International Journal of Scientific Engineering and Technology ISSN : 2277-1581
Volume No. 6, Special Issue 3. PP : 187-195 22-23 Dec. 2017

Biomass-Diesel based Hybrid Electrical Supply System for Small Network

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Abstract : In present time, distributed generation is very common concern to the researchers. Many researchers working related to micro grid and distributed generation. In rural areas, wastage is available in form of rice husks, sugarcane bagasse(for biomass), animal dung(for biogas) etc. It can be utilized in form of renewable bio energy to produce electrical energy. Main idea in this project is to use waste electrical energy and feed rural areas as well as vital loads. Biomass producer gas can be used in a hybrid system along with diesel to full the power need of rural area with less carbon emission. It can be standalone or grid connected system. Dual fuel generator with diesel and biogas/syngas is a favourable solution for emergency power backup and energy crisis.

In this paper, diesel generator set operate in emergency condition and supply the vital load when grid/renewable source fault occurs and analyse the effect of DG set with stand-alone condition.

This is done by developing numerical models for the simulation of the operating diesel generators as a back-up energy source in hybrid power systems. The dynamic analysis is completed by the help of Simulation tool.

INTRODUCTION

The increasing demand for energy, the continuous reduction in existent resources of fossil fuels and the growing concern regarding environmental pollution have compelled mankind to explore new production technologies for electrical energy using clean renewable sources such as biogas and biomass energy, solar energy, wind energy, etc.

Among the electric power technologies using renewable sources are clean, green, silent and reliable, with low maintenance costs. Along with these advantages, how-ever, electric power production systems using as primary sources exclusively solar and wind energy pose technical problems due to uncontrollable wind speed fluctuations and to the day night and summer winter alternations. As a consequence, in continuous region, the power supply continuity of a local grid should be backed-up by other reliable and non- fluctuate sources of primary energy, such as diesel generator sets. Such systems, designed for the decentralized production of electric power using combined sources of primary energy, are called hybrid systems. Diesel generator sets also used for emergency region in conventional sources energy like nuclear plant. Diesel generator set used for feed power in isolate region as well as an

emergency region.

The increased interest in using of diesel generator sets as the main energy source in isolated areas or as an stand by source in the case of renewable-based power systems can be observed by the great number of papers and studies carried out in this area. The research conducted in this domain refers to aspects such as island operations of diesel generator sets [3], simulations of diesel/pv/wind hybrid power systems [4][5],etc.

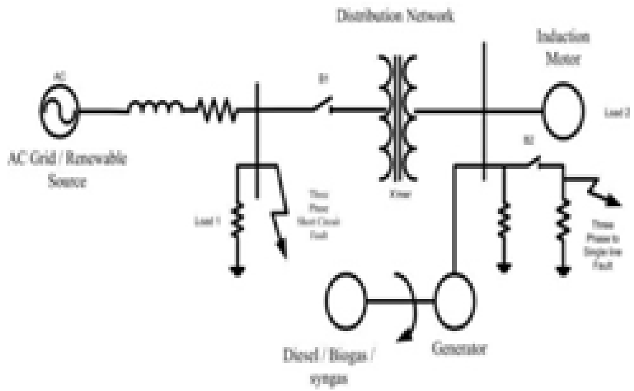

Figure1: Biomass-Diesel based small Network

1. Utilization of Biomass as Engine Fuel

As of 31 January 2014, India had an installed capacity of about 31.15 GW of non-conventional renewable technologies-based electricity, about 13.32 % of its total. Total Installed Capacity of Bio Energy as of 31, January 2014 is 4479.85 MW.

Table 2.1: Overview of biomass energy

Source	Type	Capacity
Biomass Power and Gasification	Grid-connected	1285.60 MW
Bagasse Cogeneration	Grid-connected	2512.88 MW
Non - Bagase Cogeneration	Off -grid	517.34 MW
Rural Biomass Gasifier	Off -grid	17.63 MW
Industrial Biomass Gasifier	Off -grid	146.40 MW

India produces about 600 million tonnes of agricultural residues (mainly rice husks, paddy straw, sugarcane waste, wheat residues and cotton stalks), of which 300 million tonnes are unutilized and are disposed of by burning in open fields thus creating environmental hazards. Diesel engine is capable of successful running in duel fuel mode of operation with

 ISSN : 2277-1581
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suitable biomass in gasifier. This study presents engine performance using rice husk, rice straw, cotton stalks and bagasse as biomass fuel in downdraft gasifier in dual fuel mode. Power Generation application on 100 % producer gas based system Rs. 15 lacs per 100 KW.

1.1 Introduction

As the engine had to be fuelled with syngas or biogas, the unit was fed with laboratory blends contained in specific tanks for compressed gasses. In Table 2.2 and 2.3 the standard composition and lower heat content for a syngas and biogas (anaerobic process) are reported, both derived from standard biomass and with the percentage in volume of the different components[6].

Table 2.2: Standard composition for a biogas (Anaerobic) from Biomass

CH_4	CO_2	Others	L.H.C $MJ=NM^3$
62.0	35.0	3.0	23.0

Table 2.3: Standard composition for a syngas from biomass

CH_4	CO_2	H_2	CO	Others	L.H.C $MJ=NM^3$
7.0	41.0	23.0	20.0	9.0	13.0

2.2 Experimental work on engine

In biomass gasifier (5 kW, Kirloskar, single cylinder, four stroke engine with 1500 rpm), biomass was fed through feed door and stored in hopper (Fig.2.1). Throat (or hearth) ensures relatively clean and good quality gas production. Grate holds charcoal for reduction of partial combustion products while gas outlet is connected with engine via venturi scrubber, separator box cum fine filter and check filter with an air control valve to facilitate running of engine in dual-fuel mode [7].

Table 2.4: Characterization of fuels [4]

Biomass	Ash %	C %	H %	N %	O %	S %	Calorific value, MJ/kg
Cotton stalks	6.68	43.64	5.81	0	43.87	0	17.4
Bagasse	4.27	44.80	6.20	0.20	44.40	0.01	18.11
Rice husk	17.60	38.30	4.80	0.34	35.45	0.03	14.4
Rice straw	10.70	42.30	5.60	0.90	40.50	0.02	11.7
Wood Chips	3.20	48.60	5.56	0.60	41.46	0.03	17.4

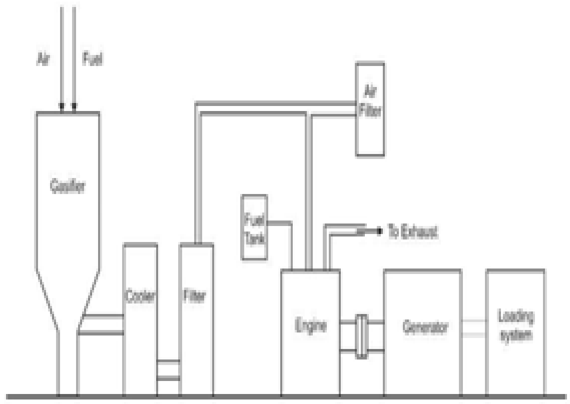

Figure 2.1: Schematic arrangement of experimental set up [4]

Dust particle of gas also removed by passing through gas filter. To control of gas valves were provided in passage of gas and air ow. A single cylinder naturally aspirated direct injection four- stroke diesel engine coupled with generator was used for power generation. Dual fuel mode of operation was carried out by supplying gas to combustion chamber of engine through inlet manifold. Gas control valve is opened gradually to feed gas into engine. Also, engine governor control knob is closes to dual fuel position, to decrease amount of diesel when sound becomes normal. With rotation of gas valve, optimum adjustment of gas and diesel is made.

2.3 Result and analysis of energy cost

As producer gas is increased, there is a decrease in diesel consumption. Hence, higher diesel substitution in dual fuel mode of operation is achieved opening producer gas valve fully so that higher amount of producer gas ow will replace higher amount of diesel. Sugar cane bagasse fuel replaced maximum diesel (82 %) at 3 kW load followed by cotton stalks fuel (80 %). As gas ow is increased in cotton stalks fuel, diesel substitution varies from 60.58 - 79.79 %, maximum diesel substitution is obtained at full opening of gas ow valve. Wood also replaces a little more diesel (80-85%) as both fuels have same characterization properties. Sugar cane bagasse for producer gas generation in gasier showed maximum diesel substitution (82.1 %) in dual fuel mode. As compared to cotton stalks and sugar cane bagasse, diesel displacement in case of rice husk as fuel
is very less (33.36-59.74%), because presence of small quantities of C (38.3 %) and H (4.5%) and also very high ash content, which creates hindrance in producer gas generation. Rice straw gave minimum diesel replacement (47%), due to nitrogen present in rice straw that dilutes producer gas quality and also ash content being very high creating hindrance in production of producer gas. Energy costs (Fig. 2) to produce 1 kWh energy (at 3 kW load), cost associated with drying, collection, storage and transportation of biomass fuels is given as[4]

Energy cost (Rs/kWh) = (cost of diesel x diesel consumption) + (cost of biomass x producer gas consumption)

(2.1)

Looking into energy costs, sugar cane bagasse is higher than cotton stalks but its

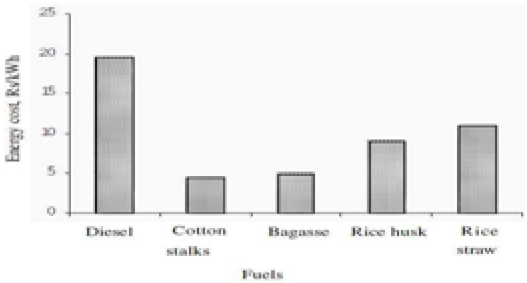

Figure 2.2: Energy cost of fuels [4]

diesel replacement is more than cotton stalks, because cost of bagasse is higher than cotton stalks. Diesel engine generator is capable of successful running in dual fuel mode of operation with suitable biomass in gasifier because of fuel is already available. To produce 1 kWh of energy, 630 ml diesel was used at Rs 19.55. Maximum diesel replacement in dual fuel mode of operation using cotton stalks in gasifier was 80 %. To produce 1 kWh of power energy, cost associated was Rs 4.46. Maximum diesel replacement in dual fuel mode of operation using sugar cane bagasse in gasifier was 82%. To produce 1 kWh of power energy, cost associated was Rs 4.82. Maximum diesel substitution in case of rice husk was 60% and to produce 1 kWh of power energy, cost associated was Rs 9.00. Maximum diesel replacement in case of rice straw was 47 % while to produce 1 kWh of power energy, cost associated was Rs 10.97. Hence, power generation cost while using biomass is cheaper than conventional power generation cost.

2.4 Energy cost analysis

Electricity can be generated using gasifiers either using DG set or using suitably modified natural gas engines/ producer gas engines. The energy cost(Rs/kWh) analysis of two types of mode in generator set are discussed below-

2.4.1 Dual fuel mode

In this the Gasifier is connected to a diesel generator and the generator is suitably modified. In this case up to 70 % diesel replacements are obtained. To generate 1 unit of electricity .08 -0.1 liter of diesel and 0.9 kg of wood or 1.4 kg of rice husk would be needed. Depending on the costs of these (wood chips, rice husk) the fuel cost of generation can be calculated. Savings obtained when a gasifier is coupled to a diesel genset is determined by this calculation.

The cost of 1 liter of diesel is Rs 55.15 and assumed the cost of 1 kg of wood or rice husk is Rs 5. One liter of diesel gives 3.5 units of electricity. Thus, fuel cost of generation for 1 unit of electricity (with diesel alone) is around Rs 15.75. For generating a unit of power when the generator set is connected to the gasifier we need

.08 -0.1 liter of diesel and 0.9 kg of wood or 1.4 kg of rice husk. If we considered the data (for rice husk) then using equation 2.1

Energy cost(Rs/kWh)= (0.1 * 55.15) + (1.4 * 5) Energy cost(Rs/kWh)= 12.515

the fuel cost of generation for 1 unit of electricity is INR 12.515.

2.4.2 100% Producer gas mode

Here the Gasifier gets connected to a gas engine generator set(modified). Biomass produced gas(producer gas) is directly given as fuel to generator(no diesel) known as 100% producer gas engine. To generate 1 unit of electricity it required 1.3 kgs of wood or 1.8 kgs of rice husk. Savings obtained when a gasifier is coupled to a gas genset is determined by this calculation, using equation 2.1

Energy cost (Rs/kWh)= (1.3 * 5) + (1.8 * 5) Energy cost(Rs/kWh) = 15.5

The cost of 1 kg of wood or rice husk is assumed around Rs 5. So, the cost of generate 1kWh energy is Rs 15.5. The cost of 1kWh energy of 100% Producer gas is high because of the cost of rice husk and wood is assumed equal to Rs 5. If the cost is less of rice husk and wood the cost of 1 kWh is also less.

2.5 Sustainability of modified gas engine

Where there is no possibility to connect to the grid (e.g. the electric energy supply of households, holiday houses, isolated objectives, equipment in industrial sites, electric installations for outdoor entertainment events, military equipment, telecommunications, etc.), or as emergency regime, as a reserve electric power source, in the event of electric power blackouts. In emergency regime the diesel generator sets usually supply only vital consumers, like re pumps, elevators, safety lighting installations, banks, hospitals, government buildings, offices, mobile towers, supermarkets and large restaurants, hotels, malls, stadiums, airports, fuel stations, private houses, and industrial sites where specific processes do not allow for blackouts, become uncontrollable or generate important losses without electric power, etc. Usually, in parallel with diesel generator sets, UPS systems are used, with a buffer, able to ensure for short periods the continuity of power supply for vital consumers, until the diesel generator sets are started-up. The minimum combined time necessary for the detection of a grid voltage drop, the start-up of internal combustion engine, reaching the stabilized regime of the generator (frequency and voltage) and the load connection is typically at least in few seconds. In the case of power systems based on renewable energies, given the uctuate character of unconventional energy sources, diesel generator sets takes on particular importance, their role being to ensure the continuity of electric power for the local grid during periods when the renewable sources of energy become unavailable or insufficient. Advantages of this modified gas engine [9] compare to diesel generator is-

- Social well being
- Economic well being
- Environmental well being
- Technology well being

3. Diesel Generator Sets

Diesel generator sets convert fuel energy (Diesel OR Gas) into mechanical energy by means of an internal combustion engine, and then into electrical energy by means of an electric machine working as generator[1]. The main characteristics of a diesel generator set are : rated power , rated voltage, rated frequency and number of phases, etc. The diesel generator sets are usually designed to run at synchronous speed 3000 rpm or

ISSN : 2277-1581
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1500 rpm at a frequency of 50Hz (for two-pole and four pole) and 3600 rpm and 1800 rpm at a frequency of 60 Hz (for two-pole and four pole). Speed regulator and voltage regulator are the two component which help to give proper operation of diesel generator set is determined to a great extent. The performance of these components are vital for the operation and utilization of diesel generator sets, their purpose being to precisely maintain the imposed parameters of electrical power(voltage and frequency). The relation between speed and frequency(f/N) of an ac machine is given by this formula-

$$f = \frac{P * N}{120}$$

where f = frequency(Hz),
P = number of poles of the generator rotor,
N = synchronous speed (rpm)
and Figure 3.1 shows the general diagram of diesel generator set.
The equation of electrical power of three-phase machine are shows the relation between fuel flow-rate and power produced by the generator.

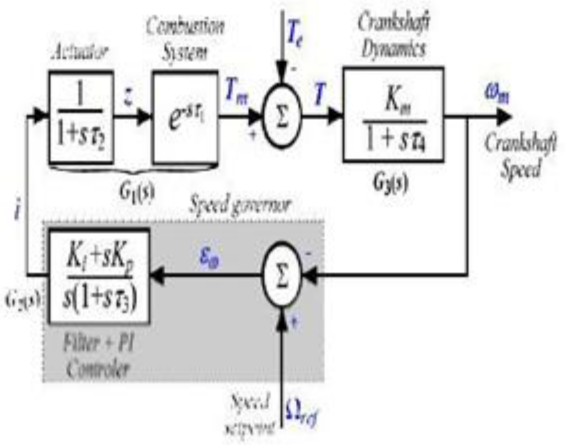

Figure 3.1: General diagram of diesel generator set[4]

The equation of three phase electrical power is given by-

$$P = \sqrt{3} V_L I_L \cos\phi$$

The generator output power is increased or decreased it is dependent on torque provided by the machine. In mostly cases the voltage of synchronous machine is rated or desired so it is fixed and power factor for resistive load is 1, and if power factor is assumed that it is equal to 1 then only current in ampere required to increase, So stator current is increase while increasing the torque because stator current is directly proportional to torque. Input fuel is also directly related to torque produce by machine it means increase in amount of fuel, also increase torque and it is increased the stator current and produced more power and vice versa. Diesel generator set combined with Prime mover, excitation system and synchronous machine.

3.1 Prime mover

The primary movers are internal combustion engines equipped with mechanical regulators or governor to keep the imposed speed, integrated in the injection pump and adjusted to obtain an output frequency of 50 Hz or 60 Hz for rated load. In diesel generator sets, there is speed governor equipped with prime mover. The purpose is ensuring that the diesel engine can be specified speed to stable operation. The combination of diesel engine and governor is used second-order to modelling and their transfer function also shown in figure 3.2

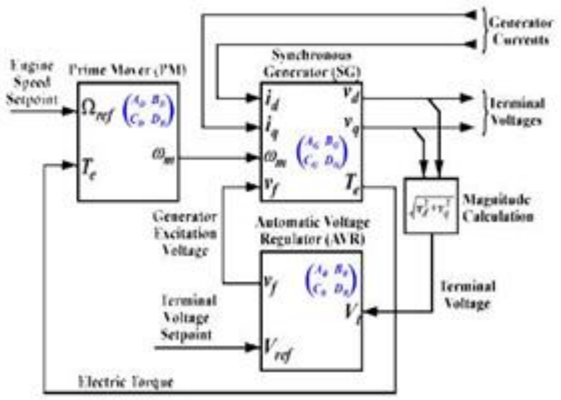

Figure 3.2: Controlled diagram of Prime Mover [4]

The speed regulator is basically designed to keep constant speed of internal combustion engine by changing the quantity of fuel consumed by the motor. Actually, frequency is directly proportion to the generator speed so the direct result of this speed regulation is a stable frequency of voltage at the generator terminals. A constant frequency requires good precision and a short response time from the speed regulator. The speed regulator starts regulating when various electric loads are connected or disconnected at the generator terminals. There are a lot of speed regulating systems, starting from simpler spring-based ones up to complex hydraulic and electronic ones able to regulate dynamically the fuel admission valve to keep the speed constant in a given range with response times at load changes smaller than 1-4 seconds.In figure,ω_{ref} (pu) is reference value of speed equal to 1 and ω(pu)is per unit value of actual speed of synchronous generator, P_{mech}(pu)is per unit mechanical output power of diesel engine used to drive generator.Speed of machine is maintain constant for e ciently using generator output power and same actuator tries to adjust the speed of machine. The simulation model of diesel engine governor is shown as figure 3.3

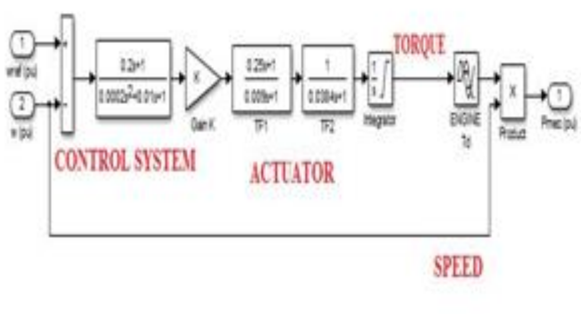

Figure 3.3: Simulation model of diesel enginegovernor
The Output speed of diesel engine is going through integral unit conversion for torque. Because diesel engine is a large time delay system, So the torque first go through delay unit

DOI : 10.5958/2277-1581.2017.00107.3

then multiplied by the actual speed of machine and such result known as mechanical power. Here in DG set engine inertia is combined with the generator inertia. The torque or mechanical power drives generator and produce electricity and then it feed to different load.

3.2 Synchronous machine

A synchronous machine is a device for converting torque into amperes or it converts the mechanical power into the electrical power. The synchronous machine block operates in both generator and motor modes if torque or mechanical power is positive it works as synchronous generator and if mechanical power is negative it works in a motor mode. The numerical models that can be used in the study of the synchronous generator can be classified into circuit models and field models, with the ones most used in electric drive systems being the circuit models. Before starting the simulation there is required to initialize the machine for starting in steady state region.

3.3 Excitation system

Excitation system is the important segment to ensure the voltage accuracy of generation and improve the stable operation of power system. Reactive power generation also depend on excitation system it means if increasing the excitation being applied to the generator rotor reactive power will increasing acts as inductive region and also power factor decreasing that time while generator terminal voltage and the local grid voltage increased slightly so result is reactive power began to ow in the generator stator winding and real power decreased. The automatic voltage regulator is to control the voltage at the generator terminals and keep it constant by limiting as fast as possible the voltage peaks and over voltages that occurs due to load variations. The function of excitation control system mainly in the following aspects-

- Maintain generator terminal voltage constant
- Control reactive power allocation of parallel operation generator
- Effectively improve system static stability
- Improve system transient stability

In all the cases of diesel generator set AC1A excitation system are used because after transient it will get stable fast so time required very less compair to other excitation system. The modelling diagram of AC1A excitation system with its transfer function is given below in figure 3.4

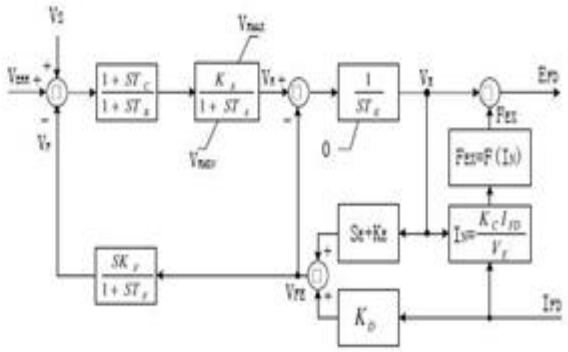

Figure 3.4: IEEE type AC1A excitation system model

3.4 Problem Identification

3.4.1 Frequency droop control

The system is in stable condition if frequency deviation is in range of plus-or-minus 3 %. When system is synchronize with the other system or grid with same frequency and voltage level the frequency is not constant. It always try to maintain frequency about constant but during sudden load increasing or decreasing frequency variation is done. During sudden connection of high load system frequency will decrease as voltage decrease and speed of synchronous generator also decreased. So it will maintain the frequency nearer to base frequency. The problem like blackout were occurs only due to this frequency droop so the control is must require for stable operation of power system. In figure 4.5 shows how to measure the frequency of synchronous generator.

3.4.2 Voltage regulation

In most case the generator terminal voltage having rated or desired value. The range of plus-or-minus 5% are allow to terminal voltage swing but more than that system collapse. The terminal voltage is the magnitude of dqo component of stator voltage V_d and V_q

i.e.

$$V_t = \sqrt{V_d^2 + V_q^2}$$

The generator terminal always maintain at 1 per unit but due to some cases like fault and rapid load change it will decrease or increase so system is in unbalance condition. If generator terminal voltage is decrease it means the stator current is increase and vice versa. For stable operation to maintain the generator terminal voltage equal to 1 pu must require. In figure 4.5 also shows the measurement of generator terminal voltage is in Pu or actual value but in mostly cases it is desired.

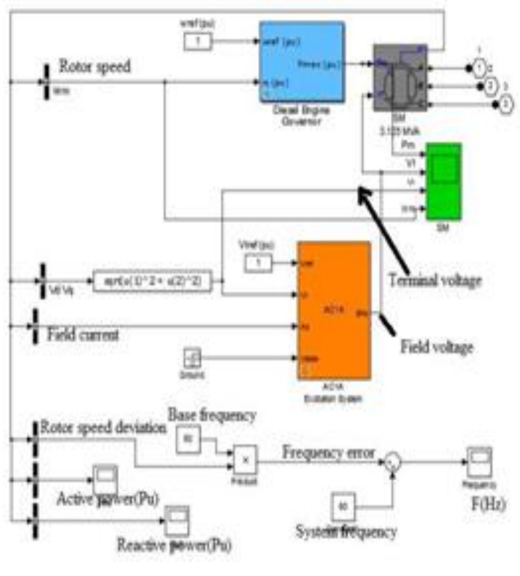

Figure 3.5: Block diagram of diesel generator set

DOI : 10.5958/2277-1581.2017.00107.3

3.4.3 Rotor speed droop control

The term fuel, torque, speed and also frequency are interrelated because speed is directly proportion to frequency ($f \propto N$). The real power generation also decreased due to this issue of speed and frequency droop. For stable or reliable operation speed maintain by governor or other regulator function nearer about 1 pu.

3.4.4 Active and reactive power control

The active power and reactive power is directly proportional to respectively governor(fuel) and excitation system. Reactive power is increased as excitation increases and real power is increase as input fuel increases with the constant power factor. If reactive power(VAr) increase so power factor is lagging at that time so it behaves as inductive region. Excitation is used to control reactive power in stator terminal of the generator. In figure 4.5 shows the measurement of active and reactive power generate in stator winding of generator.

3.5 Simulation parameter

- Power supply parameters are as follows Input source rated three phase apparent power : P_e= 7:54 MW. Rated voltage: V_e= 25KV. Rated frequency= 60 HZ. Use a static load of 5MW to simulate the total power input system. The primary and secondary voltages of transformer are 25 KV-2400 V. Three phase switch set to close in the beginning, when the three-phase ground fault happened in 0.1 seconds, the system detects the failure by the detection system and disconnects the normal power grid at that time three-phase switch are to be off. System operating state is emergency diesel generators running.
- Emergency diesel generators synchronous generator parameters are as follows: Silent pole rotor type is used in the system, where rated capacity:P_e=3:125MVA. Rated voltage: V_e = 2400V. Rated frequency: 60 Hz. X_d = 1:56, X_q = 1:06, Xd'=0.296, X_d''=0.177,T_d''=0.05, T_d'= 3.7, stator resistance R_s = 0:816, Inertia coefficient is 1.07 and Pole pairs P=2.
- Induction motor parameters are as follows : rated capacity P_e = 1:492MV A(0:8889pu), Rated voltage V_e = 2400V , Rated frequency=60 Hz, Stator resistance R_s = 0:029ohm, Stator inductance L_s = 0:0005H, Rotor resistance R_r'=0.022 ohm, Rotor Inductance L_r'=0.0005 H, Mutual Inductance L_m = 0:0345H, Moment of inertia 63.87 and pole pair P=2.
- Three static non-dynamic loads are as follows: Load 1 =5 MW, Load 2 = 0.5 MW and load 3 = 0.5 MW.

4 Diesel Generator Set Operating in Standby Mode

In the case of important equipment or objectives, electric power consumers are usually grouped into vital consumers and non-vital ones. An electric power security solution for the vital consumers is to back-up their supply by means of a diesel generator set. The installation of the diesel generator set should be done so that during a blackout resulting from a grid fault, it is possible to keep connected only the vital consumers. In the case of wind and/or solar renewable power systems, a black out could occur in the event of insufficient solar or wind power. Diesel generator used mostly for isolated purpose such as in mobile towers, hospitals, petrol pumps, colleges etc. It is fact that diesel generator generate 1 kWh energy is costly than the other alternative sources but availability and fulfil all demand so diesel generator is mostly used in isolated load. In case of Biogas or biomass gasifier plants, due to weather atmosphere generation may decreased suddenly so in such situation a three phase grid is connected in system which can be represented by a renewable power system. There are groups of resistive type consumers have the rated powers 5 MW (non-vital consumers) and other two each 0.5 MW and a motor 1.492 MW(vital consumers), and they are supplied from the grid. When a three-phase to ground fault occurs at the grid level ,the normally closed breakers B1 cut the energy supply for the non-vital consumers(5MW) and the vital load is supplied by diesel generator set. The three-phase short- circuit occurs in our case after 1.5 seconds from the simulation start. At time instant 1.6 second breakers open and diesel generator set are operated in emergency region. After 6.1 second of simulation start another single line to ground fault occurs in to the system and after 6.4 second it will be automatically cleared also the breaker B2 open at 6.1 second and auto reclose to 6.4 second Diesel generator operated in emergency region is shown in figure 4.1.
Where we can identify the time evolutions of mechanical power, rotor speed and output power in per unit. When the short-circuit or fault occurs after 0.1 seconds from the simulation start, the mechanical power produced by the generator set increase from a small value because there is no load connected before 0.1 seconds to the diesel generator set and stabilizes at the value imposed by the regulation system, The output voltage period of time, after which it comes back very quickly at the rated value. Such a voltage drop can be prevented by means of a properly sized UPS system and it is simulated with the help of simulation package in Matlab.

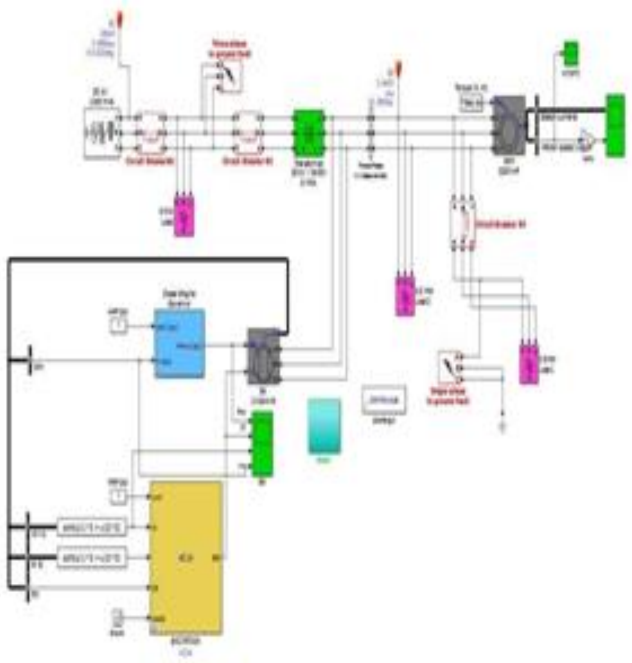

Figure 4.1: Diesel generator set operated in standby mode

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4.1 Simulation results

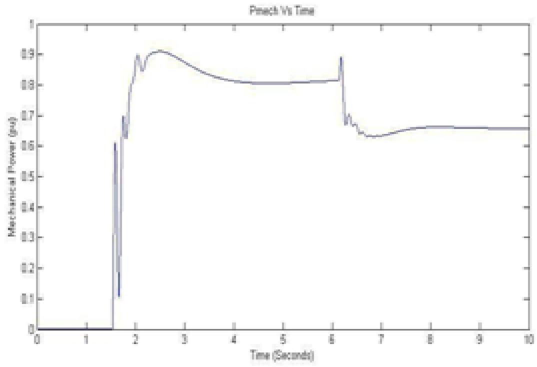


Figure 4.2: Mechanical Power of DG during standby mode

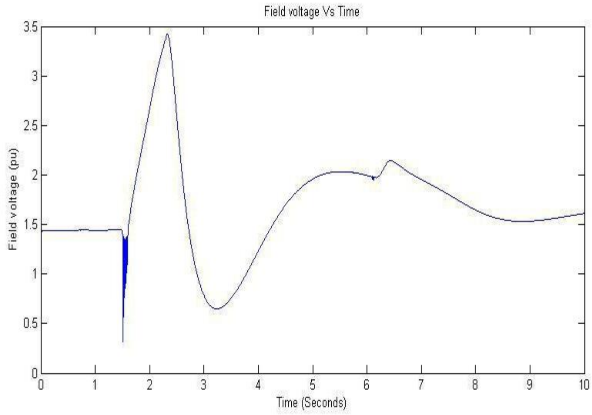


Figure 4.3: Excitation/ field voltage during DG in standby mode

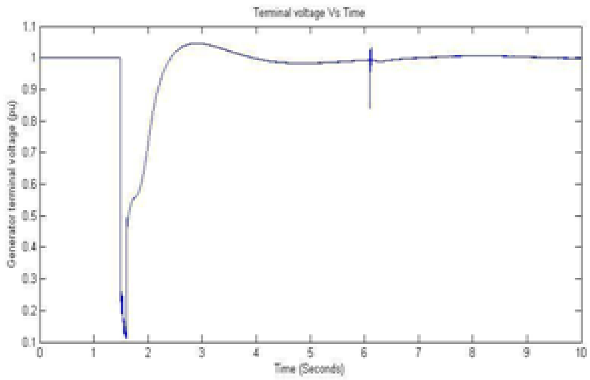


Figure 4.4: Generator terminal voltage during DG in standby mode

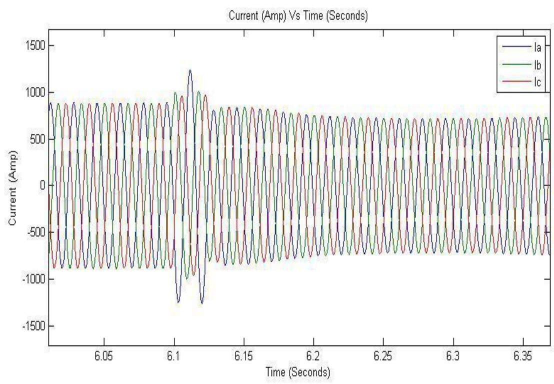


Figure 4.5: Rotor speed of machine during DG in standby mode

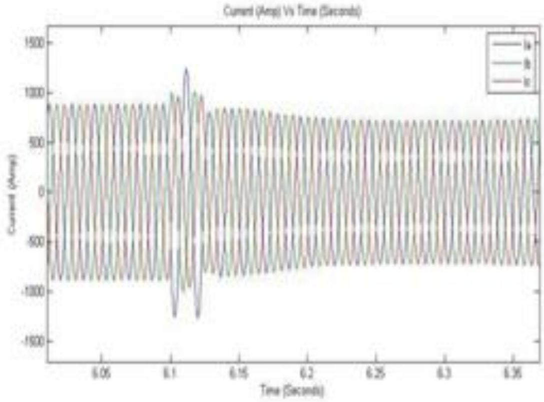


Figure 4.6: Generator output voltage under three phase short circuit

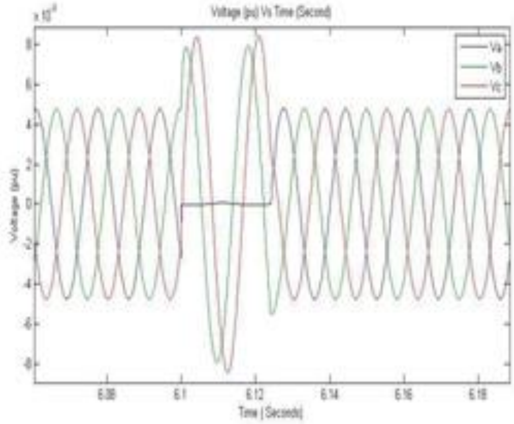
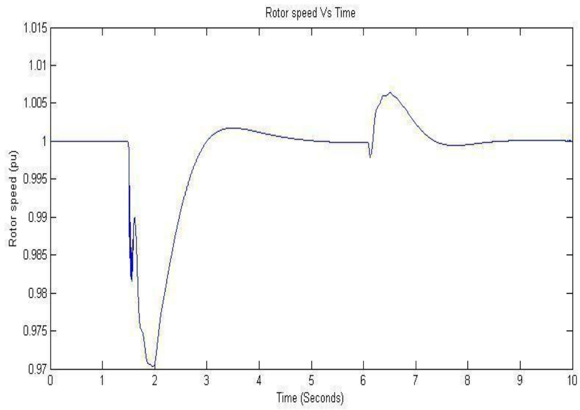


Figure 4.7: Generator output voltage under single phase to ground fault



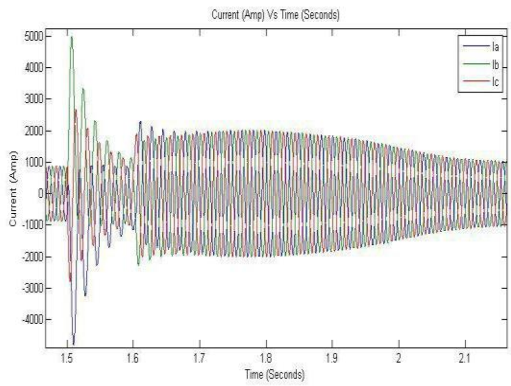


Figure 4.8: Generator output current under three phase short

ISSN : 2277-1581
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circuit fault

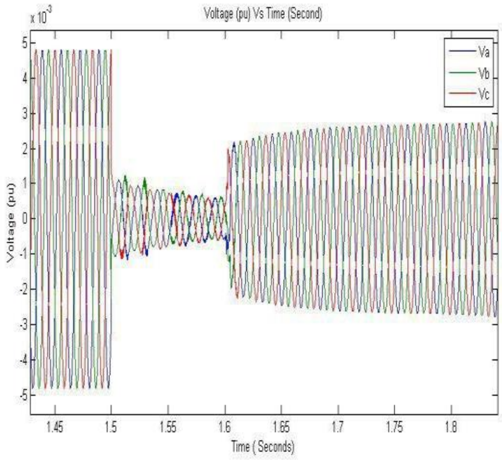

Figure 4.9: Generator output current under single phase to ground fault

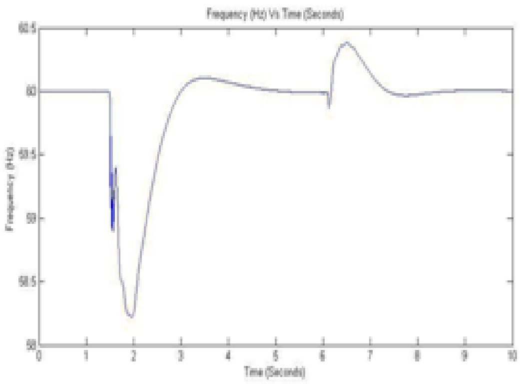

Figure 4.10: Rotor speed of motor during DG in standby mode

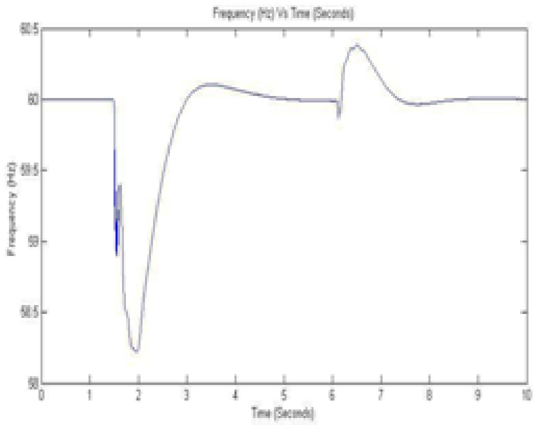

Figure 4.11: Frequency of DG set during DG in standby mode

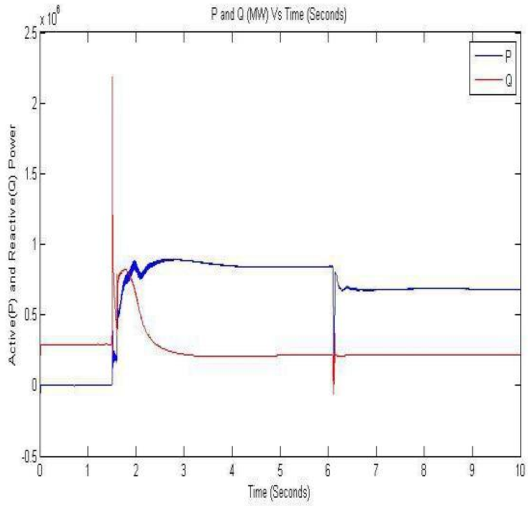

Figure 4.12: Active and reactive power during DG in standby mode

5. Result discussion

The swing equation of machine is also write as

$$J\frac{d\omega_m}{dt} = T_m - T_e$$

also

$$\omega_m J\frac{d\omega_m}{dt} = T_m - T_e$$

So, in stable or steady state operation speed always be constant to maintain the accelerating power. In case if load decreasing the torque start to accelerating and speed and frequency also increasing when load decreased and if load increasing the torque start to decelerating and also speed and frequency also decreasing while load increased.

- In figure 4.1 Three phase fault occurs at time between 1.5 to 2.0 seconds from the simulation start. At time instant 1.6 second B1 breaker opened it means renewable source is disconnected and vital resistive load connected to synchronous generator. The mechanical power initially developed by the combustion engine is very small because the synchronous generator coupled with the engine is running without load. After suddenly connecting the resistive load, the mechanical power developed by the engine increases rapidly and after few seconds, a new operation stabilized region is reached. In figure 4.2 shows the curve of mechanical power and it is cleared that within few seconds it is stabilised. Excitation voltage initially set at 1 per unit but at the time of sudden connection of resistive and motor load transient region occurs and excitation voltage increases about 1.433 pu and it also stabilize with in few seconds also it shows in figure 4.3. The voltage (pu) at the stator of generator terminals also demonstrates a significant decrease for a short time, after which it stabilizes in few seconds due to the action of the voltage regulation system. The drop of stator terminal voltage is shown in figure 5.4. During the transient regime, due to the sudden coupling of the load, the machine rotor speed (pu) decreases abruptly, the rotor speed droop is equal to ((0.97-1)/1 * 100)= -3% but within few second or short period it stabilized at the imposed value as a result of the action of the speed regulating system. The curve of rotor speed deviation shows in figure 4.5.

- In figure 4.6 and 4.8 the waveform of line voltage and line current shows that unbalance occurs due to the three-phase short circuit fault. In line voltage at time 1.5 second (During fault) current ow at low resistance path so voltage drop is reduced to some extant but in case of line current at time 1.5 seconds suddenly increased because load at that time is increased to some extent. The behaviour of line voltage and current are shows that how they increased and decreased during faulty time and then after opening of circuit breaker at time 1.6 second DG start to supplying the load and both are stabilized according their load at that time because after 1.6 second grid is disconnected.

- In figure 4.7 and 4.9 the waveform of line voltage and line current shows that the effects of single line to ground fault in the system. In line voltage and line current at time 6.1 second fault occurs and at time 6.12 second B2 circuit breaker opened so it disconnects that load. In between the unbalance of line voltage and current are shown in figure they suddenly increased to at some extant and after opening of circuit breaker both stabilized with in few seconds.

- In figure 4.10 shows that three phase short circuit occurs at time 1.5 second and that time rotor speed decreased and the speed droop is equal to ((1630-1690)/1690 *100)= -8.9%. After opening the circuit breaker B1 means grid is o and DG instantly supply to the vital load (Motor and resistive) and rotor speed of motor back in stabilized limit at 1690 rpm. At time 6.1 second another single line to ground fault occurs and that time also system unbalance and at time 6.2 second load being disconnected and the results of rotor speed of motor shown in figure 4.10.

- In figure 4.11 shows that the frequency curve for Diesel generator set operated in emergency condition. At time 1.5 second fault occurs during this frequency and speed goes down because both are proportion to each other so frequency droop during three phase short circuit fault is equal to((58.25-60)/60*100=-2.1% so it is inacceptable limit and after that 1.6 second it is stabilized back to 60 Hz. At time 6.1 second another single line to ground fault occurs and at time 6.12 second the grid is disconnected and system supply by diesel generator set so during this fault frequency also deviate to some extent and it will stabilized back to 60 Hz.

- In figure 4.12 shows the generated active and reactive power in output of diesel generated set. DG start after opening of B1 circuit breaker when main grid is disconnected till DG no active power is generate but initially reactive power is generating it shown in figure about 0.3 MW. At time 1.6 DG set generate active power nearer about 0.8 MW and it is stabilized after faulty duration. Another fault come at time 6.1 and at time 6.12 load being disconnected so actual real power decreased to some extent so it is also shown in figure 4.12

6. Conclusion and Future scope

Diesel generator set is combination of prime mover, excitation system and generator so speed and voltage are required to maintain to operate system in stable condition.

- Diesel generator set increases the reliability of the system with renewable sources in case of stand by operation and DG also used as primary source of supply electricity to vital load and it is reliable for continuous supply to vital load.
- Normally DG rating are small hence they offer better system performance while connected in distributed manner.
- This is especially suitable in remote areas and villages where power quality and reliability is a matter of concern.
- Diesel generator are used as backup supply system but
- Dual fuel type like diesel and gas (syngas) DG engine will impact less on environment and improves reliability of system.
- Use like bagasse, rice husk, wood chips, cotton stalks etc different type of fuel to replacement of diesel in DG set so per kWh energy cost also reduced.
- Involving power electronics system to further improve the performance of the system.

8. References

i. *Robert J. Best, D. John Morrow, David J. McGowan and Peter A.Crossley,\Synchronous Islanded Operation of a diesel Generator", IEEE TRANSACTION OF POWER SYSTEM, VOL.22,NO.4,NOVEMBER 2007.*

ii. *S. Krishnamurthy, T.M. Jahns, and R.H. Lasseter,\The Operation of Diesel Gensets in a CERTS Microgrid", inConf. Proceed. of 2008 IEEE Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Centruy, pp. 1-8, July 2008.*

iii. *[3] TiberiuTudorache, Cristian Roman,\The Numerical Modeling of Transient Regimes of Diesel Generator Sets", Acta Polytechnica Hungarica.Vol.7,No.2,2010.*

iv. *Ashish Malik, Lakhwinder Singh and IndrajSingh,\Utilization of biomass as engine fuel",Journal of Scientific and Industrial Research. Vol. 68, October 2009,pp. 887-890.*

v. *T. Theubou, R. Wamkeue and I. Kamwa. "Dynamic Model of Diesel Generator Set for Hybrid Wind-Diesel Small Grids Applications", IEEE Canadian Conference on Electrical and Computer Engineering(CCECE)2012: Montreal, QC, Canada.*

vi. *Yao lian-fu, Liu Qian, Li Shi and Zhang Zhen-yu. "Simulation and Dynamic Pro-cess Analysis of Nuclear Emergency Diesel Generators". International Conference on Informatics, Cybernetics, and Computer Engineering (ICCE2011) November 1920, 2011, Melbourne, AISC 112,pp 107-115.*

vii. *Aparna Pachori, PayalSuhane.\Design and Modelling of Standalone Hybrid Power System with Matlab/Simulink",International Journal of Scienti c Re-search and Management Studies(IJSRMS), ISSN:2349-3771.*

viii. *[8] BiomassGasi cation Based Power Generation by Arashi Hi-Tech Bio- Power Private Limited.*

ix. *[9] MNES Annual Report 2002-2003 (Ministry of Non-Conventional Energy Sources, Govt of India, New Delhi.*