AUTOMATIC POWER GENERATION FOR ELECTRIC LOCOMOTIVES USING DFIG

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Abstract : This paper basically deals with power generation for electric vehicles using DFIG. The main advantage is that, it works under operational (running) condition also. The Indian Railways primarily operates electric and diesel locomotives. We introduced doubly fed induction generator (DFIG) on electric locomotives and designed a prototype for propeller installation of DFIG in the locomotives. We use MATLAB for simulation of 1.5 MW DFIG and realize that, DFIG can produce electricity at 1 m/s wind speed also. We want to use that power for charging the batteries of electric train while it is running and deliver the access amount of power to the grid using pantograph. In India, Indian Railway (IR) runs more than 20,000 passenger trains daily. We also calculated that if 10 percent of electric trains are running with DFIG then how much electricity can serve by Indian Railway to whole grid system.

IndexTerms - DFIG, Indian Railway, Electric locomotive, pantograph, Grid.

I. INTRODUCTION

In future more and more energy is required for daily consumption in all walks of life. Sources and quantum of fossil energy are decreasing day by day and getting exhausted at a very fast rate. We have to introduce our country as a leading source of power in the world. All other develop countries are trying to develop their sources of energy and spread that information to others. Railway is the primarily important source of communication with a cheap cost for any country. In our country, Indian Railway is India's national railway system operated by the Ministry of Railways. It manages the fourth largest railway network in the world. This invention relates to a method for generating electricity using high wind pressure generated by fast moving vehicles channeling the induced wind in the direction of the wind turbine. A fast moving vehicle compresses the air in the front of it and pushes the air from its sides thereby creating a vacuum at its sides as it moves forward.

The kinetic energy from the wind is compressed to create large pressure on the turbine blades to produce initial torque. The main object of the present innovation is to provide a method and a system for generating electricity using easily available wind induced by moving vehicle in transit or in operation for charging batteries. The other object of our project is to deliver excess produced energy to the grid by help of IR and improve our electricity demand.

Description of Invention

Wind energy
↓
Compressed air
↓
Rotation of turbine coupled with DFIG
↓
Generate electricity
↓
Needed for electric vehicle
↓
Excess power supplied to Grid

Paper Background

Lack of energy sources is one of the major problems in India and to overcome this, our government is aspiring in all possible ways. Now a day, our nation has so many places in darkness, though India is the world's third largest producer and third largest consumer of electricity. The utility sector in India has one National Grid with an installed capacity of 350.162 GW as on 28 February 2019. And the Consumption of the Indian railway is around 2.5 percent of the country's consumption. According to an estimate, the railway sector's demand for electricity will grow by seven percent annually and by 2020. So it's around 9.5 percent of 350.162 GW I.e. 33.265 GW. Our main motive is to produce sufficient amount of electricity for particular electric locomotive and the access amount of power serve to Grid.

II. CONSTRUCTION

Duct

Duct is a tube or passageway in building or machine for air, liquid, cables, etc. Here we use duct for flowing air and create high pressure to rotate blades shaft and produce minimum torque for DFIG.

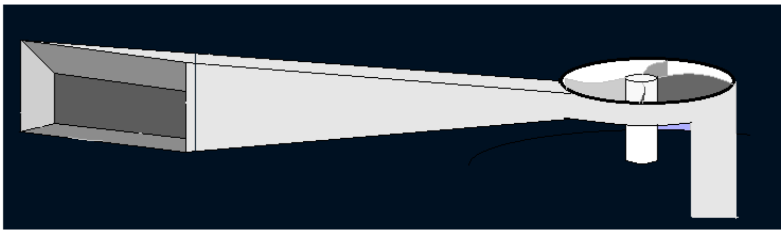

Fig. 1. Duct design

DFIG

Doubly-fed electric machines also slip-ring generators are electric motors or electric generators, where both the field magnet windings and armature windings are separately connected to equipment outside the machine. By feeding adjustable frequency AC power to the field windings, the magnetic field can be made to rotate, allowing variation in motor or generator speed. This is useful, for instance, for generators used in wind turbines.

Inverters

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). One approach to allowing wind turbine speed to vary is to accept whatever frequency the generator produces, convert it to DC (for internal use) and then Convert access power to AC at the desired output frequency using an inverter and send to step up transformer which can stepped it to 25 KV.

Transformer

Here we consider the output voltage from DFIG is 575 L-L V, but electric traction need single phase 25 KV. So one step up transformer is needed for sending access power to grid.

Setup

The whole setup which includes duct, turbine, DFIG and belt are placed on according to the design. A large inlet is made for air to enter into duct. The duct is made for such a way that it collects kinetic energy and delivers it to propeller with a high impact.

The system is made with 1.5 MW DFIG which have a small initial torque due its feedback control technology. Which help DFIG to run at minimum wind speed.

III. WORKING MODEL

A large duct is situated on the front of the locomotive coupled with propeller. When the train moves, air enters through the duct and the duct is designed in such way that it can reduce the drag force and increase the velocity of the air. Duct is designed like a converging nozzle at the entry side, so the velocity of the air is increased when it reaches the turbine. This high velocity air hits on the blades of the turbine blades and the turbine rotates.

The exit portion of the duct is designed like a diverging nozzle, so that the air gets expanded and cooled and gets into the atmosphere without providing any resistance to the performance of the train. The turbine is connected to the DFIG with belt or gear system. Thus, as the turbine rotates at minimum speed 1m/s , the DFIG can able to produce its rated power which results in generation of electricity. The generated alternate current (AC) is converted into DC for interior requirement and the access amount can supply to the grid by making same phase and voltage of the grid.

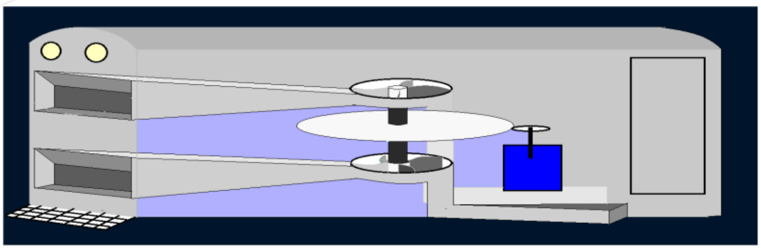

Fig. 2. Installation of duct and propeller

IV. DESIGN PARAMETER

DFIG Performance

We consider minimum wind speed is 1m/s and maximum wind speed 33.33 m/s (source railway).

SL NO	WIND SPEED m/s	OUTPUT VOLTAGE dc
1	1	1106
2	10	1106
3	20	1106
4	33.33	1107

Table. 1. Output voltage vs wind speed

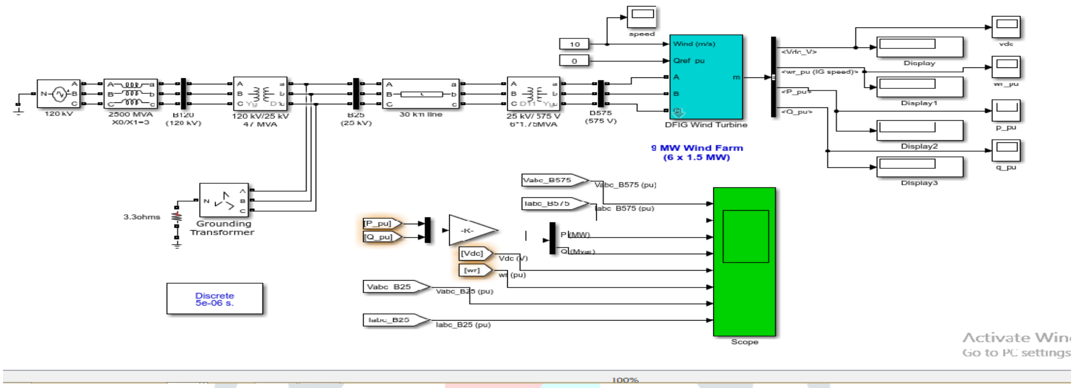

Fig. 3. Matlab simulation for 1.5 MW DFIG

DFIG output

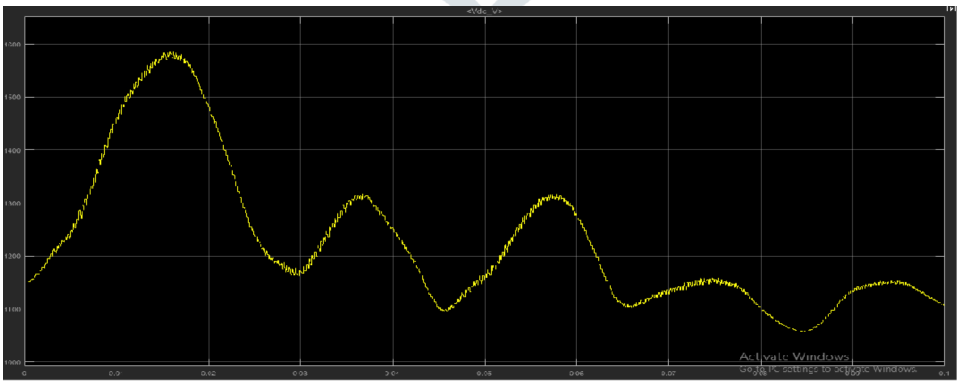

Fig. 4. DFIG output dc voltage

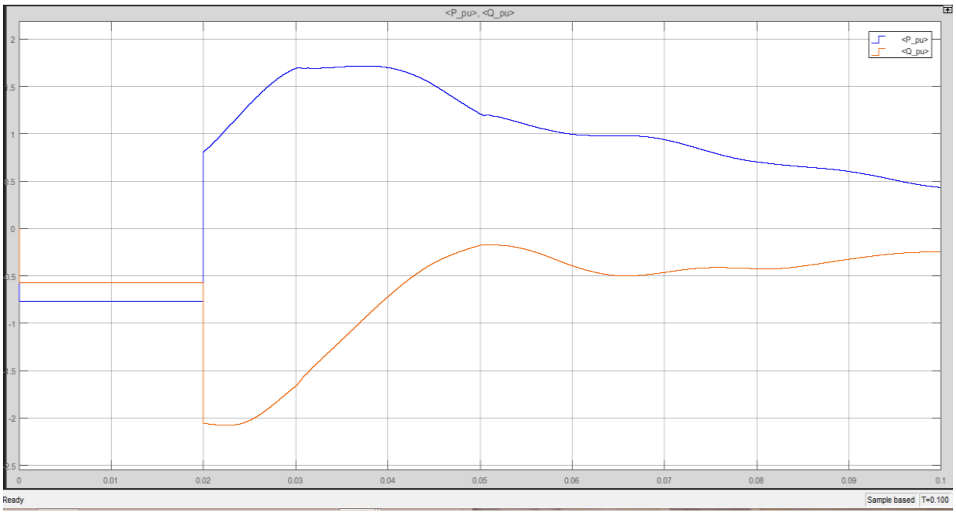

Fig. 5. Active and reactive power

This blue curve is active power and red one is reacive power. Here we can see that at .02 sec the active power is positive, that means DFIG supplies power. Before 0.02 sec DFIG is not delivering, it collects power from grid because, to overcome initial torque.

Let , consider a duct ,(comparing with train couch dimension)

Length=18 m
Width=3 m
Height=4 m

So, volume of duct =216 cubic metre.
The ISA or international standard atmosphere states the density of air is 1.225 kg/m^3 sea level at 15^0 C.
Total mass of air in duct will be
m= 264.6 kg.
And if consider the average velocity of air is
v=17.165 m/s
Then, kinetic energy developed in duct tail
K.E= 38,978.2339 Joules.
And torque will
T=21675.7914 N-m
But though DFIG is based on feedback control system, we can install 1.5MW on electric locomotive.
We consider that, if 10 percent of total locomotives are installed with 1.5MW DFIG.

Then, the total no of trains' will 2000.
So, the total power generations will 1.5×2000 i.e.3000 MW or 3GW. So, design is effective.

V. RESULTS AND DISCUSSION

In our project we just implement one DFIG on locomotives which is running at an average velocity of 17 m/s and observe that it will generate a sufficient amount of power for its interior purpose. The access amount if supplies back to grid then, the system is enough efficient for future progress. On 2020 Indian railway need 33.265 GW power for its operation. We calculated that if 2000 electric locomotive are running with 1.5 MW DFIG then the capacity of generation by Indian Railway will 3 GW. This will make a revolution on power generation in whole world.

VI. CONCLUSION

This system will help us to develop our future mobile power generation source. This will create a revolution on power generation. We consider only 10 percent of electric locomotives but it gives us 3GW capacity. This means less production of carbon emission as well as less utilization of fossil fuel. If we able to implement our all locomotives with 1.5 MW DFIG then IR can serve approximately 8.56 percent of total installed capacity by National grid.

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