputs.

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