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ABSTRACT

This learning module, one in a series of 20 related training modules for apprentice stationary engineers, deals with generators. Addressed in the individual instructional packages included in the module are the following topics: different types of generators, generator construction, and procedures for operating a generator. Each instructional package in the module contains some or all of the following: a lesson goal, performance indicators, a study guide, a vocabulary list, an introduction, instructional text, an assignment, a job sheet, a self-assessment activity, a post-assessment instrument, answers to the post-assessment instrument, and a list of recommended supplementary references. (MN)

APPRENTICESHIP

STATIONARY ENGINEERS

RELATED TRAINING MODULES

18.1 - 18.2 GENERATORS

STATEMENT OF ASSURANCE

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APPRENTICESHIP

STATIONARY ENGINEERS
RELATED TRAINING MODULES

COMPUTERS

1.1 Digital Language
1.2 Digital Logic
1.3 Computer Overview
1.4 Computer Software

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2.1 General Safety
2.2 Hand Tool Safety
2.3 Power Tool Safety
2.4 Fire Safety
2.5 Hygiene Safety
2.6 Safety and Electricity

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3.2 Blueprint Reading/Working Drawings
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3.4 Machine and Welding Symbols

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5.15 Switches and Relays
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8.7 Hydraulics - Reservoirs
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8.10 Hydraulics - Forces, Area, Pressure
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BOILERS

PUMPS

STEAM

TURBINES

STATIONARY ENGINEER
SUPPLEMENTARY REFERENCE DIRECTORY

Note: All reference packets are numbered on the upper right-hand corner of the respective cover page.

Supplementary Packet #	Description	Related Training Module
12.1	Correspondence Course, Lecture 1, Sec. 2, Steam Generators, Types of Boilers I, S.A.I.T., Calgary, Alberta, Canada	12.1 Boilers, Fire Tube Type
12.2	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Types of Boilers II, S.A.I.T., Calgary, Alberta, Canada	12.2 Boilers, Water Tube Type
12.3	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Boiler Construction & Erection, S.A.I.T., Calgary, Alberta, Canada	12.3 Boilers, Construction
12.4	Correspondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fittings II, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.4	Corresondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fitting I, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.5	Correspondence Course, Lecture 10, Sec. 2, Steam Generation, Boiler Operation, Maintenance, Inspection, S.A.I.T., Calgary, Alberta, Canada	12.5 Boilers, Operation
12.7	Correspondence Course, Lecture 3, Sec. 2, Steam Generation, Boiler Details, S.A.I.T., Calgary, Alberta, Canada	12.7 Boilers Heat Recovery Systems
12.8	Refer to reference packet 14.3/12.8	
		PUMPS
13.1	Correspondence Course, Lecture 9, Sec. 2, Steam Generator, Power Plant Pumps, S.A.I.T., Calgary, Alberta, Canada	13.1 Types & Classification
13.2		13.2 Applications
13.4		13.4 Calculating Heat & Flow
13.6		13.6 Monitoring & Troubleshooting
13.7		13.7 Maintenance
13.3	Correspondence Course, Lecture 6, Sec. 3, Steam Generators, Pumps, S.A.I.T., Calgary, Alberta, Canada	13.3 Construction
13.5		13.5 Operation

Supplementary Packet #	Description	Related Training Module
14.3 12.8	Correspondence Course, Lecture 6, Section 3, Steam Generators, Steam Generator Controls, S.A.I.T., Calgary, Alberta, Canada	14.3 Steam, Transport 12.8 Boilers, Instruments & Controls
14.4	Correspondence Course, Lecture 11, Section 2, Steam Generators, Piping II, S.A.I.T., Calgary, Alberta, Canada	14.4 Steam, Purification
15.1	Correspondence Course, Lecture 1, Sec. 4, Prime Movers & Auxiliaries, Steam Turbines, S.A.I.T., Calgary, Alberta, Canada	15.1 Steam Turbines, Types
15.2	Correspondence Course, Lecture 4, Sec. 3, Prime Movers, Steam Turbines I, S.A.I.T., Calgary, Alberta, Canada	15.2 Steam Turbines, Components
15.3	Correspondence Course, Lecture 2, Sec. 4, Prime Movers & Auxiliaries, Steam Turbine Auxiliaries, S.A.I.T., Calgary, Alberta, Canada	15.3 Steam Turbines, Auxiliaries
15.4	Correspondence Course, Lecture 6, Sec. 3, Prime Movers, Steam Turbine Operation & Maintenance, S.A.I.T., Calgary, Alberta, Canada	15.4 Steam Turbines, Operation & Maintenance
15.5	Correspondence Course, Lecture 8, Sec. 3, Prime Movers, Gas Turbines, S.A.I.T., Calgary, Alberta, Canada	15.5 Gas Turbines
16.2	Boilers Fired with Wood and Bark Residues, D.D. Junge, F.P.L., O.S.U. 1975	16.2 Combustion Types of Fuel
16.2	Correspondence Course, Lecture 5, Sec. 2, Steam Generators, Fuel Combustion, S.A.I.T., Calgary, Alberta, Canada	16.2 Combustion Types of Fuel
16.3	Correspondence Course, Lecture 5, Sec. 2, Plant Services, Fuel & Combustion, S.A.I.T., Calgary, Alberta, Canada	16.3 Combustion, Air & Fuel Gases
17.1	Correspondence Course, Lecture 12, Sec. 3, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.1 Feed Water, Types & Operation
17.2	Correspondence Course, Lecture 12, Sec. 2, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.2 Feed Water, Water Treatments

Supplementary Packet #	Description	Related Training Module
17.3	Correspondence Course, Lecture 7, Sec. 2, Steam Generators, Boiler Feed Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.3 Feed Water, Testing
18.1	Correspondence Course, Lecture 2, Sec. 5, Electricity, Direct Current Machines, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction
18.1 18.2	Correspondence Course, Lecture 4, Sec. 5, Electricity, Alternating Current Generators, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction 18.2 Generators, Operation
19.1	Corrspondence Course, Lecture 5, Sec. 4, Prime Movers & Auxiliaries, Air Compressor I, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types
19.1 19.2	Correspondence Course, Lecture 6, Sec. 4, Prime Movers & Auxiliaries, Air Compressors II, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types 19.2 Air Compressors, Operation & Maintenance
20.1	Basic Electronics, Power Transformers, EL-BE-51	20.1 Transformers
21.1	Correspondence Course, Lecture 7, Sec. 5, Electricity, Switchgear & Circuit, Protective Equipment, S.A.I.T., Calgary, Alberta, Canada	21.1 Circuit Protection
22.1	Correspondence Course, Lecture 10, Sec. 3, Prime Movers, Power Plant Erection & Installation, S.A.I.T., Calgary, Alberta, Canada	22.1 Installation Foundations

RECOMMENDATIONS FOR USING TRAINING MODULES

The following pages list modules and their corresponding numbers for this particular apprenticeship trade. As related training classroom hours vary for different reasons throughout the state, we recommend that the individual apprenticeship committees divide the total packets to fit their individual class schedules.

There are over 130 modules available. Apprentices can complete the whole set by the end of their indentured apprenticeships. Some apprentices may already have knowledge and skills that are covered in particular modules. In those cases, perhaps credit could be granted for those subjects, allowing apprentcies to advance to the remaining modules.

We suggest the the apprenticeship instructors assign the modules in numerical order to make this learning tool most effective.

SUPPLEMENTARY INFORMATION

ON CASSETTE TAPES

Tape 1: Fire Tube Boilers - Water Tube Boilers and Boiler Manholes and Safety Precautions

Tape 2: Boiler Fittings, Valves, Injectors, Pumps and Steam Traps

Tape 3: Combustion, Boiler Care and Heat Transfer and Feed Water Types

Tape 4: Boiler Safety and Steam Turbines

NOTE: The above cassette tapes are intended as additional reference material for the respective modules, as indicated, and not designated as a required assignment.

INSTRUCTIONAL LEARNING SYSTEMS

18.1

GENERATORS -- TYPES AND CONSTRUCTION

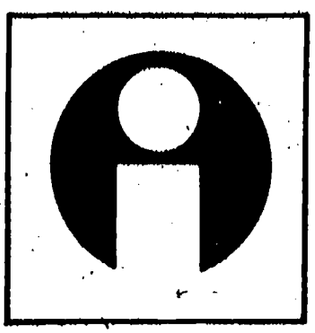
Goal:

The apprentice will be able to describe types of generators and their construction.

Performance Indicators:

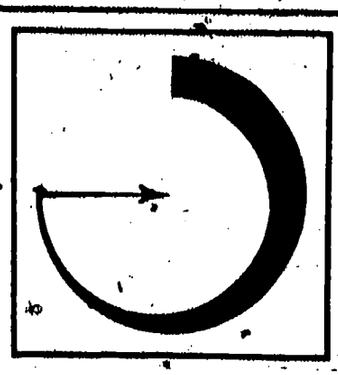
1. Describe AC generators.
2. Describe DC generators.
3. Describe field exciters.
4. Describe construction of generators.

Study Guide



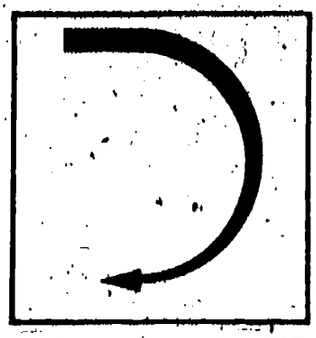
* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Air cooling
* Air gap
* Alternator
* Armature core
* Brushes
* Commutator
* Compound generator (DC)
* Core
* Cylindrical type
* Direct acting rheostatic regulator
* End caps
* Field coils
* Field poles
* Flat compounded
* Frame or yoke
* Hydrogen cooling
* Indirect acting rheostatic regulator
* Interpoles
* Liquid cooling
* Magnetic amplifier
* Motor exciter
* Over-compounded
* Pole cores
* Rotor
* Salient field pole type
* Self-excited
* Separately excited
* Series
* Shaft exciter
* Shunt
* Static regulator
* Stator
* Stator frame
* Synchronous speed
* Three-phase
* Under-compounded
* Ventilation slots
* Windings

Introduction



Generators transform mechanical energy into electrical energy. They are basic components of power generation plants. Most generators in industry are of the alternating current type. AC generators are commonly known as alternators. Steam and gas turbines are used to power most large alternators. Some small alternators are engine driven.

A direct current generator is actually an AC generator that has been equipped with a commutator. The commutator is a rectifier. DC generators are not widely used except as field exciters for large AC generators.

Turbine generators are composed of a magnetic field that rotates (rotor) inside a stationary conductor component (stator). This package will describe the types and construction of generators used in power production.

Information

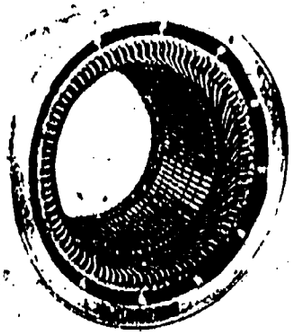
AC Generators

AC generators must be driven at a constant speed. This is to assure the frequency of supply of electricity entering a circuit load. If more than one generator is hooked in parallel, each must be operated at the same speed. That speed is called synchronous speed. The alternator is composed of two components--the stator and the rotor.

Stator Design

The stator is the stationary portion of the alternator. It has three parts:

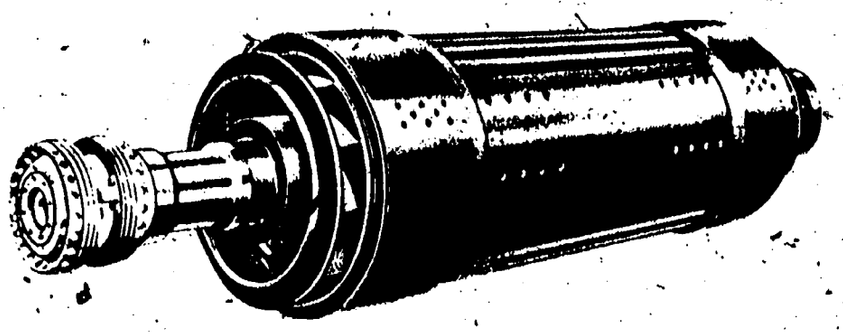
* Core -- built of segmented steel sheets that are slotted so that they can be keyed to the stator frame.
* Windings -- formed from copper conductor materials and wound to fit in the slots of the core. The windings are insulated by a bonding material such as micanite.
* Stator frame -- supports the core and windings and serves to enclose coolants.



Rotor Design

The rotor is a steel forged shaft that is slotted to receive the rotor windings. Rotor windings are strips of copper that have been insulated with micanite. The windings are held into the rotor body with steel wedges. This protects the windings against the centrifugal force of the turning rotor. Once the steel wedges are driven into place, end caps are used to lock the wedges into position. The rotor shaft is made with ultrasonic test grooves to allow examination of forging soundness. Also, the shaft has machined ventilation slots to assist in the cooling of the rotor.

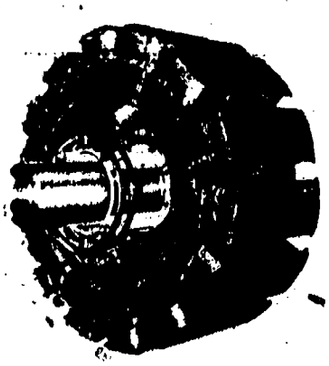
Information



ROTOR COMPLETE WITH WINDING, END BELLS, FANS AND COUPLINGS.

Types of AC Generators

Alternating current generators are of two types. The salient field pole generator is used on water turbines and diesel engine driven plants. It is a slow speed generator. A cylindrical type rotor is used on steam and gas turbine driven alternators. Salient-pole rotors have projecting field poles. The laminated pole pieces with their field coils are mounted on the rim of the steel spider and keyed to the shaft.

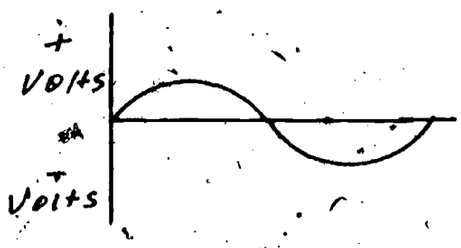


The cylindrical type rotor was shown in rotor design. It is a high speed rotor that can withstand the vibrations much better than the salient-pole type. For that reason, it will be the generator most often found in a power plant.

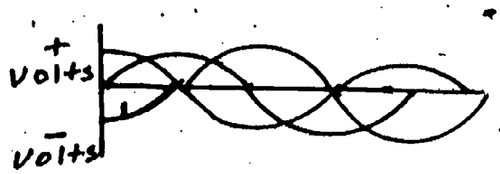
Information

Phase

Both single phase and three-phase alternators are manufactured. The three-phase is the most common type in steam generation plants. The windings are set in three groups. These groups are set apart by 120°. This causes three different, overlapping voltages which tends to even out the power. A single phase electrical wave will produce both positive and negative voltage with each pulsation.



A three phase smooths out the momentary drop by overlapping the electrical waves. This produces a more consistent power.



Cooling Design

Alternators are cooled by air, liquid or hydrogen. In an air cooled system, air is recirculated through the windings by use of an air cooler. This enclosed air system uses water as a cooling medium for the air cooler. Hydrogen cooling is also a closed circuit system. Hydrogen has many advantages over air as a cooling medium and transfers heat much more rapidly than air. Hydrogen is more explosive and must be encased in an explosion proof casing. When the stator is opened for repair, the hydrogen should be purged with CO_2 to avoid explosive mixtures of air and hydrogen. Liquid cooling of alternators is a recent design feature. Water is moved through hollow conductors in the stator. The conductors are made of copper. Water is carried to the conductors through stainless steel manifolds and plastic insulating hose.

Information

DC Generators

A direct current generator is very much like an AC generator. The big difference is the commutator. A commutator is a rectifier which changes alternating current into a one directional flow. Both AC and DC generators produce alternating current. The commutator changes alternating current to direct current.

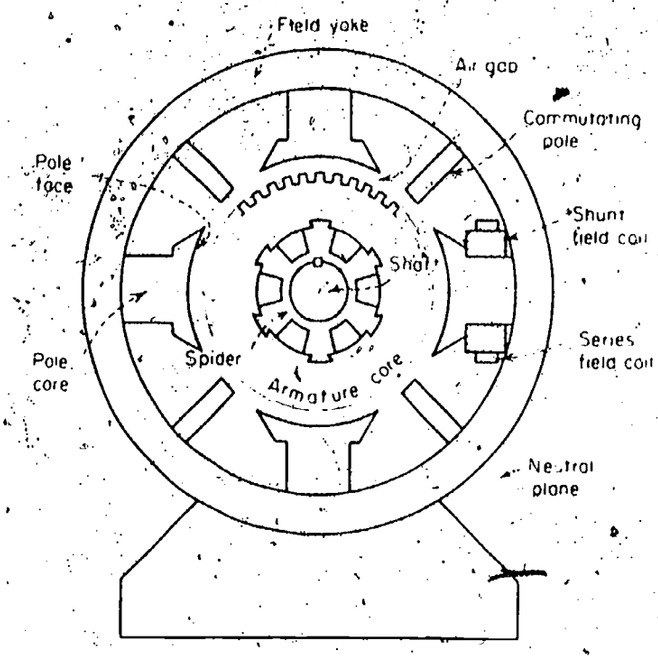
DC Design

A DC generator consists of:

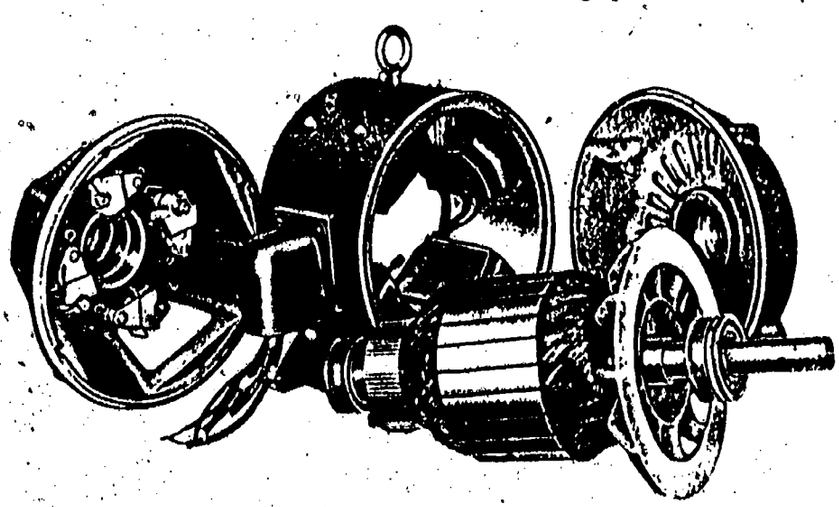
* A frame or yoke that supports the field poles and is also part of the magnetic circuit.
* Field poles that are bolted to the yoke. These field poles or pole cores are made of sheet steel laminations that are insulated from each other and riveted together.
* Armature core consists of sheet steel laminations that are keyed to a shaft. The outer surface of the core is slotted to handle armature coils.
* Air gap is the space between the armature surface and the pole face. Usually 1/16" to 1/4" in length.
* Commutator -- is secured to but insulated from the shaft. It consists of a number of copper segments that are assembled into a cylinder with each segment insulated from the others with mica. The armature coil ends are soldered to the commutator.
* Brushes — provide the electrical connection between the armature and the outside circuit. These sliding electrical connections are made of carbon and held in place by spring tension.
* Field coils are placed around the pole cores and connected in series to form a field circuit. The field coils may be connected as shunt field coils or series field coils.
* Interpoles or commutator poles are small poles placed halfway between the main poles. The interpoles are designed to improve commutation by establishing a magnetic flux when current flows through the armature circuit.

Information

The following diagram shows the parts of a DC generator.



A dismantled generator with parts is shown in the following picture.

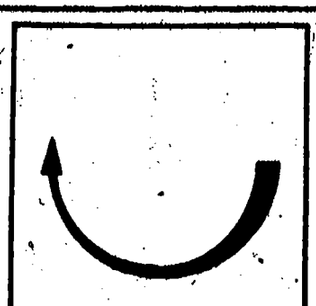


Types of DC Generators

Direct current generators may be classified into three major types.

1. Series
2. Shunt
3. Compound

Information



Generators may be classified by the way they receive their current.

* Self-excited generators receive current directly from the generator terminals.

* Separately excited generators use a separate source of current to feed the shunt winding.

A series type generator uses heavy copper windings about the field coils that are connected in series with the armature. Increases in armature current shows an increase in the voltage of the electrical current generated.

The shunt type generator shows a decrease in voltage as the load is increased. This is opposite to that of the series type generator.

In compounding a generator, both series and shunt principles are used to obtain a constant voltage under load. If the terminal voltage remains constant under all load conditions, it is called a flat-compounded generator. If more than the needed turns are made in the series field, it is called over-compounded. Less than the needed turns results in under-compounded generators.

Field Excitation

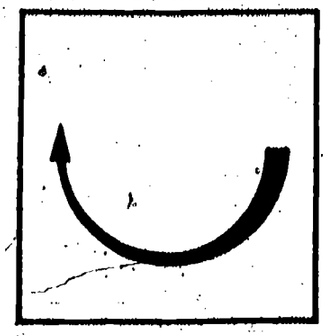
A field excitation system is all of the equipment needed to control, supply and regulate the field current. This section will deal with field excitation for alternating current generators. Field excitation is usually provided by direct current from a DC generator.

Exciters

Exciters are self-excited or separately excited through a shunt field winding. The exciters may be connected directly to the shaft (shaft exciter) or separately driven (motor exciter). An exciter may be connected with the shaft by mounting it directly on the shaft extension (direct connected type), through a direct connection to the shaft with a flexible coupling; or through a gear connection to the turbine generator. All of the above are shaft exciters.

Motor driven exciters often use large flywheels to take advantage of low commutator speeds. These units are made in large sizes.

Information



Field Circuit Breakers

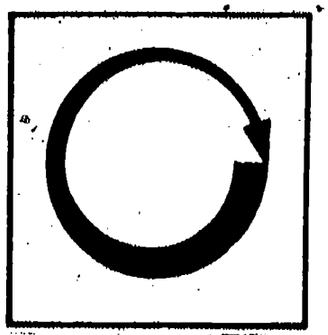
When dealing with large field currents, there is a hazard when the magnetic field collapses and high voltage surges into the field windings. To avoid damage from such voltage surges, an additional set of contacts are placed into the field circuit. The contacts use a resistor to absorb the voltage and prevent it from damaging the windings.

Voltage Regulators

Voltage regulators automatically raise or lower the excitation level of generators. When the regulator detects a change in voltage, it responds by changing the field excitation. This permits the generator to deliver output of a constant voltage. Voltage regulators are classified as:

* Direct acting rheostatic regulators that respond directly to the generator.
* Indirect acting rheostatic regulators uses an auxiliary apparatus to control a rheostat in the generator.
* Static regulators that use a magnetic amplifier and an amplidyne to regulate the voltage.

Assignment



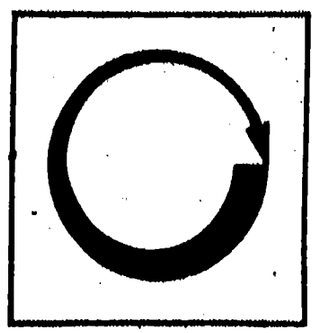
* Read pages 1 - 10 in "Direct Current Machines" of supplementary reference.
  Read pages 1 - 22 in "Alternating Current Generators" of supplementary reference.

* Complete job sheet.

* Complete self-assessment and check answers.

* Complete post-assessment and have instructor check your answers.

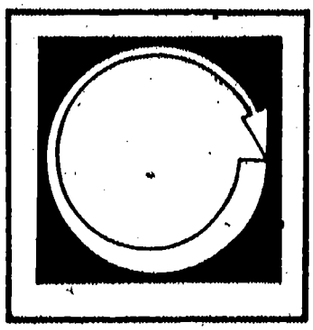
Job Sheet



COMPLETE VISUAL INSPECTION OF AN AC GENERATOR.

* Locate an AC generator. (Preferably one that is opened up for repair purposes.)
* Identify the parts of the stator, their design and construction features.
* Identify the parts of the rotor, their design and construction features.
* Identify the field exciter and how the voltage is regulated.

Self Assessment



Match the following terms and phrases.

_____	1. Rotor	A.	Used in generator cooling system.
_____	2. Commutator	B.	Shows increase in voltage as armature current increases.
_____	3. Static type	C.	Built of segmented steel sheets that are slotted.
_____	4. Windings	D.	The part of a generator that is stationary.
_____	5. Hydrogen	E.	Type of AC generator.
_____	6. Core	F.	Fit into slots in the stator core.
_____	7. Salient field pole	G.	A type of rectifier that changes alternating current to a one-direction flow.
_____	8. Stator	H.	Voltage regulator that uses a magnetic amplifier.
_____	9. Shunt type generator	I.	The part of a generator that rotates.
_____	10. Series type generator	J.	Shows decrease in voltage as load is increased.

Self Assessment Answers

I 1.

G 2.

H 3.

F 4.

A 5.

C 6.

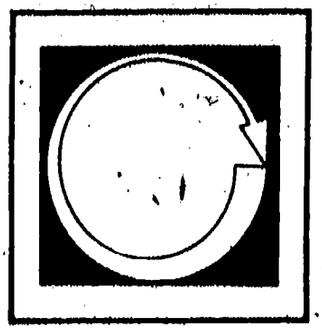
E 7.

D 8.

J 9.

B 10.

Post Assessment



1. When two generators are hooked together in parallel, they must be operated at the same speed. What is that speed called?

2. What are the two major components of a generator?

3. What is the purpose of ventilation slots in a rotor?

4. List two types of AC generators?

5. Which type of AC generator is most commonly used in steam driven power plants?

6. In a three-phase alternator, the windings are set apart by _____ degrees.

7. What is the advantage of three-phase electricity?

8. List three cooling methods for AC generators.

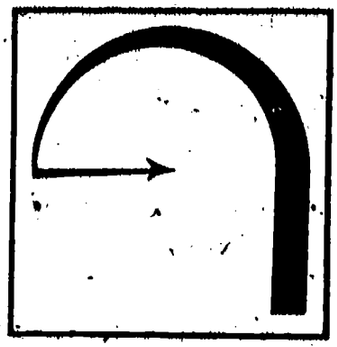
9. List three type of DC generators.

10. List two types of field exciters.

Instructor Post Assessment Answers

1. Synchronous speed
2. Rotor, stator
3. Cooling of the rotor
4. Salient field pole, cylindrical type
5. Cylindrical type
6. 120
7. Smooths out pulsations to give even power flow
8. Air, liquid, hydrogen
9. Series, shunt, compound
10. Self-excited, separately excited

Supplementary References



* Correspondence Course. Lectures 2 and 4, Section 5. Second Class. Southern Alberta Institute of Technology. Calgary, Alberta, Canada.

INSTRUCTIONAL LEARNING SYSTEMS

18.2

GENERATORS -- OPERATION

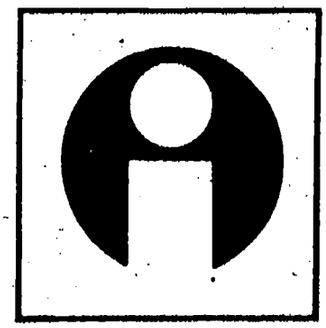
Goal:

The apprentice will be able to describe the operation of generators.

Performance Indicators:

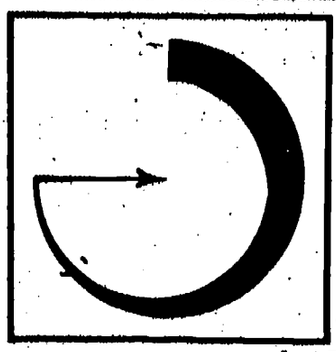
1. Describe control of power factor.
2. Describe synthronizing.
3. Describe paralleling.
4. Describe loading.
5. Describe cooling.
6. Describe safety.
7. Describe protection.
8. Describe maintenance.

Study Guide



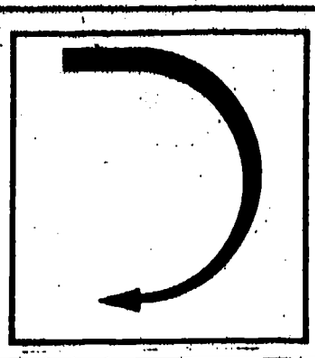
* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Cooling
* Enclosed air cooling
* Hydrogen cooling
* Liquid cooling
* Paralleling
* Power factor
* Synchronizing

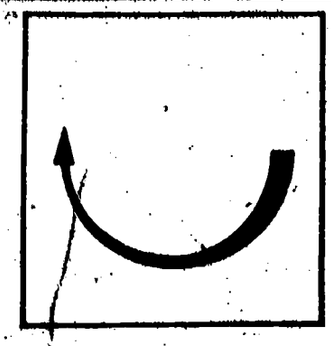
Introduction



The operation of generators is a major responsibility of a steam plant operator. The mechanical energy produced by steam must be converted into electrical energy. Although operators are not electricians, they must understand the operational processes of generators.

Operators must know how to synchronize generators that are operating in parallel. They must understand loading, cooling protection, maintenance and safety factors of electrical generators. This package introduces the apprentice to these concepts of operation. Further reading and practical experience will build upon this foundation knowledge.

Information



Controlling the Power Factor

When two or more alternators are hooked in parallel, the power factor must be controlled. This can be accomplished by trimming the resistance in the voltage regulator circuit. The excitation must be adjusted for each alternator in the parallel hookup.

Synchronizing

Operation of several alternators in parallel requires that the units be synchronized with each other. Synchronization requires that a generator being switched into a parallel system must have:

* a terminal voltage equal to that of the system
* a frequency close to that of the system
* the same phase rotation as that of the system
* the same phase relationship as the system

The voltage can be synchronized with the system by running the machine up to the voltage of the system and setting the field rheostat. Alternator frequency can be changed by adjusting the steam supply to the turbine. A phase rotation meter will show if the alternator is out of phase. Many of the modern alternators have automatic phasing equipment.

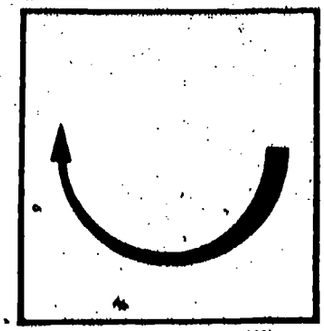
Paralleling

Paralleling is the practice of hooking several generators in parallel using common bus bars. This process is also called synchronizing as discussed in the previous paragraph. The alternators are connected as a parallel circuit which requires that each motor in the circuit be synchronized.

Loading

Alternator loading is controlled by the prime mover. When the prime mover power is increased, the alternator loading will increase. Control of the loading is handled by adjustments in the governor of the prime mover. Some machines have other types of mechanisms for controlling speeds. Whatever the method for controlling the prime mover speed, it is the only means for adjusting the load on an alternator.

Information



Cooling

Cooling of alternators is accomplished by three major methods.

* Enclosed air cooling
* Hydrogen cooling
* Liquid cooling

The enclosed air system utilizes air to cool water that flows through enclosed tubes. Air recirculates through the windings after it passes through an air cooler. The air is kept cool by circulating water that moves up and down the cooling tubes. The same air is used over and over.

Hydrogen cooling is also a closed system that circulates hydrogen instead of air. The hydrogen is a better coolant than air due to its ability to transfer heat. There is a risk of explosion when hydrogen is mixed with air. For that reason, the hydrogen system must be tightly sealed and gas tight. All hydrogen must be purged from the stator before opening up the system for repair. Purging can be accomplished with carbon dioxide. The use of clean water for cooling the hydrogen is very important. Distilled water is recommended.

Liquid cooled alternators circulate liquid coolants through hollow conductors. Water is the liquid used in this type of cooling system. High purity water is recommended because pure water has much less electrical conductivity than murky water.

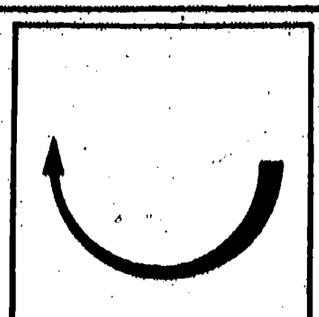
Safety

The hazard of hydrogen has been discussed. The operator should always purge out the hydrogen with carbon dioxide before opening up the generator to atmospheric air.

The hazards of electrical shock should be considered when working with generators. Some safety rules that should be closely observed are:

1. Observe the safe minimum distances for electricity. High voltage electricity will arc from 1 to 3 feet.
2. [redacted]ot carry metal objects that will tend to draw arcing while working ar[redacted]d the generators.
3. Treat all electrical conductors as though they are live wires.

Information



4. When working on equipment, trip the main breaker, lock it and tag it so that others will not turn on the juice accidentally.

5. Check all three phases of a three phase circuit before starting to work on it. One phase may give a misleading reading because of its grounding while the others remain hot.

6. Check the grounding on all equipment whether portable hand tools or major equipment.

Protection

Generators should be protected by circuit breaker equipment. Circuit breakers may be:

* Air break type that protect up to 575 volts.
* Oil immersed type for voltages beyond 575 volts.
* Air blast type -- for high voltages.

Generator protection must consider both external and internal faults. A circuit breaker is needed to protect the generator form problems in the transmission system. This allows the generator to revert to a house unit load until the problem is corrected. Another external fault occurs back of the generator. A unit trip relay is used to give protection from this type of fault.

Internal faults can occur in any of the following ways:

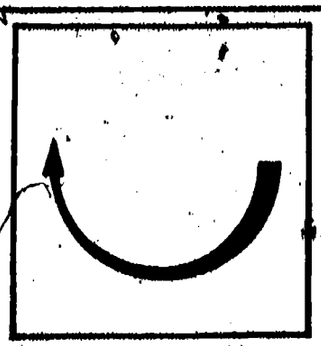
* Phase to ground
* Phase to phase
* Double phase to ground
* Three phase to ground

Protection against internal faults is afforded through a relay protection scheme and grounding through a distribution transformer. These relay schemes are somewhat complex and should be completed by a qualified electrician.

Maintenance

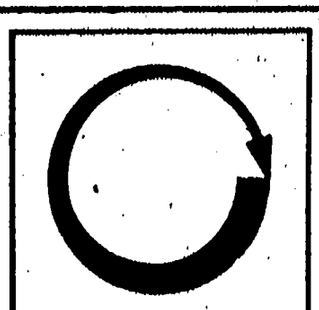
The operator is responsible for routine checks on the condition of generator equipment. Some things that should be checked regularly are:

Information



* Check for hydrogen leaks with an approved hydrogen tester.
* Check for liquid leakage by use of liquid detectors underneath the generator.
* Remove and check hydrogen coolers for water leaks.
* Inspect collector rings and brushes on field exciters for wear.
* Preheating of field windings is required on some generators.
* Follow plant procedures and/or manufacturers instructions for maintenance of generators.

Assignment



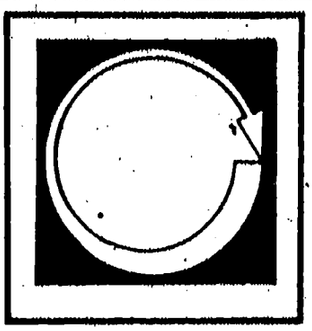
* Read pages 7 - 22 in supplementary reference.
* Complete job sheet.
* Complete self-assessment and check answers.
* Complete post-assessment and have instructor check answers.

Job Sheet

OBSERVE GENERATION OPERATION

* Observe a trained operator in the operation of a generator.
  - Synchronizing
  - Loading
  - Checking cooling system
  - Maintenance
* Observe equipment used for
  - Protection
  - Cooling

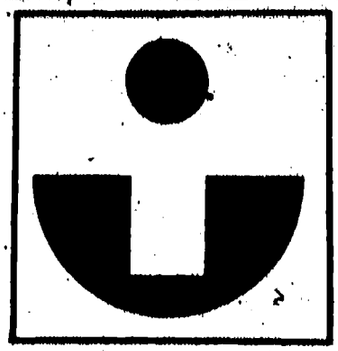
Self Assessment



Match the following terms and phrases.

_____	1. Synchronization	A. Shows if alternator is out of phase with system.
_____	2. Alternator frequency	B. Uses water as a coolant medium.
_____	3. Alternator voltage	C. Controlled by the prime mover.
_____	4. Phase rotation meter	D. Changed by adjusting the steam supply to the turbine.
_____	5. Paralleling	E. Requires that each generator have terminal voltage equal to the voltage of the system.
_____	6. Loading	F. Types of circuit protection device.
_____	7. Enclosed air system	G. Protects against internal faults in system.
_____	8. Carbon dioxide	H. Can be changed by running machine to required voltage and setting rheostat.
_____	9. Air break	I. Used to purge hydrogen from a cooling system.
_____	10. Relay scheme	J. Hooking several generators to a common bus bar.

Self Assessment Answers



E 1.

D 2.

H 3.

A 4.

J 5.

C 6.

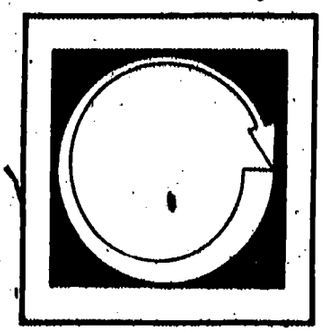
B 7.

I 8.

F 9.

G 10.

Post Assessment



1. List 3 types of internal electrical faults that can occur in a generator system?

2. What kind of device is used to protect the system faulting back of the generator?

3. What kind of device is used to protect the system from faulting that occurs in front of the generator (transmission system)?

4. List 3 types of circuit breakers used in protection of generators?

5. What precaution is important in a hydrogen cooling of generators?

6. Why is distilled water recommended for liquid cooling of generators?

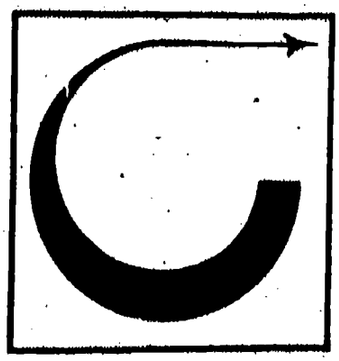
7. List 3 types of cooling systems.

8. When the prime mover power is increased, does the alternator load increase or decrease?

9. How can we determine if an alternator is out of phase with a system?

10. How is the power factor controlled in paralleling?

Instructor Post Assessment Answers



1. Phase to ground, phase to phase, double phase to ground, three phase to ground

2. Trip relay

3. Circuit breakers

4. Air break, oil immersed, air blast

5. Purge hydrogen with carbon dioxide to avoid explosion

6. Has less electrical conductivity

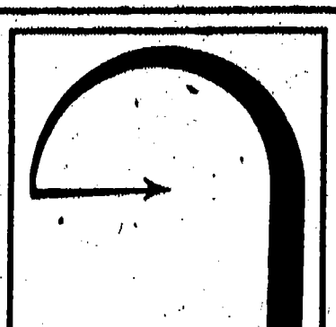
7. Enclosed air, hydrogen, liquid

8. Increase

9. By use of a phase rotation meter

10. By trimming resistance in the voltage regulator

Supplementary References



* Correspondence Course. Lecture 4, Section 5, Second Class.. Alternating Current Generators. Southern Alberta Institute of Technology. Calgary, Alberta, Canada.