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Excitation System Of Alternator

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ABSTRACT

The brush gear and slip-ring have become such a vital part that requires high maintenance and are source of failures, thus forming weak links in the system.ith the advent of mechanically robust silicon diode capable of converting AC to DC at a high power level. This paper presents brushless excitation system which overcomes these faults and has become popular and being employed.. The field excitation is provided by a standard brushless excitation system which consist of rotating armature diode, diode bridge and stationary field. The proposed system captures important characteristics of alternator that include excitation of alternator as well as voltage control method.

I. INTRODUCTION

The commercial birth of the alternator can be dated back to august 24 1891 at Germany, so the natural choice for the field system was To achieve high availability of synchronous generators for electric energy production, attention has to be paid to the increase of availability of all generator subsystems and among them of the synchronous generator excitation system during a very long-term service. Requirements on availability of excitation system, beside its technical functions, have been always highland improvements are still being implemented.a dc exciter.

A dc current, creating a magnetic field that must be rotated at synchronous speed, energizes the rotating field-winding. The rotating field winding can be energized through a set of slip rings and brushes (external excitation), or from a diode-bridge mounted on the rotor (self-excited). The rectifier-bridge is fed from a shaft-mounted alternator, which is itself excited by the pilot exciter. In externally fed fields, the source can be a shaft-driven dc generator, a separately excited dc generator, or a solid-state rectifier. Several variations to these arrangements exist. In an alternator, when the rotor rotates the stator conductors (being stationary) are cut by the magnetic flux, hence they have induced e.m.f produced in them. To produce magnetic flux the rotor of synchronous machine needs a dc field current. This field current is supplied and controlled by excitation system. he amount of excitation required to maintain the output voltage constant is a function of the generator load.

As the generator load increases, the amount of excitation increases.

II. BASIC KINDS OF EXCITERS

A. Static exciters (shunt and series)

In static excitation system, the excitation power is derived from the generator output through an excitation transformer.

In 210 MW set, the primary voltage of excitation transformer is 15—75 Kv.lt steps down to 575V (SCR) bridge or thyristor bridge.

B. Rotating Exciters (Brush and brushless)

In the system DC power source is of rotating type, which in normally coupled to the main generator rotor.

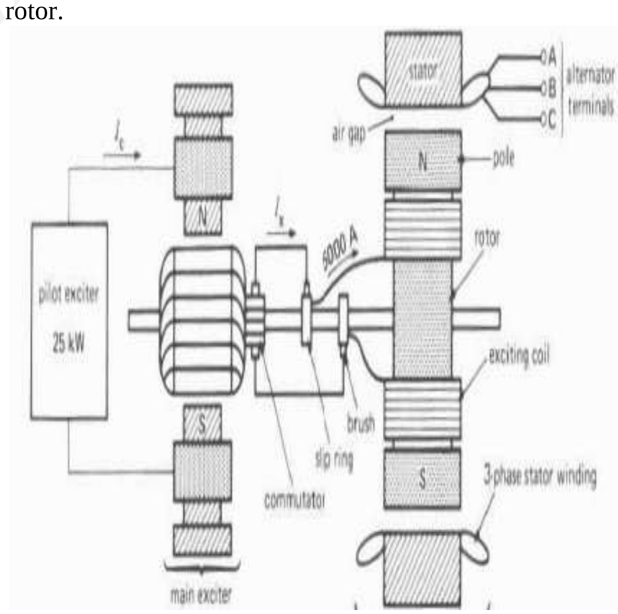

Figure 1.Brush exciter with slip ring

Rotating With Brush

i) For A Small Machine

The function of the brush is to collect current from Commutator. It is usually made of carbon or graphite and are in the shape of rectangular block. It requires

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collector ring, brushes or commutator. DC supplied to the rotor field by a dc generator called exciter. This exciter may be supplied current by smaller dc generator called pilot exciter. DC o/p of main exciter is given to the field winding of sync. machines through brushes and slip rings. But this arrangement is not very sensitive or quick acting when change of field current is required by sync. machines.

ii) For Medium Size Motor

AC exciter is used in place of DC exciter. AC exciter is 3 phase ac generator. O/P is rectified and supplied through brushes and slip rings to the rotor wdg. Of main sync.m/c.

III. BRUSHLESS EXCITATION SYSTEM

The excitation requires very large problem of conveying such amount of power through high speed sliding contacts becomes formidable and at present large sync. Generator and motor are using brushless excitation system. Brushless exciter is small direct coupled ac generator with its field circuit on stator and from circuit on motor the 3 phase o/p of ac exciter generator is rectified by solid state rectifier. The rectified o/p is directly connected to the field winding, thus eliminating the use of brushes and slip ring.The DC exciter suffered commutation and brush gear problem but also offered certain advantages. Increased demand for higher excitation currents parallel by advances in semiconductor technology brought about the introduction of the rectified ac exciter. These where either static semiconductor diode rectifiers supplying the generator field winding via slip ring, or brushless system which carry the diode rectifier on shaft .

To maximize the plant availability under black start condition, reliance on external electrical supplies is kept minimum by using direct driven permanent magnet pilot exciters. the development of solid state silicon diode with its inherent robustness and reliability , made possible the design of compact rectifier system that can be rotated at rated generator speed .

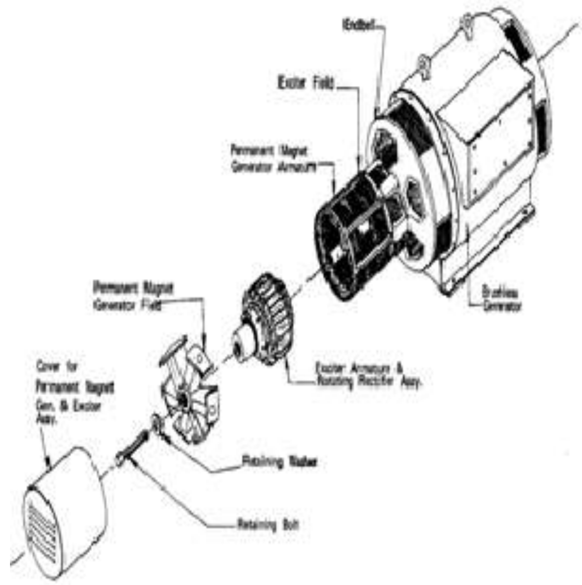

Figure 2.Brushless exciter with permanent magnet generator (Pilot Exciter)

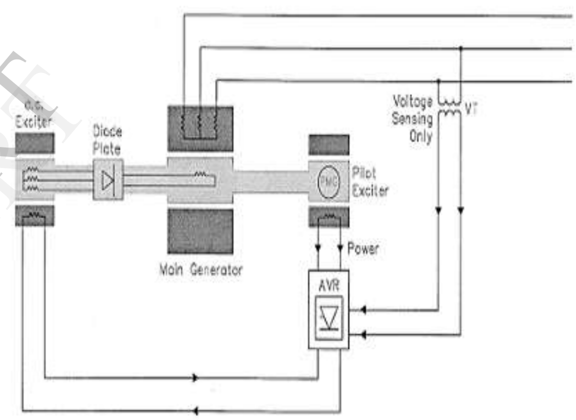

Figure 3.Block diagram of brushless excitation system

IV. PHASOR DIAGRAM OF ALTERNATOR AND EFFECT OF EXCITATION

If the rotor's excitation is slightly increased, and no torque is applied to the shaft; the rotor provides some of the excitation required to produce (E1), causing an equivalent reduction of (Φ_s). This situation represents the under excited condition shown in condition *no load* (a) in Figure 1.24. When operating under this condition, the machine is saidto behave as a *lagging condenser*, meanings it absorbs reactive power from the network.

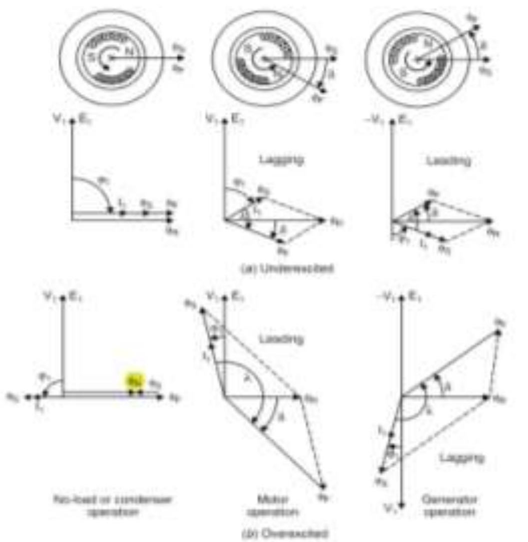

Figure 4.Phaser diagram of alternator

If the field excitation is increased over the value required to produce (E1), the stator currents generate a flux that counteracts the field-generated flux. Under Basic operation of the synchronous machine .This condition, the machine is said to be overexcited, shown as condition *no load* (b) in Figure 1.24. The machine is behaving as a leading condenser; that is, it is delivering reactive power to the network

Reactive lagging p.f. loads require more excitation than unity pf loads

Leading p.f. loads require less excitation than unity pf loads

V. PRINCIPALS OF AUTOMATIC VOLTAGE CONTROL

Voltage transformers provide signals proportional to line voltage to the AVR where it is compared to a stable reference voltage. The difference (error) signal is used to control the output of the exciter field. For example, if load on the generator increases, the reduction in output voltage produces an error signal which increases the exciter field current resulting in a corresponding increase in rotor current and thus generator output voltage. Due to the high inductance of the generator field windings, it is difficult to make rapid changes in field current. This introduces a considerable "lag" in the control system which makes it necessary to include a stabilizing control to prevent instability and optimize the generator voltage response to load changes. Without stabilizing control, the regulator would keep increasing and reducing excitation and the line voltage would continually fluctuate above and below the required value. Modern voltage regulators are designed to maintain the generator line voltage within better than +/- 1% of nominal for wide variations of machine load.

Exciter Design features:

The exciter consist of

- Rectifier wheels
- Three phase main exciter
- three phase pilot exciter
- cooler
- metering and supervisory equipment

VI. BASIC ARRANGEMENT OF BRUSHLESS EXCITATION SYSTEM

The three phase pilot exciter has a revolving field with permanent magnet poles. The three phase ac generated by the permanent magnet pilot exciters is rectified and control by the TVR to provide the variable dc current for exciting the main exciters. The three phase ac induced in the rotor of the main exciters is rectified by the rotating rectifier bridge and fed to field winding of the generator rotor through the dc leads in the rotor shaft.

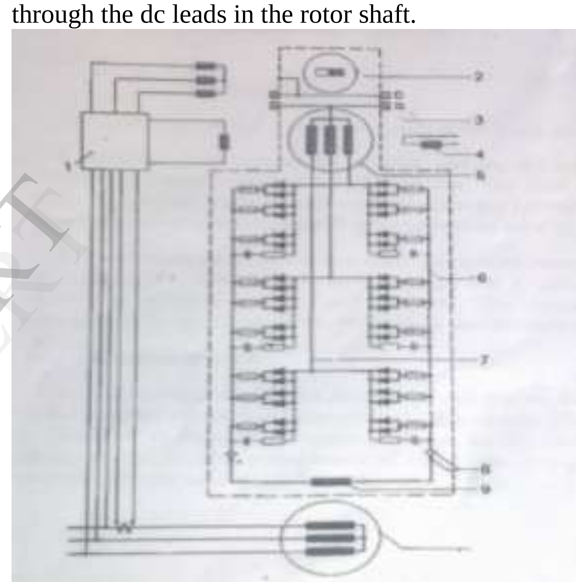

Figure 5.Basic arrangement of brushless excitation system

Key:

1. Automatic voltage regulator
2. Permanent magnet pilot exciter
3. Slip ring for field ground fault detection
4. Qudrature axis measuring coil
5. Three phase main exciter
6. Diode rectifier set
7. Three phase lead
8. Multi-contact connector
9. Rotor winding of turbo generator
10. Stator winding of turbo generator

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Figure 6.Brushless exciter

The exciters shown in figure correspond to the basic arrangement given below. Common haft caries the rectifier wheels, the rotor of the main exciters and the permanent magnet rotor of the pilot exciters. The shaft is rigidly coupled to the generator rotor. The exciters shaft is supported on the bearing between the main and pilot exciters. The generator and exciters rotors are thus supported on three bearings.
Mechanical coupling of the two shaft assemblies' results in simultaneous coupling of the dc leads in the central shaft bore through the multi-contact electrical contact system consist of plug in bolt and sockets. This contact system is also design to compensate for length variations of the leads due to thermal expansions.

VII. RECTIFIER WHEELS

The main components of the rectifier wheels are the silicon diodes which are arranged in the rectifier wheels in a three phase bride circuit. The internal arrangement of the diodes is illustrate in the fig. the contact pressure for the silicon wafer is produced by the plate spring assembly. The arrangement of the diodes is such that this contact pressure is increased by the centrifugal force during rotation.
Figure shows the additional components contains in the rectifier wheels. Two diodes each are mounted in each aluminium alloy heat sink and thus connected in parallel. Associated in heat sink is a fuse, which serves to switch off the two diodes if one diodes fails (loss of reverse blocking capacity).
For suppression of momentary voltage peak arising from commutation, each wheel is provided with six RC networks consisting of one capacitor and the one damping resistor each, which are combining in a single resin-encapsulated unit.The insulated and shrunken rectifier wheels serves as a dc buses for negative and positive sides of the rectifier bridge.

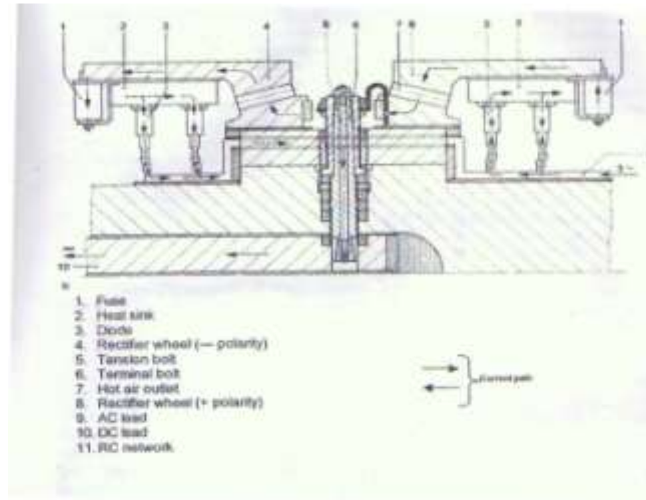

Figure 7.Additional component in the rectifier wheels

The two wheels are identical in their mechanical design and differ only in forward directions of the diodes.The direct current from the rectifier wheels is fed to the DC leads arranged in the centre bore of the shaft via radial bolts. The three phase alternating current is obtained via copper conductor arranged on the shaft circumference between the rectifier wheels sand the three phase main exciter. The conductor are attached by means of banding clips and equipped with screw on lugs for the internal diodes connections. One three phase conductor each is provided for the four diodes of the heat sink set.

VIII. THREE PHASE MAIN EXCITER

The three phase main exciter is a six pole revolving armature unit. Arranged in the stator frame are the poles with the field and damper winding. The field winding is arranged on the laminated magnetic poles. At the poles shoe bars are provided, their ends being connected so as form a damper winding. Between two poles a Qudrature axis coil is fitted for inductive measurement of the exciter current.
The rotor consists of slack laminations, which are compressed by through bolts over compression rings. The three phase winding is inserted in the slots of the laminated rotor. The winding conductors are transposed within the core length, and the end turns of the rotor winding are secured with steel bands. The connections are made on the side facing the rectifier wheels. Winding ends are run to a bus ring system to which the three phase leads to the rectifier wheels are also connected. After full impregnation with synthetic resin and curing, the complete rotor is shrunk on to the shaft. A journal bearing is arranged between main exciter and pilot exciter and has forced oil lubrication from the turbine oil supply.

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IX. THREE PHASE PILOT EXCITER

The three Phase pilot exciter is a 16 pole revolving-field unit. The frame accommodates the laminated core with the three phase winding. The rotor consists of a hub and the external poles shoe with bolts. The rotor hub is shrunk on to the free shaft end.

X. COOLING OF EXCITER

The exciter is air cooled. The cooling air is circulated in a close circuit and recooled in two cooler sections arranged alongside the exciter. The complete exciter is house in an enclosure through which the cooling air circulates. The rectifier wheels, house in their own enclosure, draw the cool air in at both ends and expel the warmed air to the compartment beneath the base plate. The main exciter enclosure receives cool air from the fan after it passes over the pilot exciter. The air enters the main exciter from both ends and is passed into ducts below the rotor body and and discharged through radial slots in the rotor core to the lower compartment. The warm air is then returned to the main enclosure via the cooler sections.

A. Hydrogen cooling

Hydrogen cooled synchronous condensers operating at speed up to 900 r.p.m. have been furnished with direct connected main exciter located in hydrogen filled compartment which can be isolated from the main condenser compartment when maintenance is to be done on the exciter. It has been found that hydrogen cooling of exciter not only reduces the temperature rise of exciter but also decreases the wear of the commutator and brushes. Hydrogen cooling has been proposed for the exciters of turbo-generator.

B. Emergency Cooling Of Exciter

Emergency cooling is provided to permit continued operation in the event of cooler failure. In such an emergency, flaps in the hot and cold air compartments are automatically operated by actuators admitting cold air from outside the exciter enclosure and discharging the hot air through openings in base frame.

XI. EXCITER DRYING

A dryer (dehumidifier) and an anti-condensation heating system are provided to avoid the formation of moisture condensate inside the exciter with the turbine-generator at rest or on turning gear.

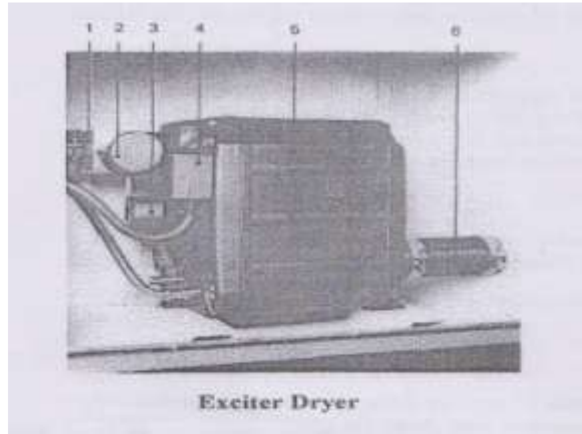

Figure 8.Exciter dryer

MODE OF OPERATION

The dryer dehumidifies the air within the exciter enclosure. The dryer wheel is made of a non-flammable material. On its inlet side, the wheel is provided with a system of tubular ducts, the surfaces of which are impregnated with a highly a highly hygroscopic material. The tubular ducts are dimensioned so that a laminar flow with low pressure loss is obtained even at high air velocity. The moisture absorbed by the dryer wheel is removed in a regeneration section by a stream of hot air directed through the wheel in the opposite direction of the inlet air and then discharged to the atmosphere. A shutoff valve in the dry air outlet line prevents that contaminated air from the powerhouse will be drawn during load operation of the exciter.

A. Adsorption Section

The air to be dehumidified passes through the adsorption section of the dryer wheel, with part of the moisture contained in the air being removed by the adsorbent material, is that lithium chloride. The moisture is removed as a result of the partial pressure drop existing between the air and the adsorbent material.

B. Regeneration Section

In the regeneration section of the dryer wheel, the accumulated moisture is removed from the dryer wheel by the heated regeneration air.

Continuous rotation of the dryer wheel ensures continuous dehumidification of the air within the exciter.

XII.STROBOSCOPE FOR FUSE MONITORING

The fuses on the rectifier wheels may be checked during operation with the stroboscope.

The stroboscope is located adjustment to the rectifier wheel in the exciter enclosure so that the fuses may be observed from outside the exciter enclosure while controlling the stroboscope. The observation period for one full revolution of the rectifier wheel (360˚) is approximately 25 sec. at approximately 450˚, the stroboscope resets to the initial position of the wheel and repeats the scan. The continuous can be interrupted at any time to hold a stationary image.

XIII. SUPERVISION OF EXCITER

The most essential measuring and supervisory devices at the exciter are:

- Temperature monitoring system
- Fuse monitoring system
- Ground fault detection system
- Excitation current measuring device

A .Temperature monitoring system

The exciter is provided with devices for monitoring the temperature of the cold air after the exciter cooler and the hot air leaving the rectifier wheels and main exciter.

B .Fuse monitoring system

The indicator flags of the fuses on the rectifier wheels may be checked during operation with the built in stroboscope.

C .Ground fault detection system

Two slip rings are installed on the shaft between the main exciter and the bearing. One is connected to the star point of the three phases winding of the main exciter and the other to the Frame. These slip rings permit ground fault detection. The field ground fault detection system detects high resistance and low resistance ground faults in the exciter field circuit. It is very important for safe operation of a generator, because a double fault causes magnetic unbalance with very high currents flowing through the faulted part, resulting in its destruction within a very short time.

If the field ground fault detection system detects a ground faults, an alarm is activated at Re < 80kΏ (1st stage).if the insulation resistance between the exciter field circuit and ground either suddenly or slowly drops to Re < 5kΩ the generator electrical protection is tripped (2nd stage).The generator is thus automatically disconnected from the system and de excited.

D .Excitation current measuring device

The excitation current is measured indirectly through a coil arranged between two poles of the main exciter. The voltage induced in this coil is proportional to the main excitation current thus enabling a determination of the excitation current.

XIV. CONCLUSION

Brushless excitation system is always preferred with slip ring excitation system because the losses are minimized in large extent. So the efficiency also increases by use of brushless excitation system. To maximized plant availability under '**Black Start**' condition, reliance on external electrical supplies is kept minimum by using direct driven This alternative to the conventional slip ring excitation system eliminates the need for brush gear maintenance and reduces the overall unit size.Large power transformation can be achieved in modern power plant almost all brushless excitation system is preferred.

REFFERENCES

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