Design and Fabrication of a self excited Induction Generator

A Project Report

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report entitled **"Design and Fabrication of a self excited Induction Generator"** is the bonafide work of

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ABSTRACT

In this project a normal three-phase induction motor as a capacitor self-excited Induction generator(SEIG).The thermal limit of the stator windings being the limiting factor, the capacity of the SEIG is determined. The steady-state performance of such induction, generators, maintaining a constant terminal voltage is analyzed under resistive and reactive loads. Typical experimental results are also presented. An analytical method employing Newton-Raphson technique is used to obtain the desired performance. Certain performance indices are defined which would provide guidelines in the development of induction generators systems including the voltage regulator. It has been found that for normal low power motors, the maximum power that can be extracted as generators is 148% to 160% of the motor rating for resistive loads and 118% to 128% of the motor rating for 0.8 power factor (PF) loads. Capacitive reactive volt-ampere (VAR) required to maintain constant voltage at 1.0 p.u. speed is in the range 85% to 140% of the power rating of the motor with resistive loads and 100% to 140% with lagging loads.

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INTRODUCTION TO INDUCTION GENERATORS

CHAPTER 1

INTRODUCTION TO INDUCTION GENERATORS

INTRODUCTION:

A three-phase induction machine can be made to work as a self-excited generator when its rotor is driven at suitable speeds by an external prime mover and its excitation is provided by connecting a three-phase capacitor bank at the stator terminals. The induced emf and current in the stator windings will continue to rise until an equilibrium is attained due to the magnet i.e. saturation in the machine. The topic has received considerable attention in recent years in view of the suitablitiy of induction generators for isolated power generation using conventional and renewable energy sources.

Such a induction generator compares favourably in cost, ease of operation and maintenance with a conventional alternator. Owing to the changed emphasis on energy problems, the development of suitable low cost isolated power generators, driven by energy sources such as wind, biogas etc. is indeed a promising alternative. The acceptability of these generators as viable generating units would be decided by their ability to provide desired voltage and frequency at all low speeds. The development of static power converters facilitates control of the generated power to the required voltage or frequency levels.

OBJECTIVE:

To design and fabricate an efficient Self-excited Induction generator with an additional identical stator winding which leads to constant speed operation and improvement of power factor.

NEED OF THE PROJECT:

Today mostly synchronous generators are used for power production. Whereas in Wind power generation synchronous generator is not effective because of its

1. DC excitation of the rotor.
2. High cost.
3. Maintenance is costlier.

To overcome these problems Induction generators are preferred for power production in Wind Engineering.

Induction Generators are commonly used due to advantages such as

1. No excitation of the rotor,
2. Availability,
3. Low cost,
4. Ease of Operation,
5. Maintenance and
6. Robustness with a conventional alternator.

A Three phase Induction machine can be made to run as a generator when its rotor is driven at suitable speeds by an external prime mover.

LIMITATIONS IN INDUCTION GENERATOR:

1. Consumption of reactive power from the grid.
2. Inrush of starting current.
3. Low power factor.

SOLUTIONS:

- To run the induction machine with additional stator winding i.e. delta-star winding which has the following advantages.
  1. Reactive power drawn is reduced
  2. This helps in attaining constant voltage and frequency
  3. Improving power factor

ORGANISATION OF THE PROJECT:

The report describes about the use of an induction motor as an induction generator also the power factor improvement, the design of an identical delta-star winding in the stator and also about self excitation using capacitors.

Chapter 1: It introduces the need, problems and solutions of the Induction Generator with the methodology used for operation.

Chapter 2: The theoretical section of the project is discussed in this Chapter.

Chapter 3: The design details, design of exciter winding, load winding and Selection of capacitance is detailed in this chapter.

Chapter 4: The test results, tabulation, block diagram and the Characteristics of the designed Induction Generator are described in this chapter.

Chapter 5: It deals with conclusion and scope for the future development

METHADOLOGY:

1. Design of stator with an identical delta-star winding
2. Coupling of DC Shunt motor with Induction generator to give mechanical input power.
3. Testing of the machine without capacitor bank.
4. Testing of the machine with capacitor bank.

CHAPTER 2

THEORETICAL SECTION

CHAPTER 2

THEORETICAL SECTION

2.1. DC SHUNT MOTOR

DC shunt motor is the prime mover used to run the Induction Machine. This motor is particularly used because of its constant speed. DC motor is used here instead of a wind turbine which is used to run the Induction Generators.

The main characteristic of the DC Shunt motor is as long as the voltage is constant, which is generally so in practice, the flux produced is also constant. Hence DC Shunt motor is called constant Flux motor.

$$\Phi \propto I_{sh}$$

Where

Φ, is the Flux in Weber.

I_{sh}. the shunt current through the field winding.

The above equation proves the constant speed operation.

Speed-Torque characteristics :

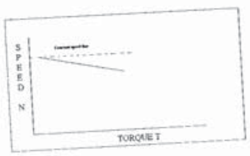


Fig 2.1. SPEED Vs TORQUE

2.2. INDUCTION MACHINE:

Induction machines are commonly used in almost all applications. The feature of the Induction machine is that if the machine is made to run below rated speed it acts as a Motor if made to run above rated speed acts as a Generator.

Here in the project an induction motor is made to run above rated speed by using a prime mover as a Induction Generator because motors are cheaper than installing the generator itself.

The characteristics of the Induction Machine is as given below.

Where N = - Ns	N = 0	N = Ns	N = +Ns
S > 1	S = 1	S = 0	S < 0
BRAKING REGION		MOTORING REGION	GENERATING REGION

2.3. LITERATURE SURVEY:

The literature survey deals with the comparison of performance of the new design of an identical delta-star winding of the Induction machine with that of the conventional Induction machine.

The study from S.S.Murthy, B.P.Singh has confirmed that a normally designed Induction motor can be successfully used as a three phase self-excited generator for low power applications. In order to maintain constancy of the generator terminal voltage, it has been shown that the values of capacitance varies over a wide range. For the machines considered, the desired range of capacitance kVAR variation has been found to be 85 to 185 % of the machine rating. The criteria of limiting the starting current in the

determination of the maximum generated power has been found to be appropriate. The study extended to cover a wide range of standard motors up to 100 KW are also studied.

Thus the normal Induction motors can be employed as Self – excited generators, with the constant speed prime movers.

The study from J.B.Ekanayake tells the principle of operation of the three- phase induction generator under single-phase loading has been presented. The three phase generator can be converted to a single phase generator which can be used for small Hydro schemes as single phase Induction generators are more expensive than three phase Induction generators.

Studies from N.Kumaresan and M.Subbiah confirm that the delta-star configuration of an Induction machine has been successfully applied for wind-driven grid-connected Induction generators. Thus design of a conventional Induction machine as a self-excited Induction generator leads to the improvement of power factor and about self excitation.

2.4. CAPACITANCE REQUIREMENTS:

Capacitors or the Capacitor banks are required for excitation of the stator winding (delta in the new design). This excitation of the winding in the generator proves the generator is Self – exciting. The minimum value of the capacitance required for initiating voltage build – up in a three phase self excited Induction generator using the steady state equivalent circuit model is determined in detail in the next chapter. A consideration of the circuit conductances yields a 6 th degree polynomial in the per – unit frequency.

The polynomial can be solved for real roots which enables the value of the minimum capacitance to be calculated.

These minimum values of capacitance in the project deals with two main purpose. They are

1. Capacitance connected in the excitation side serve as self-Excitation of the Induction generator.
2. Capacitance connected in the load side or the generating side is for the Improvement of the power factor.

Thus design and selection of the capacitor banks play a major role in the project.

2.5. USE OF DOUBLE WINDING

The Conventional Induction machine has only one winding in the stator. (i.e.) either star or delta as shown in the figure. An innovative delta – star three phase winding, developed earlier in 3 – phase induction motors, is applied for constant speed grid – connected Induction Generators. A method has been developed for the prediction of the performance of the generator with such an unconventional winding. It has been demonstrated that with a suitable switching arrangement, the proposed delta – star generator can result in increased real power delivered to the grid and reduced reactive power drawn from the grid, as compared to a fixed stator configuration. The facility of using the star mode of the generator while connecting it to the grid with much reduced inrush current

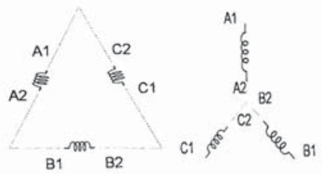


FIG 2.2. DESIGN OF THE STATOR OF A CONVENTIONAL MACHINE

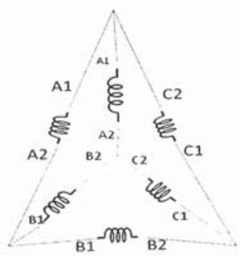


FIG 2.3. DESIGN OF A SELF-EXCITED INDUCTION GENERATOR WITH AN IDENTICAL DELTA-STAR WINDING

2.6. OPERATION:

SINGLE WINDING:

- The conventional Induction machine is made to run as Induction generator and experimental results are tabulated.
- The power factor is calculated for the normal Induction machine and the readings are tabulated.

DOUBLE WINDING:

- Initially the supply is given to the DC motor which acts as a prime mover to the Induction machine.
- The motor runs at a constant speed say 1500 rpm.
- Now the supply to the Induction machine is given through the auto – transformer and the voltage to the delta of the excitation winding is gradually increased.
- The speed of the DC motor is varied to the above rated speed as to make the Induction machine act as a Generator.
- The capacitance initially connected to the excitation side gets charged.
- Now the autotransformer supply is switched off. The charge stored in the capacitance is sufficient to excite the delta of the stator winding. This is called as self – Excitation.
- Load is connected to the newly designed star winding of the stator.
- Readings are tabulated and the power factor is measured.

- Now the capacitors are connected to the load side of the generator. (The load side is also called as the generating side).
- With the capacitors on both sides experimental results are tabulated.
- Power factor is measured using these values.

CHAPTER 3

DESIGN CONSIDERATIONS

CHAPTER 3:

DESIGN PROCEDURE:

3.1. DESIGN CONSIDERATIONS:

The design of the Induction Generator involves the study of suitability of the conventional Induction Motor. The principle-limiting factor in such an application is the thermal limit of the stator windings. Therefore it is evident that the induction motors can be used in generation mode only for low power operations, while the large power operations require some special modifications from the conventional design to remain thermally stable. There are many more factors that affect the use of induction motors as generators.

The studies done by Murthy, S.S. et al was find the practical suitability of the induction motors as generators. They considered various features including the above mentioned one to study the applicability. These studies were used by us before we started to design our own scheme for the stand-alone operation of the self-excited induction generator.

The use of the induction motor as a generator generally has a cost advantage over the other conventional modes of generation owing to its simple and low cost construction. Due to its robust construction, less maintenance is required by a induction motor, this advantage is passed to the induction generator. With the development of the various static power converters has led to the wide acceptance of induction generators for low cost power generation.

There are two alternatives for the development of induction machine based generating system.

Redesign the induction machine to obtain the required generator operation.

Use the existing available induction motor as a self-excited induction generator.

There have been efforts to specifically design the induction generator for large power applications. While it is not economically feasible for low power applications. Generally for low power applications it is preferred to use the available induction machine. Hence, we have used an available induction motor for our project work.

ROLE OF "AIR-GAP VOLTAGE TO FREQUENCY "RATIO:

It is desired that the induction generator should provide a constant terminal voltage even under varying loads. In practice, a drop in terminal voltage and the frequency is an observed feature under varying loads. A constant voltage alone implies an increased air gap flux for the induction generator would result in a continuously varying magnetizing reactance. But a constant "air-gap voltage to frequency "ratio would ensure the operation of the induction generator at a constant air gap flux. Hence it is necessary to consider the "air-gap voltage to frequency ratio" for a constant flux operation of induction generators.

ROLE OF THERMAL LIMIT:

It is desirable to have a machine that functions equally well either as a motor or as a generator. In the case of the squirrel cage motor when it is operated as a generator, the heating of the stator windings is the limiting

factor on the capacity of the power generation rather than the rotor cage is capable of withstanding considerable thermal overload. This thermal instability arises due to the fact that, in the generating mode the stator winding carry a current equal to the vector sum of the magnetizing current and the rotor current. Whereas, in motoring mode the stator winding carries a current equal to the vector difference of the rotor current and the magnetizing current. Thus the allowable range of the induction generator operation with a imposed limit on the rotor current does not contain the entire available range of the stator current, this implies that power can be extracted from the generator even under the condition when the rotor current is more than its rated value and the stator current is within its maximum limit.

3.2. DESIGN SPECIFICATIONS OF THE MACHINE USED IN OUR PROJECT:

The machine used in our project is a 2 hp (2.2 KW), 3 phase, 400 V, 3.4 A, 50 Hz, 4-pole squirrel cage induction motor.

The main dimensions of the machine are D = 13.9 cm and L = 10 cm.

3.3. DESIGN OF STATOR WINDING:

Flux density in the stator core (B_{av}) = 1 Wb/m^2 (on assumption)

At the core, the flux density, $B_{av} = B_m$.

Current density in the windings is taken to be 6 A/mm^2.

CALCULATION OF THE FLUX:

Flux (Φ) = 2 * (core depth) * (length of the core) * B_{av} Wb. (3.1)

The factor 2 is multiplied to get the actual flux, since only half of the flux is distributed in the stator core (Φ/2).

Hence,

Flux $(\Phi) = 2 * (1.7*10^{-2}\ m) * (10*10^{-2}\ m) * (1\ Wb/m^2)$

$= 34 \times 10^{-4}$ Wb.

3.3.1. DESIGN OF EXCITER WINDING:

The number of the turns per phase was obtained from the EMF equation,

$E_s = 4.44 * f * \Phi_m * T_s * K_{ws}$ Volts. (3.2)

Here the E_S is 400 volts, and the winding factor (K_{ws}) is 0.9.

Hence to find the unknown parameter, we substitute the known parameter in the EMF equation.

$400 = 4.44 * 50(34*10^{-4}) *0.9*T_S$

T_S = 588.82 turns/ phase.

There are totally 12 coils.

The number of turns per coil = turns per phase / number of coils.

The number of turns per coil = 588.82/12

= 49.

We have taken 48 turns/coil for the fabrication of the excitation coil.

The excitation winding is connected as delta.

The excitation winding was fabricated with wire of 22 SWG (d = 0.711 mm).

Current in the exciter winding = 6 * π * $(0.711)^2$ /4 = 2.38 A = 2 A.

3.3.2. DESIGN OF LOAD WINDING:

The load winding is connected in star. Hence the terminal voltage is 1.732 times less than that of input voltage.

Therefore, on applying the EMF equation,

$(400/\sqrt{3}) = 4.44 * 50 * (34*10^{-4}) * 0.9 * Ts$

The number of turns per phase (Ts) is 339.957.

The number of turns per coil is 28.

The load winding was fabricated with a wire of 20 SWG (d = .914).

Current in the load winding = 6 * π * $(0.914)^2$ / 4 = 4 A.

These two windings are placed in the stator core as two double layered windings, with load winding at the bottom and the excitation winding occupying the top position.

3. 4 DETERMINATION OF CRITICAL CAPACITANCE:

Equivalent Network at Excited Frequency:

Equivalent circuits where all the parameters are referred to rated frequency, assuming all inductive reactances are proportional to the frequency. The circuit shown in the figure 3.1, where the symbols a and b have the following significance.

The slip S can be expressed as S = (a – b)/a. Furthermore, since S is negative, b is greater than a.

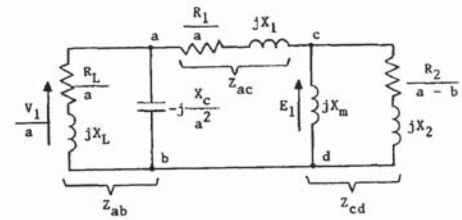


FIG 3.1. EQUIVALENT CIRCUIT OF THE SYSTEM

The equivalent circuit can be simplified into the form shown below.

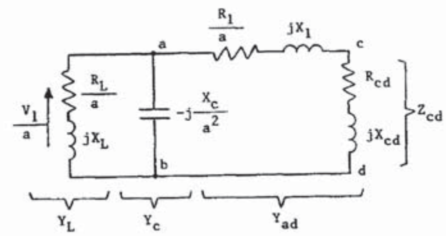


FIG 3.2. SIMPLIFIED EQUIVALENT CIRCUIT

Where,

$$R_{ad} = \frac{(a-b)R_2X_m^2}{R_2^2+(a-b)^2(X_m+X_2)^2}$$

$$X_{ad} = \frac{R_2^2X_m+(a-b)^2X_mX_2(X_m+X_2)}{R_2^2+(a-b)^2(X_m+X_2)^2}$$

$$Z_{AD} = R_{AD} + j\,X_{AD}$$

$$R_{AD} = R_1/a + R_{CD}$$

$$X_{AD} = X_1 + X_{CD}$$

The admittance Y_L and Y_{AD} are given by

$$Y_{ad} = \frac{R_{ad}}{R_{ad}^2+X_{ad}^2} - j\frac{X_{ad}}{R_{ad}^2+X_{ad}^2}$$

$$Y_L = \frac{aR_L}{R_L^2+a^2X_L^2} - j\frac{a^2X_L}{R_L^2+a^2X_L^2}$$

By KCL, the sum of currents at a node should be equal to zero.

$(V_1/a)\,(Y_c+Y_L+Y_{AD}) = 0.$

For successful build up V1 should not be equal to zero.

$$(Y_C + Y_L + Y_{AD}) = 0$$

$$\frac{aR_L}{R_L^2+a^2X_L^2} + \frac{R_{ad}}{R_{ad}^2+X_{ad}^2} = 0$$

$$\frac{a^2}{X_c} - \frac{a^2X_L}{R_L^2+a^2X_L^2} - \frac{X_{ad}}{R_{ad}^2+X_{ad}^2} = 0$$

From the above equations a 6 th order equation can be performed

$$p_6a^6+p_5a^5+p_4a^4+p_3a^3+p_2a^2+p_1a+p_0=0$$

Solving this equation we take the largest positive real root a_{max} and determine the minimum capacitance as follows:

$$C_{min} = \frac{1}{2\pi f_y Z_y a_{max}^2}\left\{\frac{a_{max}^2X_L}{R_L^2+a_{max}^2X_L^2} + \frac{X_{ad}}{R_{ad}^2+X_{ad}^2}\right\}$$

Under no-load,

$$a_{max} = b - \frac{b}{2}\left\{\frac{1-\sqrt{1-\left(\frac{b_c}{b}\right)^2}}{1+\left(\frac{R_1}{R_2}\right)\left(1+\frac{X_2}{X_m}\right)^2}\right\}$$

Where,

$$b_c = \frac{2R_1}{X_m}\sqrt{\frac{R_2}{R_1}+\left(1+\frac{X_2}{X_m}\right)^2}$$

$$X_c = a_{max}^2(X_1+X_{cd})$$

Hence, C_{min} is given by,

$$C_{min} = \frac{1}{2\pi f_b Z_b a_{max}^2}\left\{\frac{X_L + X_1 + X_{cd}}{X_L(X_1 + X_{cd})}\right\}$$

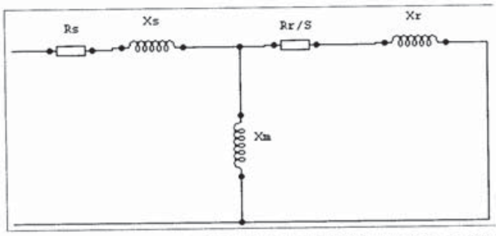


Fig 3.4. EQUIVALENT CIRCUIT OF LOAD WINDING WITH EXCITER WINDING OPEN

Using these formulae and simplifying the equations the value of the capacitance is found to be

b_c = 0.110 p.u.

a_{max} = 0.9309 p.u.

X_{CD} = 2.0559 p.u.

X_c = 2.3848 p.u.

C_{min} = 14.3 µF

CHAPTER 4

TESTS AND INTERFACES

CHAPTER 4

TESTS AND INFERENCES

4.1. TEST PROCEDURE:

MAGNETIZING CHARACTERISTICS:

Magnetizing characteristics is an accurate version of no load test. The machine runs at a very low slip at no load under rated voltage and hence is assumed to be zero. In magnetizing characteristics we adopt the following procedure.

- The circuit connections are as shown in fig 4.1(4.2).
- The autotransformer is set at zero and the supply is switched on.
- The prime mover (in this case a DC motor) is driven at the synchronous speed of the Induction machine.
- The autotransformer turns ratio is varied and voltage is brought to rated value in steps.
- The current drawn by the induction machine is noted at each step.
- The terminal voltage Vs current characteristics are drawn.
- This curve gives an idea of the saturation in the machine. Also if the input is measured at rated voltage, this can be used in determination of equivalent circuit.

PERFORMANCE EVALUATION OF SEPARATELY EXCITED INDUCTION GENERATOR:

- Connections are made as per fig4.3 (4.4).
- The field rheostats are set at minimum position and the DC motor is started using a starter.
- By adjusting the DC field the speed is brought to the synchronous value of the induction machine.
- Zero position of autotransformer is ensured and the AC supply is switched on.
- The capacitance is varied and the performance is observed again.
- The asynchronous generator is loaded by increasing the speed till the rated output is obtained.

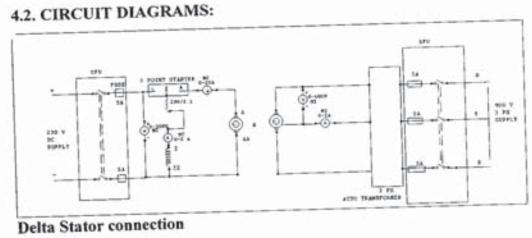
PERFORMANCE EVALUATION OF SELF-EXCITED INDUCTION MACHINE (UNDER RESISTIVE LOAD):

- Connections are given as per fig 4.5(4.6).
- The DC field is set at minimum and the motor is started using a starter.
- Desired speed is set by armature or field control.
- Capacitance is varied to bring the rated voltage across the induction machine.
- Resistive loading is done.
- Varying the capacitance does maintenance of voltage under load.
- Varying the speed carries out the finer adjustments in voltage.

PERFORMANCE EVALUATION OF SELF-EXCITED INDUCTION MACHINE (UNDER REACTIVE LOAD):

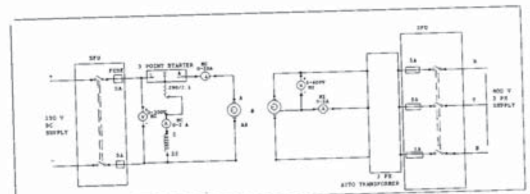
- Connections are given as per fig (prescribed for resistive load).
- The procedure used for resistive loading is followed.
- Since the excitation is very sensitive to inductive loading, loading is done carefully to prevent drain of capacitance resulting in 100 % regulation.

4.2. CIRCUIT DIAGRAMS:



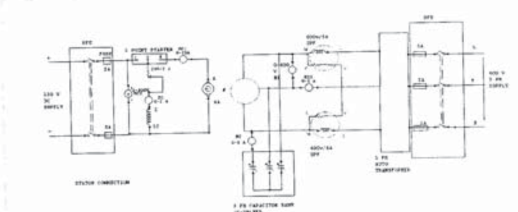
Delta Stator connection

FIG 4.1. Magnetising Characteristics of Conventional IG



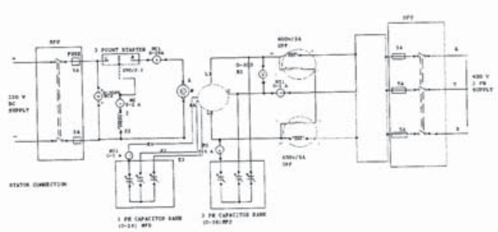
Delta-Star Stator Connection

Fig 4 .2. Magnetising Characteristics Of Double Winding IG



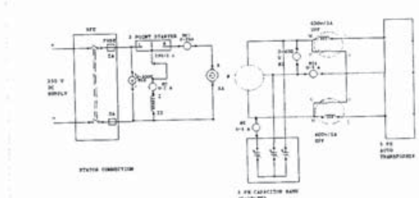
Delta Stator Connection

Fig 4.3. Separately Excited Conventional IG



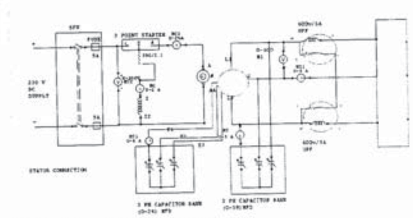
Delta – Star Stator Connection

Fig 4.4. Separately Excited Double Winding IG



Delta Stator Connection

Fig 4.5. Conventional SEIG – Resistive Load



Delta – Star Stator connection

Fig 4.6. Double Winding SEIG – Resistive Load

4.3. TABULATION:

The test results are tabulated for both the Conventional Induction Machine and the newly designed Induction machine with and without Capacitors. They are as follows:

SINGLE WINDING IG CHARACTERISTICS:

SL NO	VOLTAGE(V)	CURRENT(A)
1	100	0.60
2	150	0.80
3	200	0.95
4	250	1.15
5	300	1.35
6	350	1.55
7	400	1.78

TABLE: 4.1. MAGNETIZING CHARACTERISTICS

S NO	SPEED (RPM)	VOLTAGE (V)	I_L(A)	CAP. (μF)	V_{DC}(V)	I_F(A)
1	1408	400	0	4	190	0.62
2	1395	395	0.55	8	188	0.63
3	1340	400	1.0	14	186	0.64
4	1296	410	1.55	20	180	0.64

TABLE 4.2: RESISTIVE LOADING

S.NO	VOLTAGE (v)	SPEED (RPM)	CURRENT(A)	WATTMETER READING (WATTS) W1	W2	V_{DC} (V)	I_{DC} (A)	PF
1	400	1500	1.55	240	-200	205	1.8	0.37
2	400	1516	2.05	680	0	205	4.0	0.48
3	400	1525	2.5	1000	200	204	5.20	0.69
4	400	1540	2.9	1480	440	198	8.4	0.79
5	400	1550	3.1	1840	640	198	12.2	0.79

TABLE 4.3 LOADING OF THE SEPARATELY EXCITED INDUCTION GENERATOR WITHOUT CAPACITANCE

S.NO	V (V)	I(A)	C(μF)	N(RPM)	WATTMETER READING (WATT) W1	W2	V_{DC} (V)	I_{DC}(A)	I_F(A)	PF
1	400	2.3	0	1500	840	40	168	6	0.4	0.54
2	405	3.0	0	1518	1180	260	140	8.5	0.32	0.68
3	405	2.76	4	1516	1080	360	140	9.7	0.32	0.76
4	405	2.65	8	1516	1060	400	140	11.2	0.32	0.77
5	405	3.1	12	1520	1320	340	140	12.3	0.30	0.78

TABLE 4.4 LOADING OF SEPARATELY EXCITED INDUCTION GENARATOR WITH CAPACITANCE

DOUBLE WINDING IG CHARACTERISTICS:

S.NO	VOLTAGE(V)	CURRENT(A)
1	45	1.0
2	85	1.7
3	125	1.94
4	165	2.14
5	200	2.35
6	330	2.91
7	400	3.1

TABLE 4.5: EXCITATION WINDING MAGNETIZING CHARACTERISTICS

S.NO	VOLTAGE(V)	CURRENT(A)
1	45	0.8
2	85	1.5
3	125	1.65
4	165	1.92
5	200	2.16
6	330	2.38
7	400	3.1

TABLE 4.6: LOAD WINDING MAGNETIZING CHARACTERISTICS

S.NO	N(RPM)	V(V)	I_L(A)	C_{EXC}(UF)	C_{LOAD}(UF)	WATTMETER READING (WATT) W1	W2	V_{DC} (V)	I_F(A)	PF
1	1530	400	2.16	0	4	800	200	172	0.32	0.67
2	1540	400	2.39	4	4	720	320	169	0.31	0.78
3	1545	400	2.80	8	8	880	360	170	0.29	0.79
4	1550	400	3.12	14	8	1160	440	175	0.26	0.81
5	1560	400	2.9	20	12	1080	400	173	0.25	0.81

TABLE 4.7 : LOADING OF SEPARATELY EXCITED INDUCTION GENARATOR WITHOUT CAPACITANCE

4.4. PERFORMANCE ANALYSIS:

SPEED AND VOLTAGE STABILITY:

The controllability of voltage is much smoother in a double winding IG than the conventional one. By adjusting the DC field of the prime mover and the capacitance simultaneously constant speed, constant voltage operation is obtained. Constant frequency operation is also possible by reducing the capacitance so that the machine operates at lesser slip. Two graphs are plotted based on the readings obtained in table 4.2 and 4.7.

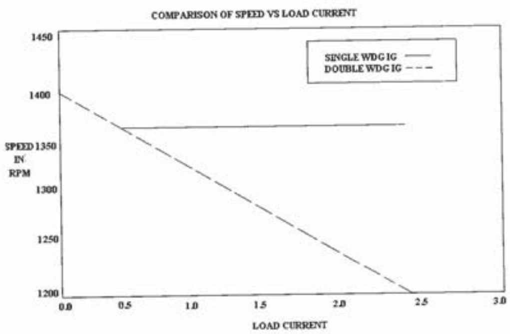


FIG 4.7. COMPARISOM OF SPEED VS LOAD CURRENT

POWER FACTOR:

In separately excited operation since the excitation is now supplied to different winding there is a slight improvement in the power factor. The tables illustrate this effect.

MAGNETIZING CHARACTERISTICS:

Since the original motor was designed for a higher flux with a starting current of almost 3.0 A the core withstands higher flux density. Hence the saturation effect, which the authors claim could not be established prominently. Nevertheless the characteristics of the conventional and double winding induction machines are provided below:

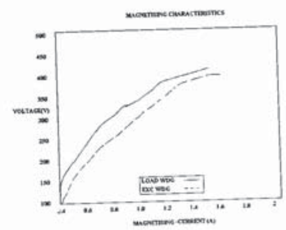


Fig. 4.8. Double Winding I M/C

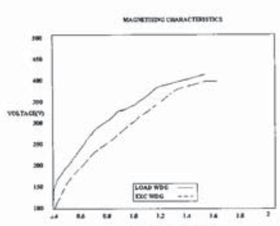


Fig.4.9. Conventional I M/C

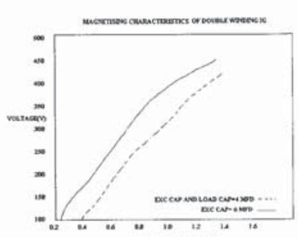


Fig 4.10. Magnetizing Characteristics of the Double Winding IG at Various Capacitance

CHAPTER 5

CONCLUSION

CONCLUSION:

The project has confirmed that a normally designed induction motor can be successfully used as a three-phase self-excited generator for low power applications. For each of the four machines considered in this investigation, it has been shown that the maximum available power, as a generator, is in the range of 118 percent to 160 percent of the respective motor rating.

In order to maintain the constancy of the generator terminal voltage, it has been shown that the value of the capacitance varies over a wide range. For the machines considered, the desired range of capacitance kVAR variation has been found to be 85 to 185% of the machine rating. The criterion of the limiting the stator current in the determination of the maximum generated power, has been found to be appropriate. Test results confirm the validity of the analytical method employed.

Thus the normal induction motors can be employed as self-excited generators, with constant speed prime movers,

1. To implement in wind engineering
2. To provide max power factor with low cost
3. To reduce the increasing prices
4. To implement in portable gen-set with low power and Non-conventional energy plants.

SUGGESTION FOR FUTURE IMPROVEMENT :

1. To implement in wind engineering
2. To provide max power factor with low cost
3. To reduce the increasing prices
4. To implement in portable gen-set with low power and Non-conventional energy plants.
5. Control switch can be used to change the connection depending on the wind speed.
6. By altering the magnetic circuit of the machine the coefficient of coupling can be improved to unity.
7. With efficient cooling and improved design of the frames the two winding machine can approach the conventional machine in rating Vs volume.
8. Design of winding without phase and space shift can be attempted.
9. Applying voltages of different values and nature (AC – DC or AC with different frequencies) at the windings speed and power factor variations (in terms of supply frequency) can be studied.

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APPENDIX