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## Review on Wind Energy Conversion at Variable Speed

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**ABSTRACT:** Recently we observe that electricity is use in tremendous manner so that the statistical data deals with the DFIG which is based with the turbine of the wind having the fluctuating nature .so, it occurs the change in speed & variable pitch control .it is the common turbine in the developing wind market. We know that the fuel cell is the new technique or way for energy saving that has the potential to complete with the other conventional system facilities. In various generation & distributed sectors the fuel cell acts as the potential source for the electricity because fuel cells easy to handled. The wind having fluctuating nature so, the dynamic model of SOFC is combined the wind turbine for reliable and proper enough operation. In that we have to use the bi-directional power flow convertor. which is derived from the speed above and below of synchronous speed. The fuel cell having priority in market because it having higher efficiency, cleanliness and cost-effective. So that it having grate demand in from the utility. A dynamic model of SOFC based fuel cell using the Nernst equation and variable load is can be analysis and simulated for that conversion system is block with the DFIG and two back-to-back PWM Insulated Gate Bipolar Transistors (IGBTs) with voltage source converters in rotor circuit all is based with vector control technique.

**KEYWORDS:** -SOFC (Solid Oxide Fuel Cell), WECS (wind Energy Conversion System), DFIG (Doubly-Fed Induction Generator), PWM (Pulse Width Modulation)

### I.INTRODUCTION

Recently, there has widely research on the voltage and frequency control of squirrel cage type, but there will be less research efforts have been done to the use of the slip-ring induction machine for generator applications. The DGs are in general having small generator which having starting power is less. The non-renewable energy sources are related to some fossil fuels and some natural gases those having some types like diesel oil, propane, methane coal and some of the heat producing fuel which are related to the sources. We know that the energy having the unlimited ranges which are not died out, Which causes small and not create any environmental issues that having solar cell, solar thermal, geothermal, tidal hydro plant, wind plant, Biomass and Biogas. The DGs are popular and widely used in the world. the slip-ring machine is more expensive and requires maintenance, it permits rotor slip-power control when driven by a change in speed turbine. the small-scale generation systems such as wind turbine, photovoltaic, micro-turbines, fuel cells, etc. plays an important role to meet the consumers demand using the concepts of distributed generation. The wind turbine referred DFIG which having the wound rotor induction generator and used the ac-dc-ac insulated gate bipolar transistors based with pulse with modulated convertor. To require the more power efficiency and reliable system for operation in present market so it is the grid connected DFIG. In that we studied that the stator and its winding that means the stator winding is connected with the standard frequency grid and the rotor is driven at the changing frequency by ac-dc-ac convertor. The main objective of using DFIG is to derived the more power from the wind at the fluctuating nature of wind and variable speed and while during that process we have to removes or minimizes the stresses on the turbine and achieve the efficient and reliable system.[2,5,10]

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## II. OPERATING MECHANISM

Firstly, we have studied about the mechanism which having the major components these all are included in the operating mechanism of system. The stator is connected with AC main and rotor(Wound) is driven from the electronics converters through the slip ring which is allow DFIG to get works at the fluctuating nature of wind which gives their response at the variable speed while occurring this process the frequency of the grid voltage is should maintained fixed with wind speed with the help of back –to-back converters .

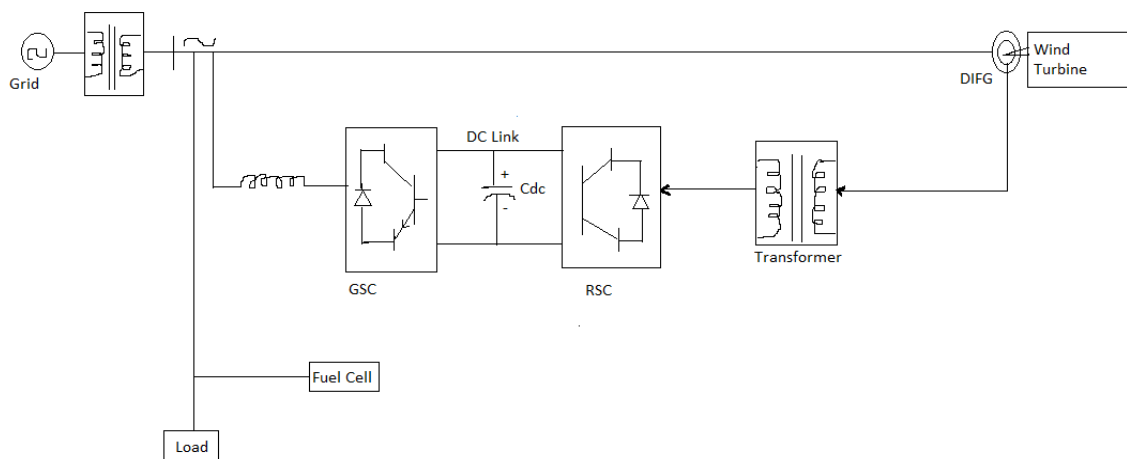


Fig 1 :- DFIG – Fuel cell test system with Simulink configuration

The stator gives there response at the two stage such as sub – synchronous speed and super synchronous speed. at the sub –synchronous speed the stator is generate the power but some power fed to rotor. and second at super-synchronous speed both components i.e. stator and rotor are generating the power to the grid. This show the bi-directional power flow means view like to rotor from supply and form supply to the rotor so due that operation the speed of machine or the motor can be maintained and controlled from either rotor or from the stator side converter in both two cases i.e. sub-synchronous and super-synchronous speed rage. This can be clear that the machine can controlled by helping the generator or motor in two cases of synchronizing working modes. The construction and the working of fuel cell are same like battery but there is only one exception that fuel cell can be continuously fed to the cell.[10,11]

The components are as follows:

- A. Wind turbine
- B. Doubly fed induction generator
- C. Fuel cell
- D. Simulation of DFIG-SOFC grid test system

Now we have to study the above component

- A. Wind turbine:** -The wind energy is overcome by which that wind is used for the purpose to produce the mechanical energy with the help of kinetic energy of wind. Wind Energy conversion system for convert the wind energy into mechanical energy that can be rotate an electrical generator for production of electricity. The Wind energy conversion system consist of mainly components such as aerodynamics, mechanical and electrical components the bellow fig shows components of WECs.

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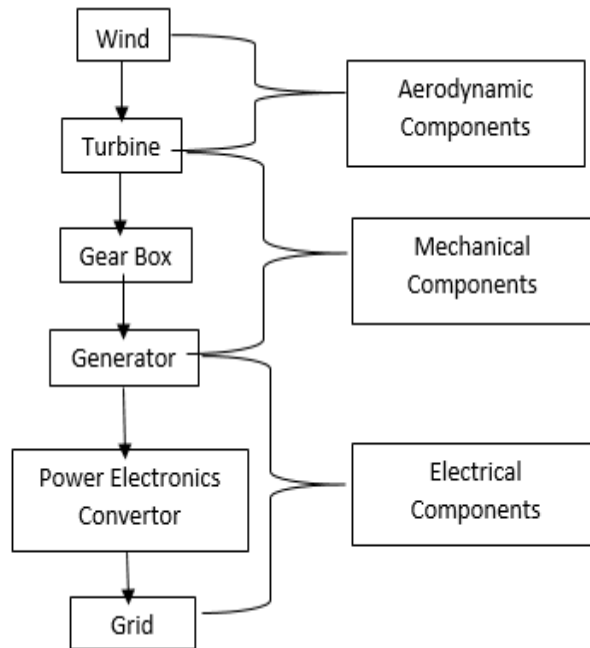


Fig 2:-Block Diagram of Components of WECs connected to grid

From diagram (2) the working information conveys that the wind is passes through turbine blades generating blades generating lift and also the tuning force .The all procedure shows that the rotating blades of mill turn into shaft inside the nacelle which enters into a gearbox , The rotational speed increases the level which is suitable for the generator , these can be uses the magnetic fields to rotational energy into the electrical energy, Here some wind turbines topologies are given:-constant speed turbine i.. type A and changing speed turbine ,Type B turbine which are soft starter , Type C turbine which is doubly fed induction generator with partial convertor , Type D turbine . In that Type C is operate at partial scale while Type D at full scale. The partial scale frequency works the reactive power compensation and the smoother grid connection. it having vast range in dynamic speed control [1,2]

**Doubly fed induction generator:** - It consists of the parameters like: -

### 1.D-Q theory: -

D-Q theory is the reference frame theory it the concept derived by Park He transformed stator variables to the rotating reference frame which is fixed in rotor. [2]

### 2.DIFG Constructional view and vector control method principle: -

The DIFG having basic components are DIFG (wound rotor type induction machine), PWM voltage source converters, Utility grid, PI controller.

Vector control this can be used on the suitable control action t has the main role in the unit vector is to convert the 2-phase model to 3-phase model. This method explains two axes for representation. Principle involved the following parameters

i)Rotor Side convertor(RSC): -The main goal of the machine side converter is to maintain the rotor speed constant irrespective to the speed of wind it having controlled by the two axes of active and reactive power. [5]

For that side the vector control is operate to control the active and reactive power flow in that we sue the proportional integral to regulate and reduce the power error zero so that the output is injected into the rotor using RSC.

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In that case the the  $i_{dr}$  and  $i_{qr}$  are with the reference rotor currents  $i_{rd}^*$  and  $i_{rq}^*$  which is produces the signals from the side of rotor converter.

$$V_{dr}^* = V_{dr}' + R_r i_{dr} - (\omega_e - \omega_r) [L_r i_{qr} + L_m i_{qs}] \dots\dots (1)$$

$$V_{qr}^* = V_{qr}' + R_r i_{qr} + (\omega_e - \omega_r) [L_r i_{dr} + L_m i_{ds}] \dots\dots (2)$$

Where,  $V_{dr}$  and  $V_{qr}$  get from the error sorting procedure by PI controllers. [5]

**ii) Grid Side Converters(GSC):** -The main purpose of GSC to maintain the DC-link constant i.e. Voltage for the necessary action. this vector control technique is basically composed for to solving the fluctuating voltage problems.

In that we are observing below synchronous speed the converters is acts as the rectifier and in opposite condition acts as the inverter to supply all producing power to the grid at the DC link voltage.

GSC is to maintain the dc-link voltage constant so that vector controlling technique is suitable for the control of GSC the PWM converter is the regulating device with two axes parameters i.e.  $i_{dr}$  and  $i_{qr}$  we can elaborate the power factor operation by set reactive power demand zero [4].

$$V_q^* = V_{q1} - V_d' \dots\dots (3)$$

Where,  $V_{q1} = V_q - i_{q1}^* + \omega_e L_{id}^*$

$$V_d^* = V_{d1} - V' \dots\dots (4)$$

Where ,  $V_{d1} = V_d - i_{d1}^* + \omega_e L_{iq}^*$

Where  $v_{d1}$  and  $v_{q1}$  are the two phase voltages found from  $v_a'$ ,  $v_b'$  and  $v_c'$  using d-q theory.

### B. Fuel Cell :-

Types of Fuel Cell :-

The fuel cell is categorized according to the electrolyte used in the cell the electrolyte used in the cell with increasing range of the temperature which is given by

- Proton exchange membrane fuel cell (175<sup>0</sup> F)
- Phosphoric acid fuel cell (400<sup>0</sup> F)
- Molten carbonate fuel cell (1250<sup>0</sup> F)
- Solid Oxide fuel cell (SOFC – 1800<sup>0</sup> F)

### III.WORKING OF SOFC (Solid Oxide Fuel cell)

The SOFC is a high temperature which having the high potential so this gives the use in stationary application, this fuel cell contain the electrolyte as yttria and zirconia it having the fuel type as  $H_2$  ,  $CH_4$  , and other hydrocarbons ,the range of operating temperature of the cell is 1000<sup>0</sup> C . it having efficiency is greater than 50 % which possessing solid electrolyte and produce high grade waste heat also beneficial and applicable for the utility, power plant services, commercial cogenerations and for the portable power stage.

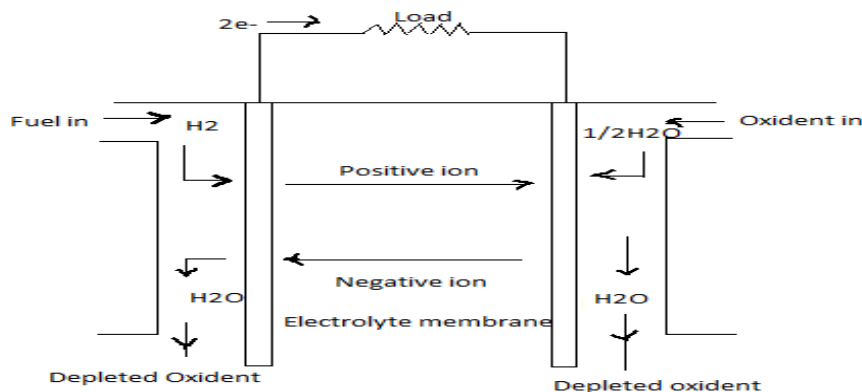


Fig.3 :-Fuel Cell

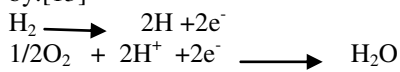
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The functioning of fuel cell is similar to battery except that the fuel cell can be continuously fed in the cell. It consists of two electrodes i.e. anode(+ve) and cathode(-ve) The fuel cell is fed into the anode here occurs the redox reaction. the reaction having oxidation and reduction where at anode there is the oxidation takes place and oxidation occurs at cathode to produce the electric current in preliminary products of the reaction. the redox reaction is given by:[13]



The modelling of SOFC is based on the following things

- 1) temperature supposed to be constant
- 2) The gases are ideal
- 3) based on Nernst equation

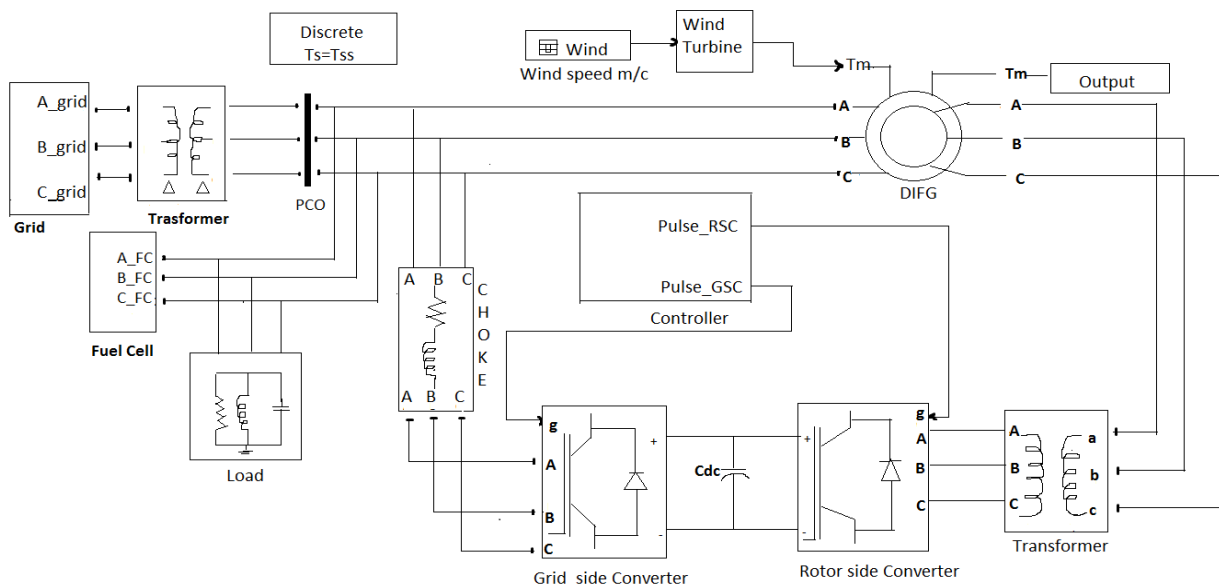


Fig.4 :-Simulation of DFIG-SOFC Grid test system

### IV.SIMULATION RESULT AND OUTPUT

The wind having the fluctuating nature so that it is continuously simulation time  $t=5$  sec we used DFIG so that we get the result having constant nature and fairly constant the voltage which set up as  $V_{dc}=830$  V In that the active and reactive power remains constant not withstanding of wind speed deviations. So that the performance is at 15 KW in the terms DC constant which having the active and reactive power is zero at unity power factor. Take some result for  $t=0.5$  sec that means very short duration then load is increases gradually up to 30 to 100KW then it is observe that power supplied by DFIG and SOFC then remaining generated power is fed to the grid. When we have to increase the demand up to the 100 KW then remaining power is drawn by grid if there is transient is occurs then system runs with synchronism deprived of oscillations.[10,14]

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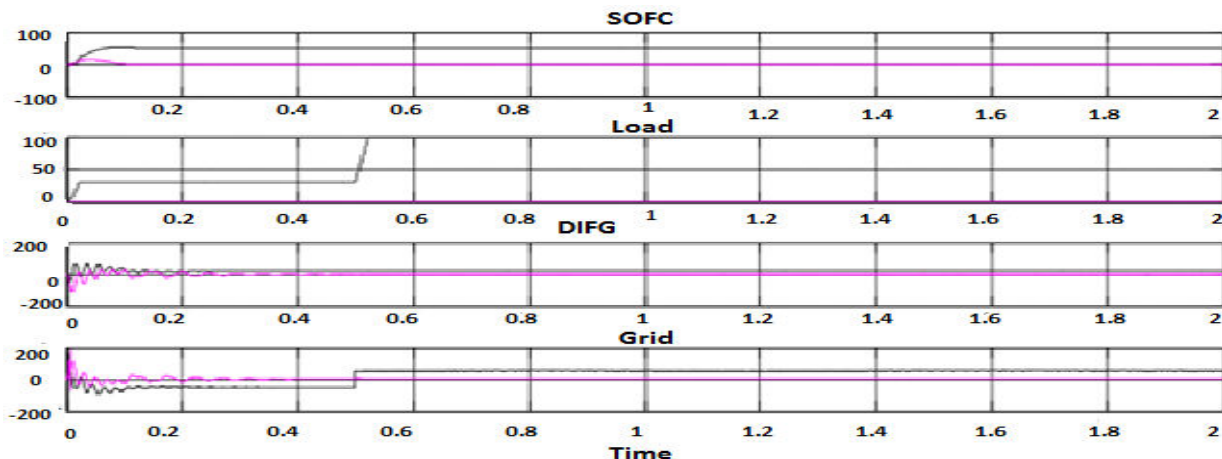


Fig.5 :-Performance of DFIG ,SOFC grid active & reactive power at t=0.5 sec

## V.CONCLUSION

This is clear that the vector control technique is beneficial for the controlling of wind speed and also controlling the grid side converters and rotor side converters that this is utilized for to minimize the fluctuating nature of the wind. Here the conversion system with vector control maintains the dc link voltage and reduces the fluctuating nature of voltage. The DFIG is synchronized with grid and variation in load demand as per the rating. This technique maintains reliable and efficient operation, Used of fuel cell is having good record to the system so, this paper having some result that the system accept the future advancing challenges.

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