UNIT -V

CONTROL OF TURBINE

Types of steam turbines – impulse and reaction turbines – compounding – Turbine governing system – Speed and Load control – Transient speed rise – Free governor mode operation – Automatic Load Frequency Control – Turbine oil system – Oil pressure drop relay – Oil cooling system – Turbine run up system.

STEAM TURBINES:

- A steam turbine converts the energy of high-pressure, high temperature steam produced by a steam generator into shaft work.
- The energy conversion is brought about in the following ways:
  1. The high-pressure, high-temperature steam first expands in the nozzles emanates as a high velocity fluid stream.
  2. The high velocity steam coming out of the nozzles impinges on the blades mounted on a wheel. The fluid stream suffers a loss of momentum while flowing past the blades that is absorbed by the rotating wheel entailing production of torque.
  3. The moving blades move as a result of the impulse of steam (caused by the change of momentum) and also as a result of expansion and acceleration of the steam relative to them. In other words they also act as the nozzles.
- A steam turbine is basically an assembly of nozzles fixed to a stationary casing and rotating blades mounted on the wheels attached on a shaft in a row-wise manner.
- Steam turbines are employed as the prime movers together with the electric generators in thermal and nuclear power plants to produce electricity.
- Turbines can be condensing or non-condensing types depending on whether the back pressure is below or equal to the atmosphere pressure.

TYPES OF STEAM TURBINES:

IMPULSE TURBINES:

- In this turbine expansion of the steam takes place in one set of nozzles
- As the steam flows through the nozzle its pressure falls from steam chest pressure to condenser pressure
- Due to this relatively higher ratio of expansion, the steam coming out at a very high velocity through the fixed nozzles impinges on the blades fixed on the periphery of a rotor.
- The blades change the direction of the steam flow without changing its pressure
- The resulting motive force (due to change in momentum) gives the rotation to the turbine shaft.
- It is evident that the velocity of the steam leaving the moving blades is a large portion of the maximum velocity of the steam when leaving the nozzles.
- The loss of energy due to this higher exit velocity is commonly “carry over loss” or “leaving loss”
- Following figure 1 shows the simple impulse turbine

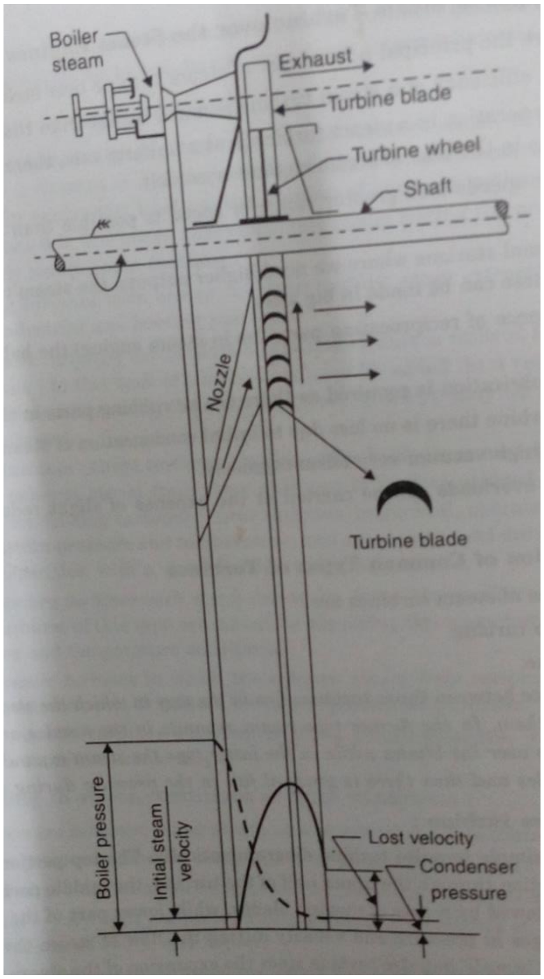


Figure 1 Impulse Turbine

- Example: De-Laval, Curtis and Reteau

REACTION TURBINES:

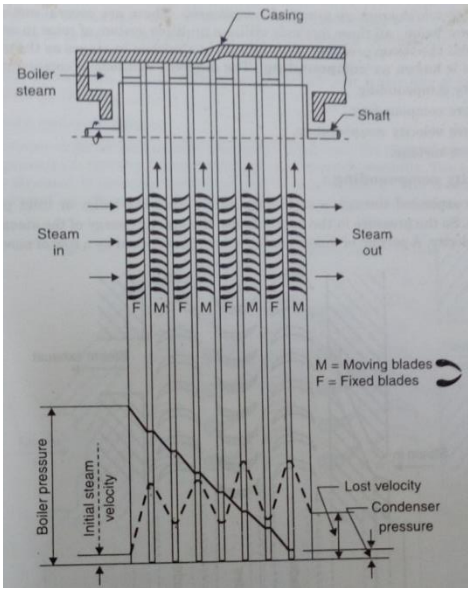
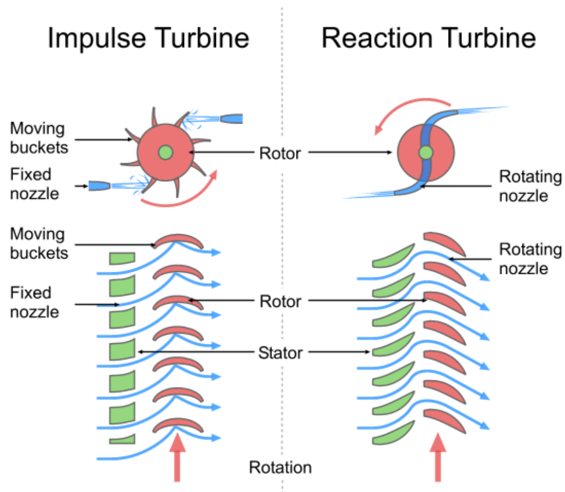


Figure 2 Reaction Turbine

- In this type of turbine, there is a gradual pressure drop and takes place continuously over the fixed and moving blades
- The function of fixed blade is that they alter the direction of the steam as well as allow it to expand to a larger velocity
- As the steam passes over the moving blades its kinetic energy is absorbed by them
- Above shown figure 2 is a multi-stage reaction turbine with change in pressure and velocity
- The volume of steam increases at lower pressure therefore, the diameter of the turbine must increase after each group of blade rings
- It may be noted that in this turbine since the pressure drop per stage is small, therefore, the number of stages required is much higher than an impulse turbine of the same capacity

IMPULSE-REACTION TURBINE:

- The steam expands both in fixed and moving blades continuously as the steam passes over them.
- Therefore the pressure drop occurs gradually and continuously over both moving and fixed blades.
- Example: Parson's turbine



S. No	Impulse Turbine	Reaction Turbine
1.	In impulse turbine all hydraulic energy is converted into kinetic energy by a nozzle and it is the jet so produced which strikes the runner blades.	In reaction turbine only some amount of the available energy is converted into kinetic energy before the fluid enters the runner.
2.	The velocity of jet which changes, the pressure throughout remaining atmosphere.	Both pressure and velocity changes as fluid passes through a runner. Pressure at inlet is much higher than at outlet.
3.	Water-tight casing is not necessary. Casing has no hydraulic function to perform. It only serves to prevent	The runner must be enclosed within a watertight casing.

	splashing and guide water to the tail race.	
4.	Water is admitted only in the form of jets. There may be one or more jets striking equal number of buckets simultaneously.	Water is admitted over the entire circumference of the runner.
5.	The turbine doesn't run full and air has a free access to the bucket.	Water completely fills at the passages between the blades and while flowing between inlet and outlet sections does work on the blades.
6.	The turbine is always installed above the tail race and there is no draft tube used.	Reaction turbine are generally connected to the tail race through a draft tube which is a gradually expanding passage. It may be installed below or above the tail race.
7.	Flow regulation is done by means of a needle valve fitted into the nozzle.	The flow regulation in reaction turbine is carried out by means of a guide-vane assembly. Other component parts are scroll casing, stay ring runner and the draft tub.
8.	Impulse turbine have more hydraulic efficiency.	Reaction turbine have relatively less efficiency.
9.	Impulse turbine operates at high water heads.	Reaction turbine operate at low and medium heads.
10.	Water flow is tangential direction to the turbine wheel.	Water flows in radial and axial direction to turbine wheel.
11.	Needs low discharge of water.	Needs medium and high discharge of water.
12.	Degree of reaction is zero.	Degree of reaction is more than zero and less than or equal to one.
13.	Impulse turbine involves less maintenance work.	Reaction turbine involves more maintenance work.

COMPOUNDING:

- In impulse turbine that if steam is expanded from the boiler pressure to condenser pressure in one stage the speed of the rotor becomes tremendously high which crops up practical complicacies
- There are several methods of reducing this speed to lower value, all these methods utilise a multiple system of rotor in series, keyed on a common shaft and the steam pressure of jet velocity is absorbed in stages as the steam flows over the blades. This is known as compounding
- Different types of compounding are
    - Velocity compounding
    - Pressure compounding
    - Pressure Velocity compounding
- **Velocity compounding**
    - Steam is expanded through a stationary nozzle from the boiler or inlet pressure to condenser pressure

- So the pressure in the nozzle drops, the kinetic energy of the steam increases due to increase in velocity
- A portion of this available energy is absorbed by a row of moving blades
- The steam (whose velocity has decreased while moving over the moving blades) then flows through the second row of blades which are fixed
- The function of these fixed blades is to redirect the steam flow without altering its velocity to the following next row moving blades where again work is done on them and steam leaves the turbine with a low velocity
- Following figure 3 shows a stage of blades and changes in pressure as the steam passes through the nozzle, fixed and moving blades.

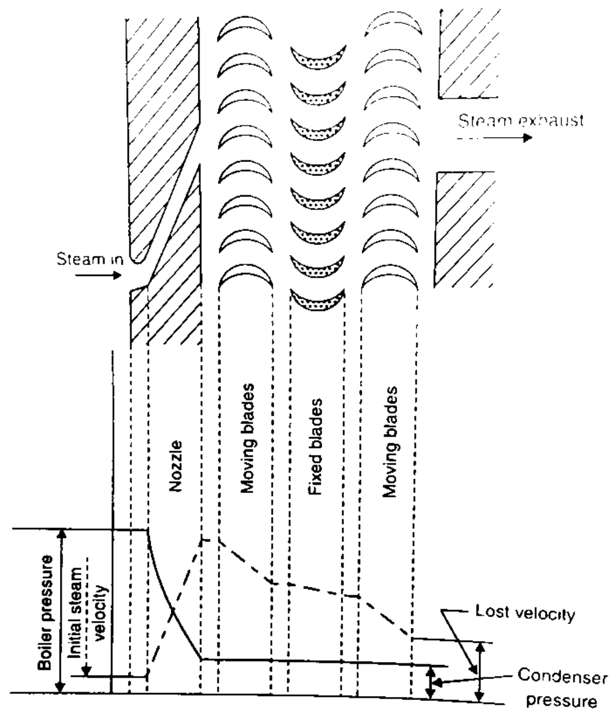


Figure 3 Velocity Compounding

- Advantage:
  - Low initial cost due to lesser number of stages
- Disadvantage:
  - Its efficiency is low

❖ Pressure compounding

- Following figure 4 shows a rings of fixed nozzles incorporated between the rings of moving blades
- The steam at boiler pressure enters the first set of nozzles and expands partially
- The kinetic energy of the steam thus obtained is absorbed by the moving blades (stage 1)
- The steam then expands partially in the second set of nozzles where its pressure again falls and the velocity increases, the partially in the second set of nozzles where its pressure again falls and the velocity increases, the kinetic energy so obtained is absorbed by the second ring of moving blades (stage 2)

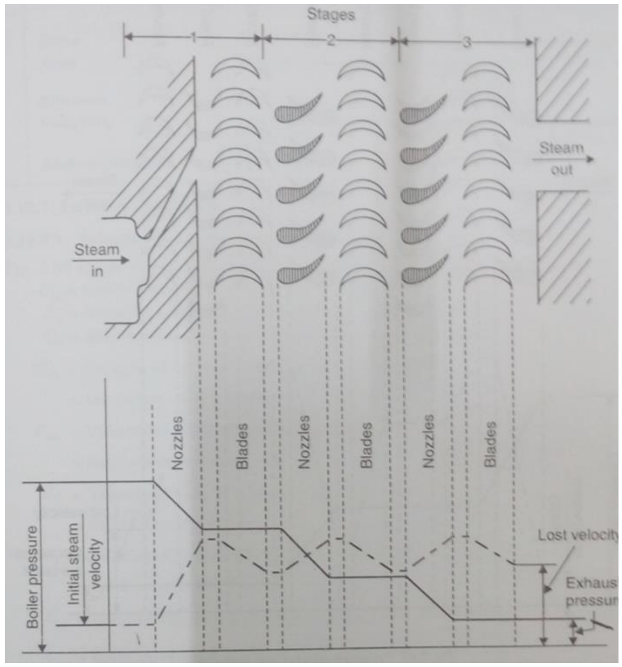


Figure 4 Pressure Compounding

- This is repeated in stage 3 and steam finally leaves the turbine at low velocity and pressure
- The number of stages depends on the number of rows of nozzles through which the steam must pass
- Advantage:
  - Most efficient turbine since the speed ratio remains constant
- Disadvantage:
  - High cost due to number of stages

❖ Pressure Velocity compounding

- This method of compounding is the combination of two previously discussed method
- The total drop in steam pressure is divided into stages and the velocity obtained in each stage and pressure remains constant during each stage
- The change in pressure and velocity are shown in following figure 5

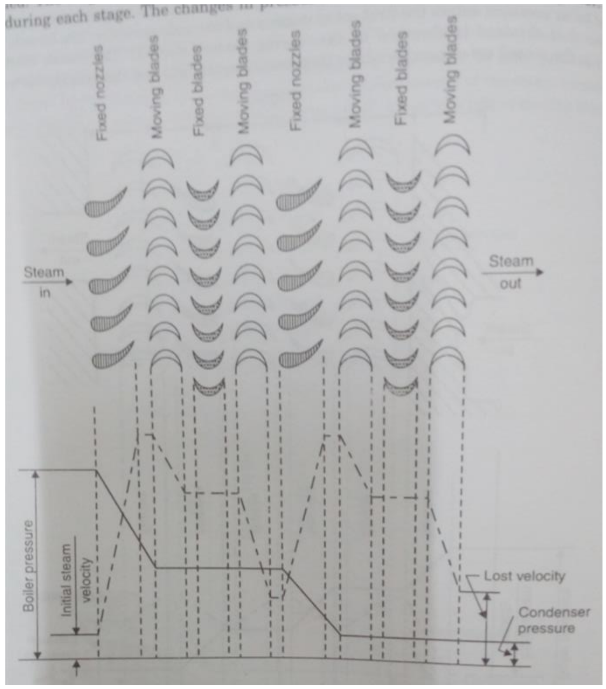


Figure 5 Pressure Velocity Compounding

TURBINE CLASSIFICATION:

- ❖ The turbines may be classified based on the process condition, they are
  - Condensing turbine
  - Non-Condensing turbine
  - Extraction turbine
- ❖ Condensing turbine:
  - The input to the turbine may be from a single source or from a number of boilers connected to a steam bus and then supplied
  - The output may be condensing in which the exhaust pressure is sub-atmospheric (vacuum)
  - The condensed water is recirculated back into feed water stream to avoid treatment of more freshwater
  - Here the makeup water requirement is kept at minimum
- ❖ Non-Condensing turbine
  - The input to the turbine is similar to that of condensing turbine, but the output may be 'non-condensing' in which the exhaust pressure is greater than atmospheric
  - Such a turbine is also called backpressure turbine
  - The steam that exhausted with some pressure may be utilized as process steam for other purposes in the plant
  - Such a steam is called process steam or intermediate pressure steam or low pressure steam

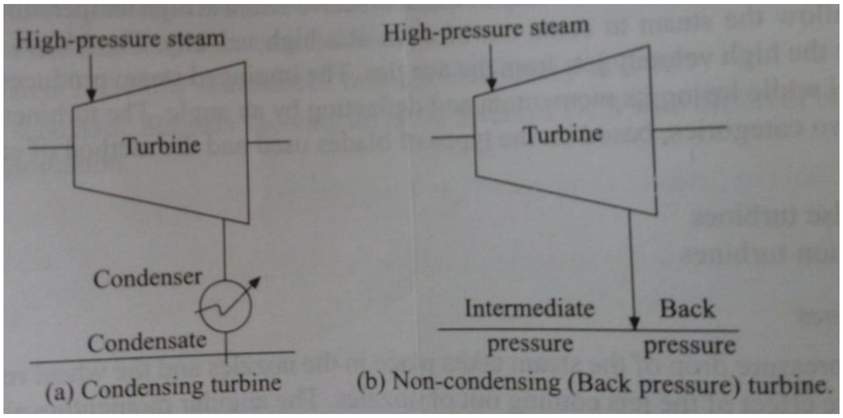


Figure 6 Condensing and Non-condensing Turbine

- Extraction turbine
  - Both in condensing and non-condensing turbines, the outlet from the turbine is only one.
  - One or two more outlets may be provided to extract steam at different pressures for other uses
  - Such a turbine is called extraction turbine
  - It may be condensing or non condensing
  - One such extraction turbine which is also condensing is shown in figure 7

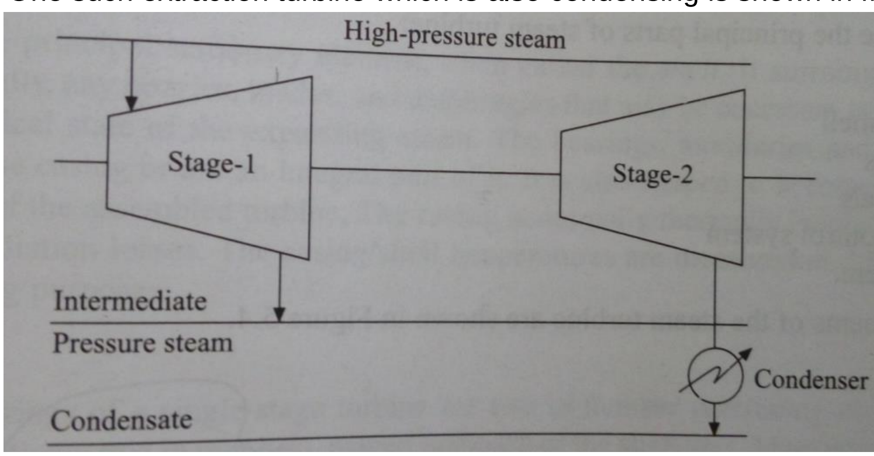


Figure 7 Extraction Turbine

  - Topping and bottoming Turbines:
    - The non condensing back pressure turbine has its inlet to the plants high pressure header
    - Its outlet is connected to a intermediate pressure header from where the steam is supplied for other purposes
    - As this turbine is using steam from the top of the pressure range in the plant, it is also called “topping turbine” as shown in figure
    - Sometimes the exhaust of one turbine is used as inlet to another turbine whose outlet is condensed
    - Such a turbine is called a “bottoming turbine” as it uses low pressure steam as inlet as shown in figure 8

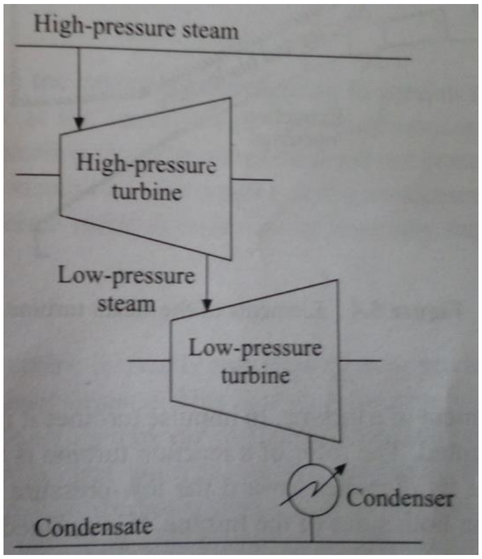


Figure 8 Bottoming Turbine

PRINCIPAL PARTS OF STEAM TURBINES:

- The following are the principal parts of steam turbine:
    - Rotor
    - Casing/shell
    - Bearings
    - Shaft seals
    - Steam control system
    - Oil system
- The various elements of the steam turbine are shown in figure 9

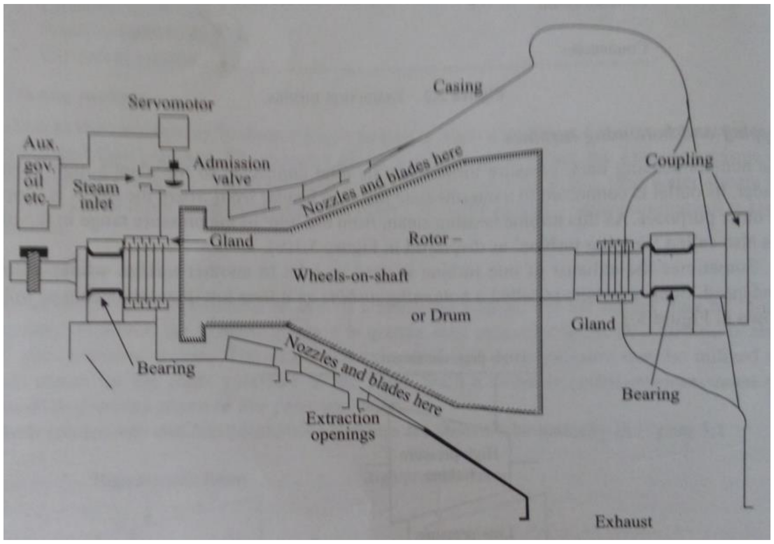


Figure 9 Turbine

- Rotor:
    - This is the main moving elements of a turbine
    - In impulse turbine it is a shaft on which the wheels carrying the blades are mounted

- The rotor of a reaction turbine is a drum
- It will be stepped or tapered in order to increase its diameter towards the low-pressure end
- The rotor is supported through bearings mounted on both sides of the turbine
- It is coupled tot the rotor of the alternator which is again supported through bearings mounted on both sides of the alternator
- The converted rotational energy of the turbine is transmitted to the alternator rotor which in turn, converts the mechanical rotational energy into electricity
- A simple single stage turbo-alternator will have at least four bearings supports

❖ Casing/Shell:

- Casing is the principal stationary element, often called the shell
- It surrounds the rotor and holds, internally any nozzles, blades and diaphragm that may be necessary to control the path and the physical state of the expanding steam
- The bearings, auxiliaries and steam lines are attached to the casing or are an integral part of it
- It is also shaped to become the main frame and support of the assembled turbine
- The casing is normally thermally insulated from outside to prevent radiation losses
- The casing/shell temperatures are measured at different locations for monitoring purposes

❖ Bearings:

- The main bearings of a single stage turbine are two in number (excluding alternator bearings which are additional in two number), placed outboard of the shaft seal
- Most journals run in plain babbitted bearings
- Some small turbines are ring-oiled from reservoirs, other follow large turbine practice with pressurized oiling system
- Thrust is carried by separate thrust bearings, plain or ball
- Where the large end thrusts are produced as in the case of reaction turbines, they are mainly neutralized by steam loaded balance plates of the rotor
- The amount of heat energy dissipated because of the friction in the bearings depends mainly on the turbine load conditions
- This may result in increase of bearings temperature which can be controlled through lubrication of the bearings
- The bearings temperature measurement is also a way of detecting deterioration in bearings before complete mechanical failure
- Hence a lubrication system with pressure / flow, temperature and /or oil tank level controls become part of the bearings system

❖ Shaft Seals:

- Where the shaft emerges from the casing it needs sealing to prevent steam outflow at the high pressure end and air inflow at the vacuum end
- On small non-condensing turbines, this is accomplished by mechanical sealing rings; however these are not practical if the shaft diameter is large

- Labyrinth glands with steam or water sealing at the condenser end are employed on all large turbines
- Multistage internal turbines must also be internally sealed between the shaft and diaphragms

- Steam Control System:
  - Flow of the steam through a turbine is usually regulated so as to produce constant rotative speed in the presence of variable power demand
  - This is always the case where the turbine is used for electric generation
  - Control is exercised by varying the quantity and pressure of the steam flowing through the turbine
  - If quantity control could be had alone, it would be employed, but the turbine has fixed size nozzles and pressure control is the most practical method of varying quantity
  - In large turbines, power is varied with minimum throttling by subdividing the first stage nozzles into groups which come into action in sequence as load is increased
  - However, beyond the first stage the entire nozzle group is always in action, and pressure and quantity are variable when power is changes
- Oil System:
  - Oil is required for lubricating the bearings
  - Most turbines use the oil pressure system for both bearing lubrication and governor servomechanism operation
  - An integral oil pump, driven from the main shaft, provides the pressure oil relays and governor valve operating cylinders
  - The same oil, when reduced somewhat in pressure, serves for circulating to the bearings
  - An oil reservoir, oil filter and oil cooler are included in this system
  - Sometimes a separately driven emergency oil pump is provided even though the fault were immediately detected and the emergency valve tripped
  - This is because of the enormous store of energy in the massive rotor running at 1500 or 3000 rpm.

TURBINE GOVERNING SYSTEM [SPEED AND LOAD CONTROL / FREE GOVERNOR MODE OPERATION]:

- The generators are always required to run at the constant speed irrespective of the variations in the load.
- This constant speed or the synchronous speed for which it is designed is expressed as

N=120f/P

Where, N= Synchronous speed

f=frequency of the power generated

P= Number of poles

- If the load on the generator goes on varying and if the input for the turbine remains the same, then the speed of the runner tends to increase if the load goes down or it tends to decrease if the load on the generator goes up.

❖ Therefore the speed of the generator and hence the frequency will vary accordingly, which is not desired.
❖ Therefore the speed of the runner is always required to be maintained at a constant level at all loads.
❖ It is done automatically by the governor which regulates the quantity of water/steam flowing through the runner in proportion to the load.
❖ The different methods which are commonly used for governing the steam turbines are listed below.
    - Throttle governing
    - Nozzle control governing
    - By-pass governing

Throttle Governing:

❖ The arrangement of this governing is shown in figure

❖ The quantity of steam entering into the turbine is reduced by the throttling of the steam
❖ The throttling is achieved with the help of double heat balanced valve which is operated by a centrifugal governor through the servo-mechanism as shown in figure 10

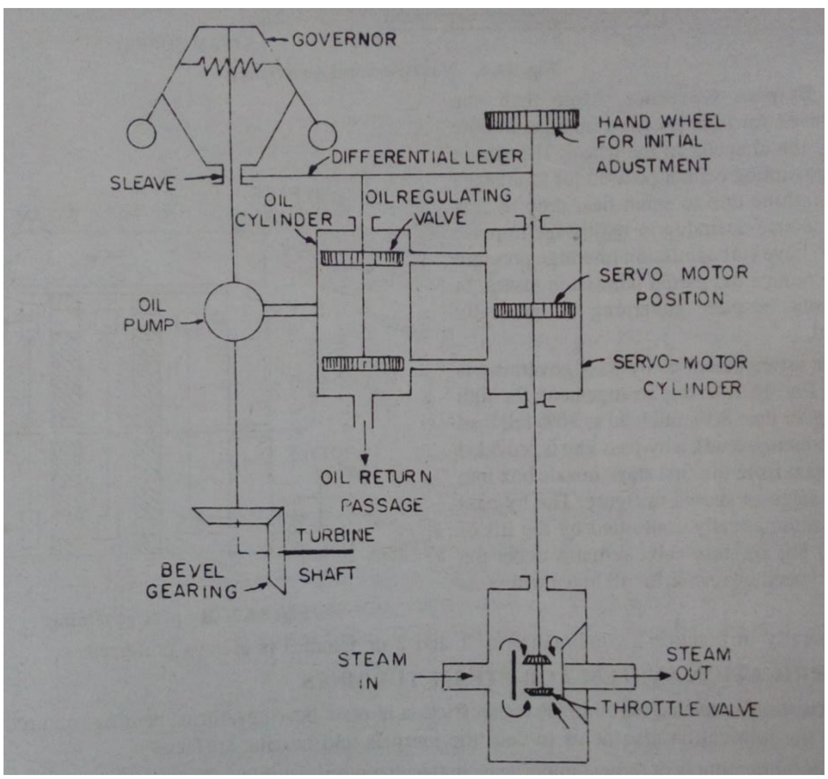


Figure 10 Throttle Governing

❖ The effort of the governor may not be sufficient to move the valve against the piston in big units

- Therefore an oil operated relay (servo-mechanism) is incorporated in the circuit to magnify the small force produced by the governor to operate the valve
- Let the position of the governor (position of pilot and relay option) shown in figure correspond to the full load on the turbine and running at full speed.
- If the load on the turbine is reduced, the turbine will start to rotate at speed greater than full load speed as the energy supplied is same
- An increased speed of the turbine shaft causes the governor sleeve to move upward and this causes to move the pilot piston upwards
- The upward motion of the pilot piston allows the high pressure oil to enter on the top side of the relay piston through upper part and allows the oil from the relay cylinder to come out (to oil return) through pilot cylinder
- The downward motion of the relay piston partly closes the throttle valve causing the reduction in steam supply.
- The reverse operation takes place when the load on the turbine increases.

Nozzle Control Governing:

- In this method of control, the steam supplied to the different nozzle groups is controlled by uncovering as many steam passages as are necessary to meet the load by poppet values.
- An arrangement often used for large steam power plants is shown in figure 11
- The number of nozzles supplying the steam to the turbine are divided into groups as N1,N2 and N3 and the supply to the nozzles is controlled by valves V1,V2 and V3

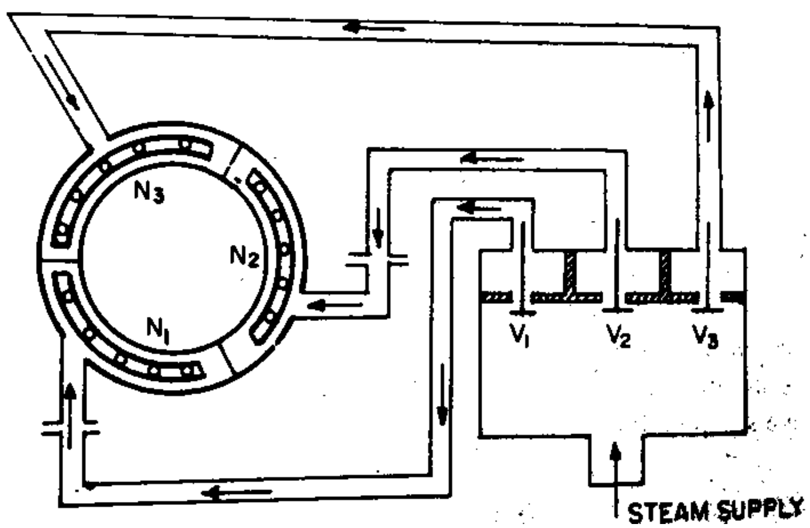


Figure 11 Nozzle Control Governing

By-pass Governing:

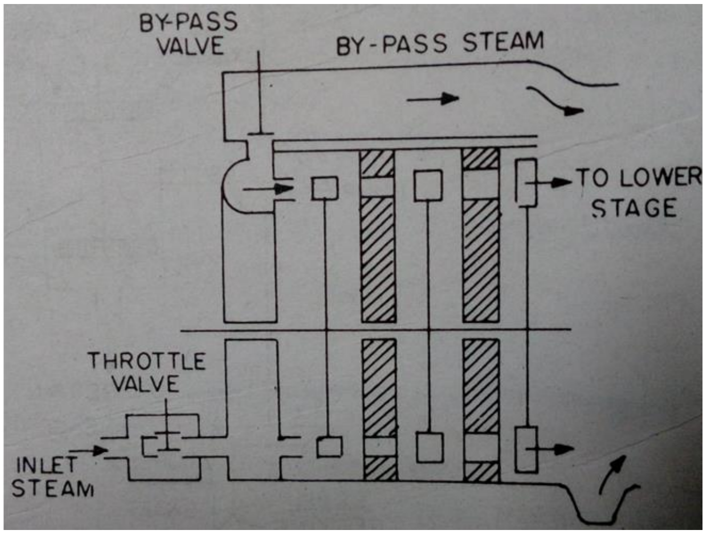


Figure 12 by-pass Governing

- More than one stage is used for high pressure impulse turbine to reduce the diameter of the wheel
- The nozzle control governing cannot be used for multistage impulse turbine due to small heat drop in first stage
- It is also desirable in multistage impulse turbine to have full admission into high pressure stages to reduce the partial admission losses
- In such cases by-pass governing is generally employed
- The arrangement of by-pass governing is shown in above figure.
- In this arrangement, for high loads, (higher than 80% full load as 80% full load is most economic load), a by-pass line is provided for the steam from the first stage nozzle box into latter stage as shown in figure 12
- The by-pass steam is automatically controlled by the lift of the valve
- The by-pass valve remains under the control of speed governor for all loads within its range

TRANSIENT SPEED RISE:

- Sudden increase in the turbine speed is called as transient speed rise

AUTOMATIC LOAD FREQUENCY CONTROL:

- This chapter deals with the control mechanism needed to maintain the system frequency. The topic of maintaining the system frequency constant is commonly known as AUTOMATIC LOAD FREQUENCY CONTROL (ALFC). It has got other nomenclatures such as Load Frequency Control, Power Frequency Control, Real Power Frequency Control and Automatic Generation Control.
- The basic role of ALFC is:
    - To maintain the desired megawatt output power of a generator matching with the changing load.
    - To assist in controlling the frequency of larger interconnection.

- To keep the net interchange power between pool members, at the predetermined values.

❖ The ALFC loop will maintain control only during small and slow changes in load and frequency.

❖ It will not provide adequate control during emergency situation when large megawatt imbalances occur.

❖ **Combined ALFC and AVR:**
  - In an interconnected power system, Automatic load frequency control (ALFC) and Automatic Voltage Regulator (AVR) equipment is installed for each generator.
  - The controllers are set for a particular operating condition and take care of small changes in load demand to maintain the frequency and voltage magnitude within the specified limits.
  - The excitation system time constant is much smaller than the prime mover time constant and its transient decay much faster than and does not affect the LFC dynamic.
  - Thus the cross coupling between the LFC loop and the AVR loop is negligible, and the load frequency and excitation voltage control are analyzed interpedently.
  - The schematic diagram of Combined ALFC and AVR loops as shown in below Figure 13

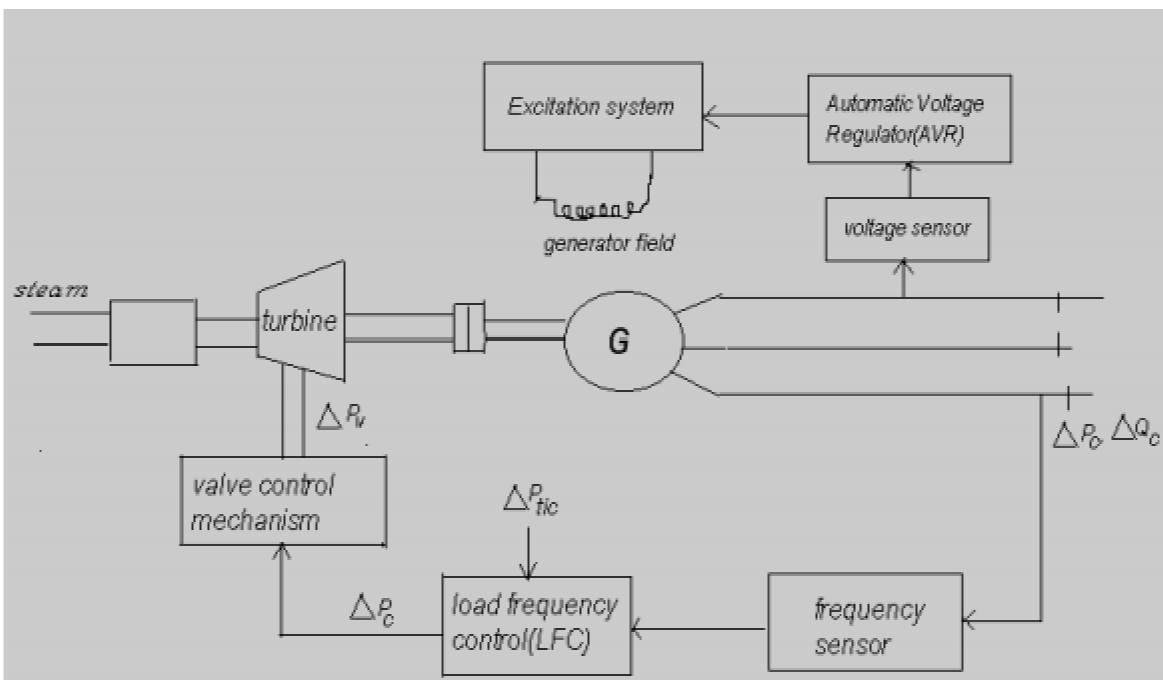


Figure 13 Combined ALFC and AVR

  - The primary ALFC loop shown in Figure 14 is used to achieve the primary goal of real power balance by adjusting the turbine output ∆Pm to match the change in load demand ∆PD.
  - All the participating generating units contribute to the change in generation.
  - But a change in load results in a steady state frequency deviation ∆f.

- The restoration of the frequency to the nominal value requires an additional control loop called the supplementary loop.
- This objective is met by using integral controller which makes the frequency deviation zero.
- The ALFC with the supplementary loop is generally called the AGC.
- The main objectives of AGC are
  - To regulate the frequency (using both primary and supplementary controls)
  - To maintain the scheduled tie-line flows.
- A secondary objective of the ALFC is
  - To distribute the required change in generation among the connected generating units economically (to obtain least operating costs)
- As shown in Fig.7 below which is the combined block diagram of ALFC and AVR loops illustrating the fundamental principles of both the controllers.

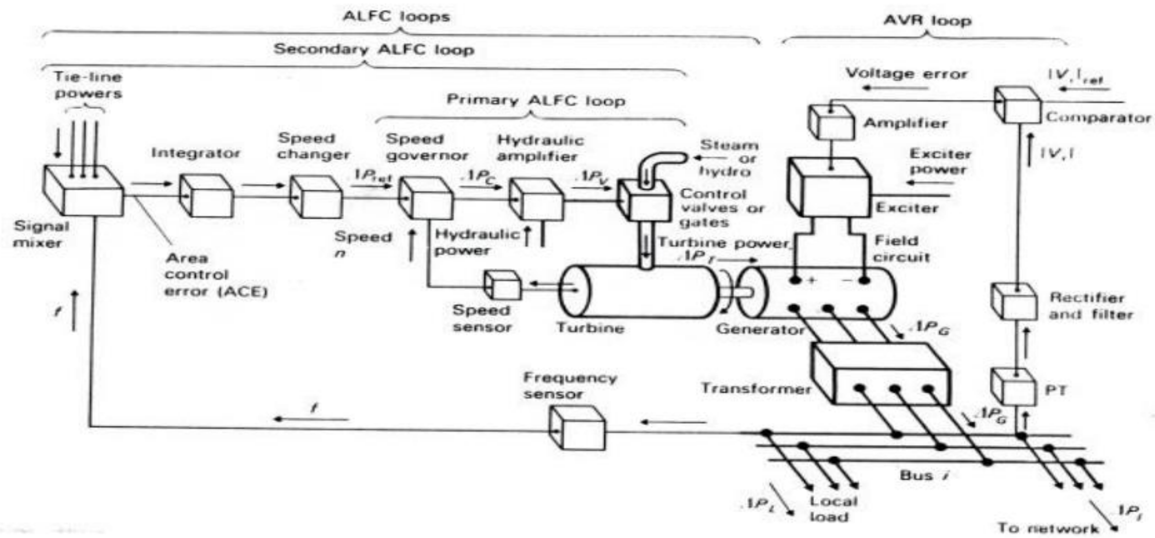


Figure 14 Combined Primary/ Secondary ALFC loops combined with AVR loop

TURBINE OIL SYSTEM: (TURBO-ALTERNATOR)

- Turbo-alternator is a continuously running machine
- While running, the components like main bearings, thrust bearings and reduction gears may get heated up due to turning friction.
- Hence a full-fledged lubrication system is needed for the turbo alternators
- Also lubrication helps cooling of journals and bearing surfaces
- The lubrication oil has to flow continuously with pressure and temperature maintained.
- It should be free from injurious foreign matter

<u>Lubrication System:</u>

- The block diagram of a lubrication system for turbo-alternator is shown in figure 15

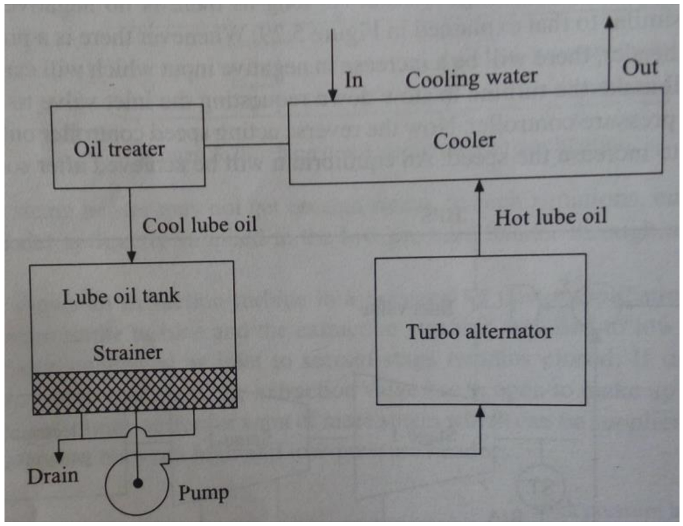


Figure 15 Lubrication System for Turbo-Alternator

- Main lube oil tank is installed at an elevated plane
- Though only one pump is shown in figure, the system will normally have a centrifugal pump attached to the turbine shaft, jet pumps to create enough pressure in the loop and auxiliary pups, etc
- A distribution box is added to divert the oil to different sections
- To maintain the purity of oil, strainer and oil treater are used
- Part of the oil from the tank is drained periodically from the tank to avoid contamination due to sledge formation\oil cooler is used to bring down the temperature of the oil coming out of the turbine lubrication system, do it can be recirculated

Control in Lubrication System

- To ensure proper lubrication oil circulation to the different sections of the turbo alternator, the following 3 control loops are necessary
    - Lube oil pressure or flow rate in the line
    - Lube oil temperature while entering from the main tank to the piping system
    - Lube oil main tank level to ensure always the availability of enough oil quantity

i)Lube oil pressure or flow Control:

- To ensure always the lubrication oil circulation in the system, either pressure in the system or the fow rate has to be automatically controlled.
- One simple control system for this purpose is shown in figure 16
- It is always possible to measure both pressure and flow rate and use one of them for controlling purpose
- The other one may be used for indication and recording purpose

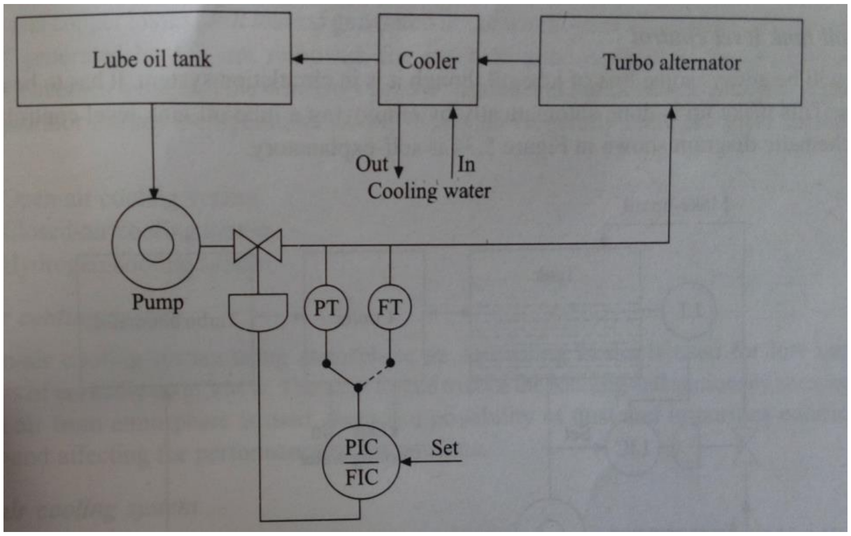


Figure 16 Lube Oil Pressure/Flow Control

ii) Lube Oil Temperature Control (Oil Cooling System):

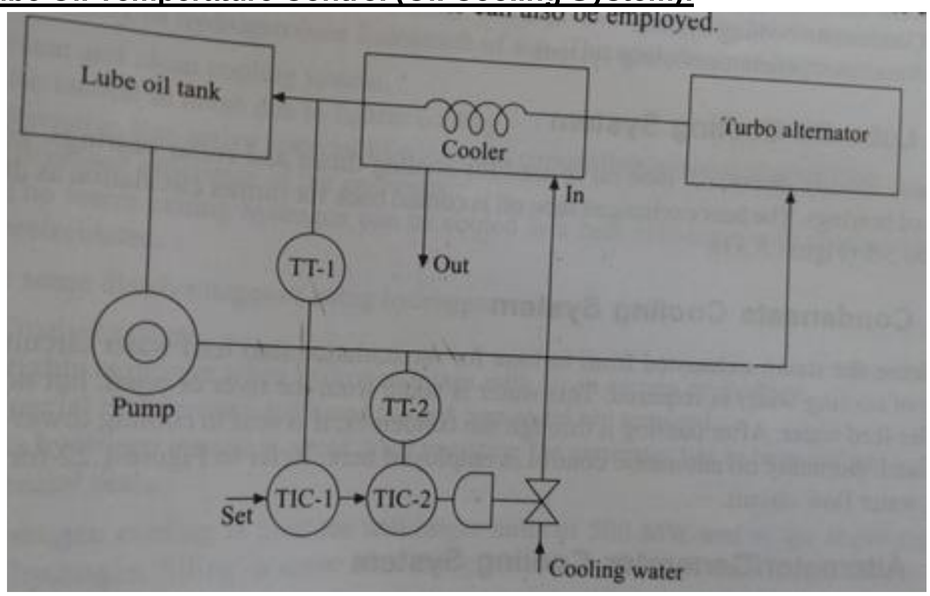


Figure 17 Lube Oil Temperature Control

- The lubrication oil while passing through bearings and gears exchange heat energy andhence it becomes heated up.
- It is essential to cool it to almost normal temperature so that the same oil can be recirculated.
- A cascade control system with cooler outlet temperature in master loop and the lube oil tank outlet temperature in slave loop is shown in above figure 17.
- The cooling medium used is normally ordinary water with room temperature and is drained out.
- For effective cooling, any other liquid or refrigerated water can also be employed.

iii) Lube Oil Tank Level Control:

- There will be always some loss of lube oil though it is in circulation system
- It has to be made up always
- This make up is done automatically by employing a lube oil tank level control system
- The schematic diagram is shown in figure 18

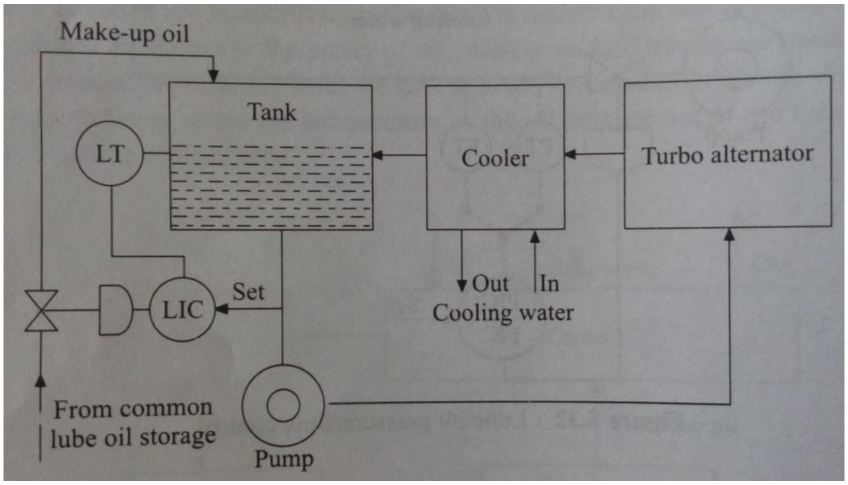


Figure 18 Lube Oil Tank Level Control

OIL PRESSURE DROP RELAY:

- This is a device designed to monitor a process pressure and provide an output when a set pressure (setpoint) is reached.
- A pressure switch does this by applying the process pressure to a diaphragm or piston to generate a force which is compared to that of a pre-compressed range spring.
- A pressure switch is used to detect the presence of fluid pressure.
- Most pressure switches use a diaphragm or bellow as the sensing element.
- The movement of this sensing element is used to actuate one or more switch contacts to indicate an alarm or initiate a control action.
- Pressure switches have different designs with different sensing elements.
- One of the most common is the one with diaphragms or bellows as the sensing elements
- The one I will discuss here uses a piston as the pressure sensing element.
- In any case, the operating principle for this piston type is the same with a diaphragm or bellow type pressure switch.

Basic Parts of a Pressure Switch:

- The basic parts of a typical pressure switch are shown in the schematic diagram below:

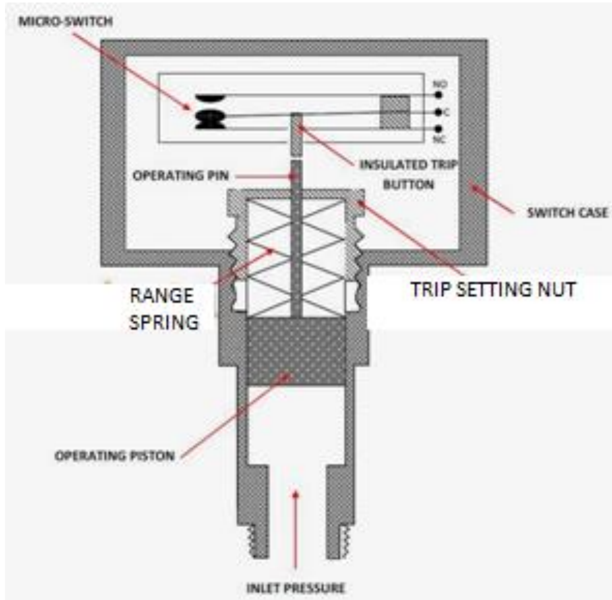


Figure 19 Sectional View of Oil Pressure Drop Relay

❖ A sectional view of the pressure switch showing all the basic parts of the switch is shown above figure 19. Also shown below figure 20 is a pictorial view of the pressure switch:

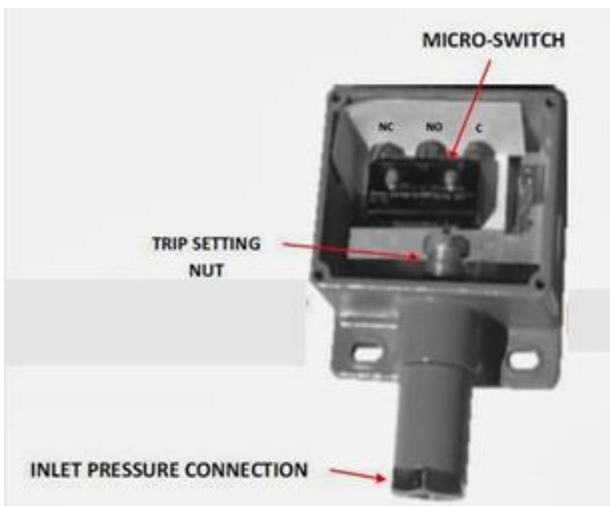


Figure 20 Pictorial View of Oil Pressure Drop Relay

❖ The following basic parts can be identified on the sectional view of the pressure switch:

- Micro-switch
- Insulated trip button
- Operating pin
- Trip setting nut
- Range spring
- Operating piston
- Switch case or housing

❖ **Micro-switch:**

- The micro-switch is used to make or break an electrical circuit when the pressure switch operates.
- The micro-switch in the sectional view is a single-pole double-throw (S.P.D.T.) switch.
- This switch is made up of one normally close contact (NC) and one normally open contact (NO).
- When the pressure switch actuates, the NO contact become close and the NC becomes open.
- Micro-switches with gold contacts are normally used on low voltage, low current applications (i.e. on circuits that are intrinsically safe).
- For higher voltages/currents silver contacts are used.

❖ **Insulated Trip Button:**
- This button causes the NO and NC contacts to switch when the pressure switch actuates

❖ **Operating Pin**
- As shown in the sectional view of the pressure switch above, the operating pin is attached to the operating piston.
- When the piston actuates as a result of inlet pressure changes, the operating pin either moves up and make contact with the trip button or moves down and breaks contact with the trip button

❖ **Trip Setting Nut**
- The trip setting nut(could also be called a range screw) is used to adjust the setpoint of the pressure switch.
- It does this by changing the amount of compression on the range spring.
- The more the range spring is compressed by the trip setting nut, the higher the pressure set point for the switch.
- The lesser the compression, the lower the setpoint for the pressure switch

❖ **Range Spring**
- This is a pre-compressed spring and the force generated by this determines the pressure at which the switch operates.

❖ **Operating Piston**
- This is the part of the pressure switch in contact with the process.
- The process pressure acting upon the area of the operating piston generates the force that opposes that of the range spring.
- The range of the switch is a function of the area of the operating piston and the rate of the range spring (measured in lbf/inch, N/mm etc).

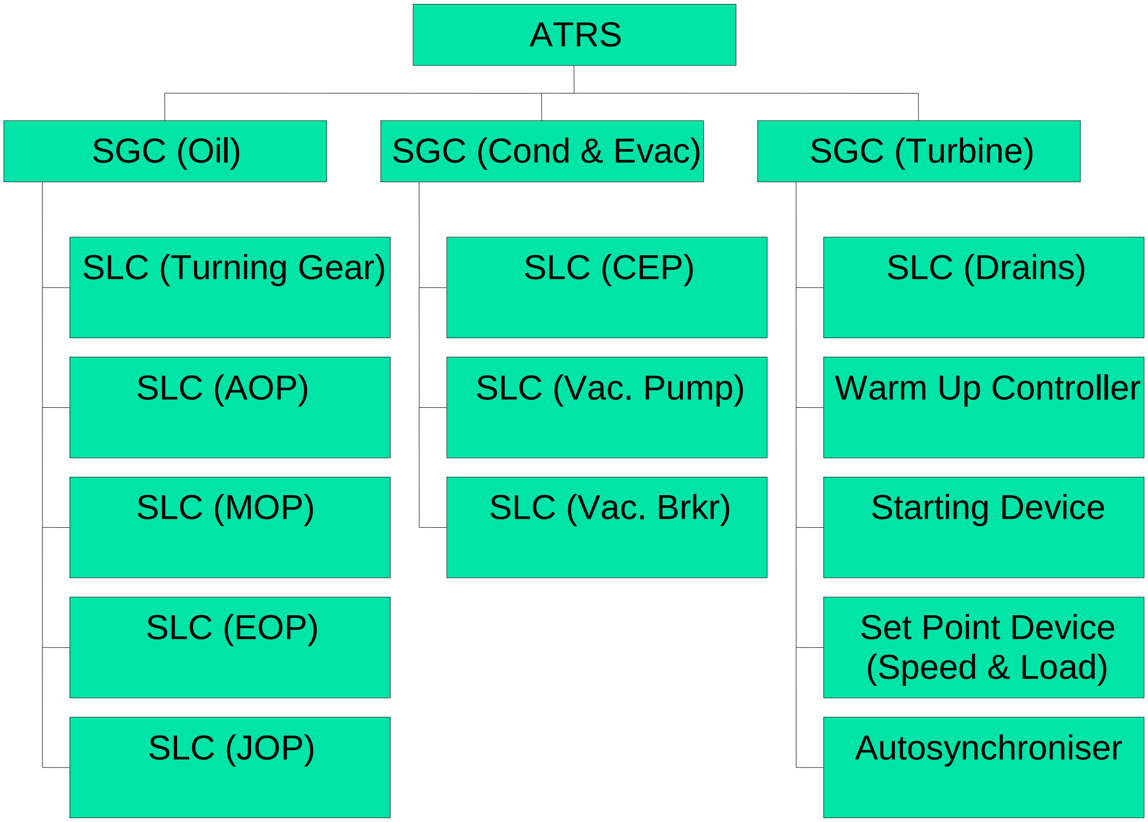
❖ **Switch Case or Housing**
- The enclosure containing the micro-switch and other accessories of the pressure switch is called the switch case or housing.
- For a pressure switch giving out an electrical output one or more tapped connections are provided to allow the cable to be brought into the housing via a suitable gland.
- For switch with a pneumatic output two or more bulkhead connections are provided for the output connections.

- Switch housings are usually available in either aluminium or stainless steel.

- **Operating Principle of a Pressure Switch**
  - As shown in the sectional view of the pressure switch above, the inlet pressure is applied to the bottom of the operating piston.
  - This piston is forced upwards by the inlet pressure against the range spring.
  - The tension of the range spring can be adjusted so that it is compressed at a certain pressure or setpoint.
  - When this pressure is reached, the operating pin will hit the trip button on the micro-switch and change it over.
  - The normally open contacts (NO to C) will become closed and the normally closed contacts (NC to C) will open.
  - The pressure at which the micro-switch changes over is set by adjusting the trip setting nut.
  - This nut adjusts the tension of the range spring (e.g. if the nut is turned clockwise the trip pressure will be higher).

TURBINE RUN UP SYSTEM:

- Acquisition, analysis and collation of various parameters during Startup
- Sequential Control of Drives
- Unit Synchronization and Minimum Load Operation
- Organised and hierarchically arranged as Sub Group Control (SGC), Sub-loop Control (SLC), and Control Interface
- ATRS: Functional Group is shown below
- Three major SGC in turbine are

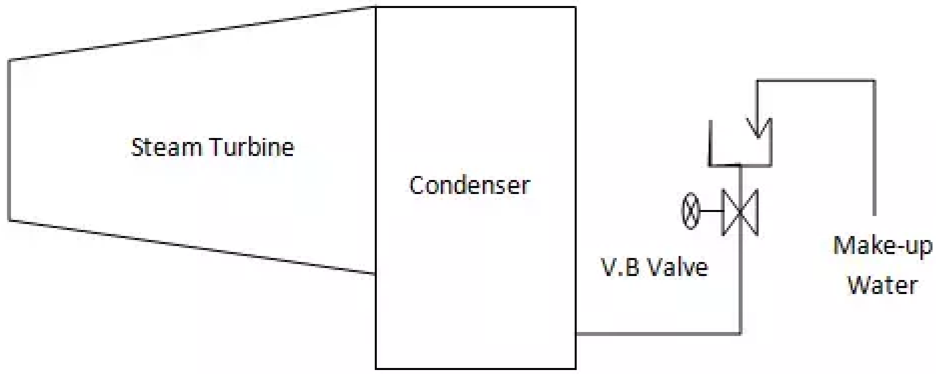


Oil

- Condenser and Evacuation
- Turbine

❖ SLC of oil loop group are
  - Auxiliary Oil Pump (AOP)
  - Emergency Oil Pump (EOP)
  - Jacking Oil Pump (JOP)
  - Main Oil Pump (MOP)

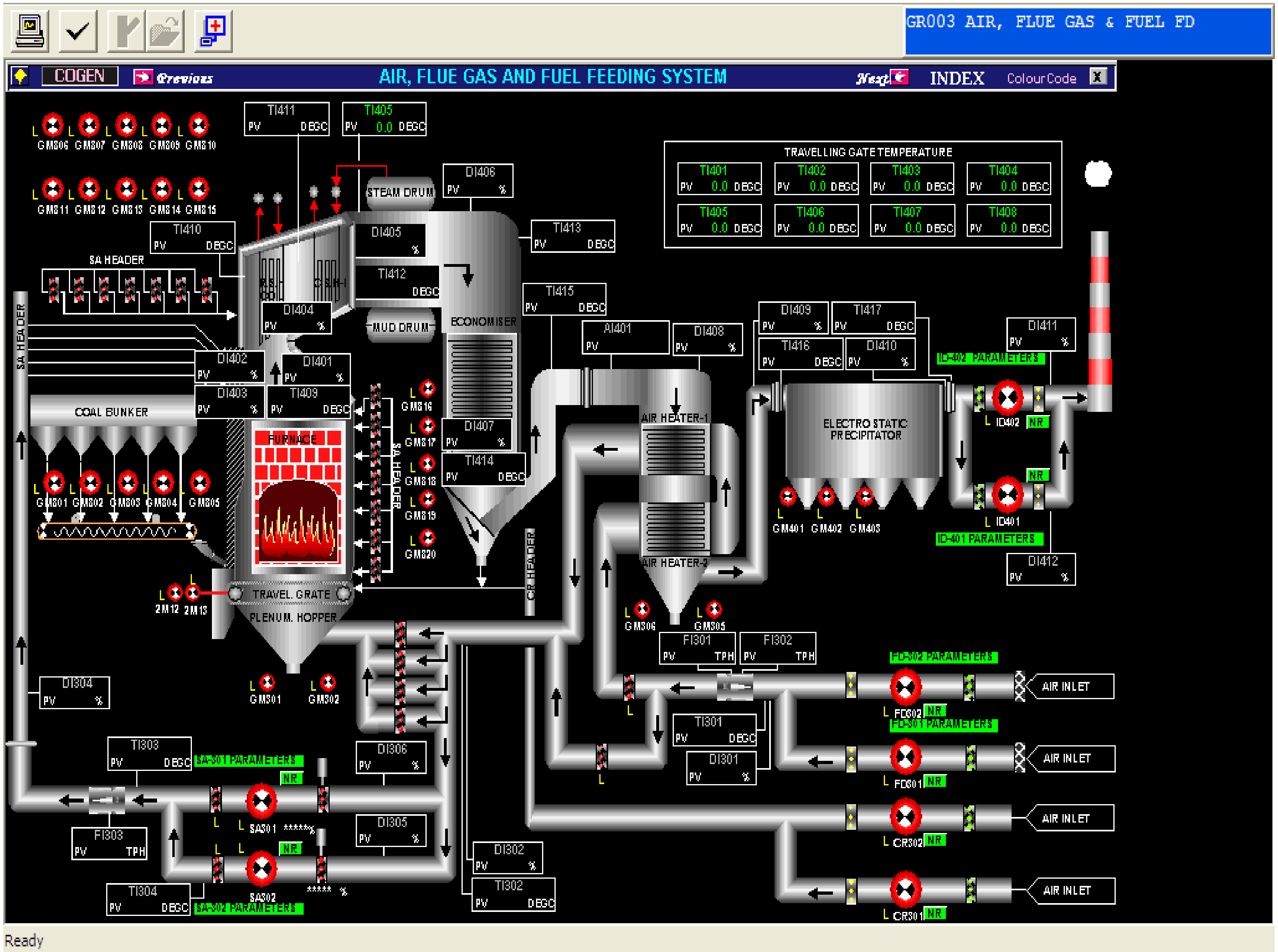
❖ SLC of Condenser and vacuum group consists of following loops
  - Condensate Extraction Pump (CEP):
    - The purpose of CEP is as the name suggests to remove condensate from the steam side of the condenser
  - Vacuum Pump
    - These pumps maintain a vacuum at the condenser side preventing turbine back pressure
  - Vacuum Breaker (VB)
    - Safety instrument provided on the steam turbine, in case of major issue with steam and it has to stop immediately

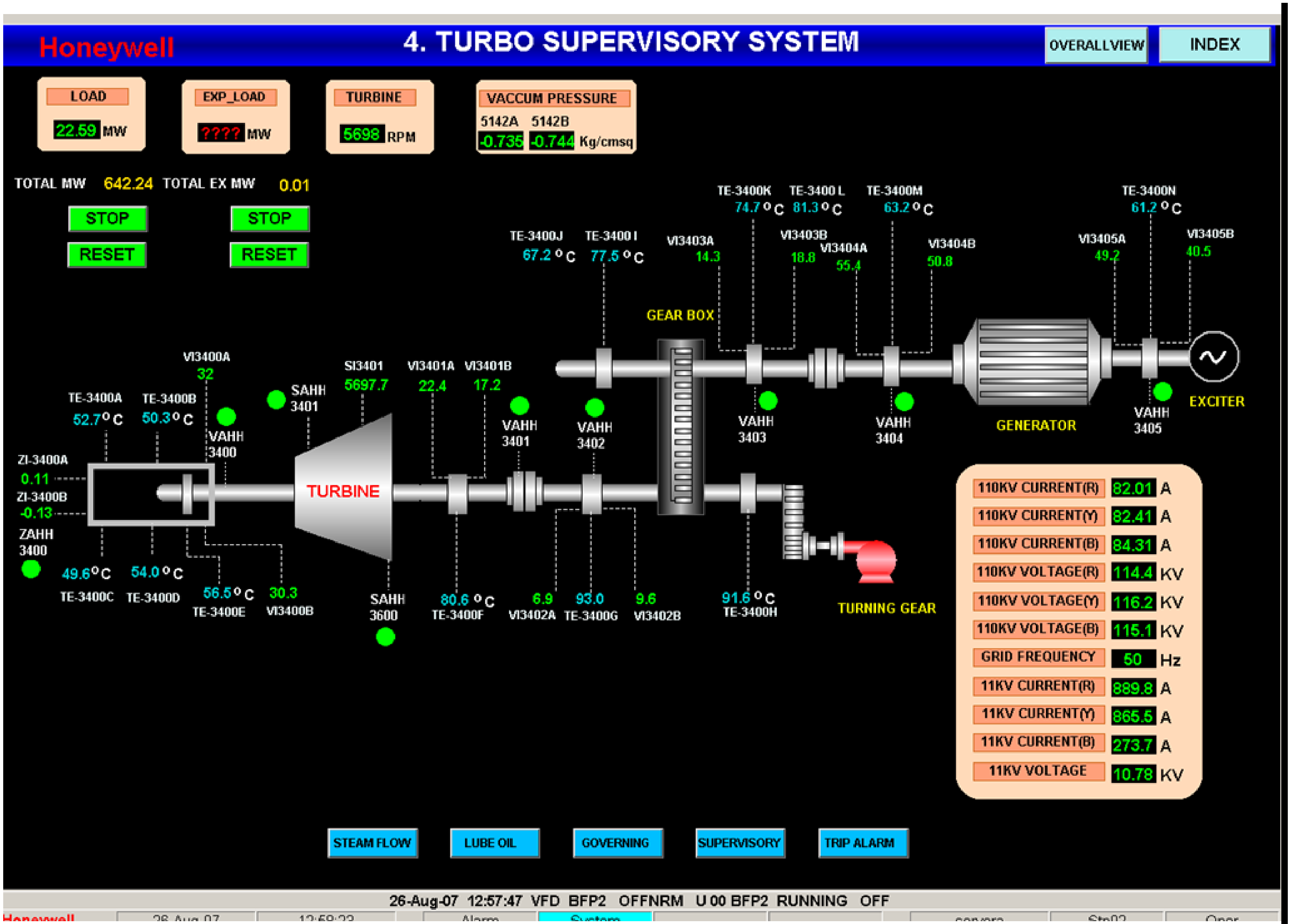


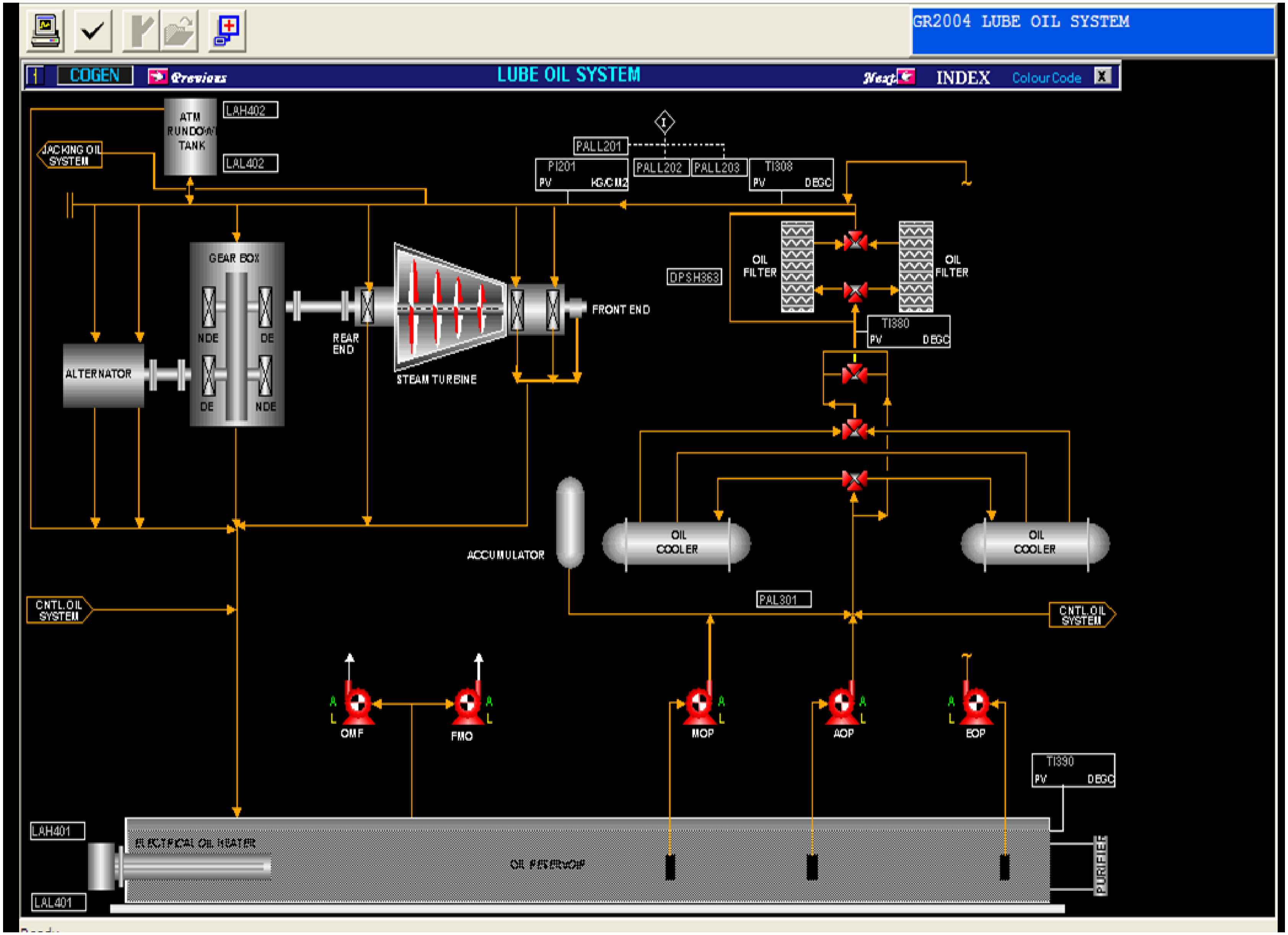
- During normal operation the VB valve will be in closed condition and water will be filled in the chamber above VB valve (Level to be maintained)
- In emergency the VB valve will be opened and the water will be drained to condenser
- As soon as the water drains, air will be pulled inside the condenser, breaking the vacuum
- This air will provide a drag and resistance to the turbine blades to bring down the turbine RPM quickly
- Without VB valve 156MW turbine takes 45 minutes to standstill position

❖ SLC of turbine group consists of following loops
  - Drain
  - Warm up controller
  - Starting device
  - Speed and load
  - Autosynchroniser

ANNEXURE


GR003 AIR, FLUE GAS & FUEL FD
COGEN
Previous
AIR, FLUE GAS AND FUEL FEEDING SYSTEM
Next
INDEX
ColourCode
TRAVELLING GATE TEMPERATURE
STEAM DRUM
MUD DRUM
ECONOMISER
SA HEADER
COAL BUNKER
FURNACE
TRAVEL. GRATE
PLENUM. HOPPER
AIR HEATER-1
AIR HEATER-2
ELECTRO STATIC PRECIPITATOR
CR HEADER
ID-402 PARAMETERS
ID-401 PARAMETERS
FD-302 PARAMETERS
FD-301 PARAMETERS
SA-301 PARAMETERS
SA-302 PARAMETERS
AIR INLET
Ready


Honeywell
4. TURBO SUPERVISORY SYSTEM
OVERALLVIEW
INDEX
LOAD
22.59 MW
EXP_LOAD
???? MW
TURBINE
5698 RPM
VACCUM PRESSURE
5142A 5142B
-0.735 -0.744 Kg/cmsq
TOTAL MW 642.24 TOTAL EX MW 0.01
STOP
RESET
STOP
RESET
TE-3400K 74.7 °C
TE-3400 L 81.3 °C
TE-3400M 63.2 °C
TE-3400N 61.2 °C
TE-3400J 67.2 °C
TE-3400 I 77.5 °C
VI3403A 14.3
VI3403B 18.8
VI3404A 55.4
VI3404B 50.8
VI3405A 49.2
VI3405B 40.5
GEAR BOX
VI3400A 32
SI3401 5697.7
VI3401A 22.4
VI3401B 17.2
SAHH 3401
TE-3400A 52.7 °C
TE-3400B 50.3 °C
VAHH 3400
VAHH 3401
VAHH 3402
VAHH 3403
VAHH 3404
VAHH 3405
EXCITER
GENERATOR
ZI-3400A 0.11
ZI-3400B -0.13
ZAHH 3400
TURBINE
49.6 °C TE-3400C
54.0 °C TE-3400D
56.5 °C TE-3400E
30.3 VI3400B
SAHH 3600
80.6 °C TE-3400F
6.9 VI3402A
93.0 TE-3400G
9.6 VI3402B
91.6 °C TE-3400H
TURNING GEAR
110KV CURRENT(R) 82.01 A
110KV CURRENT(Y) 82.41 A
110KV CURRENT(B) 84.31 A
110KV VOLTAGE(R) 114.4 KV
110KV VOLTAGE(Y) 116.2 KV
110KV VOLTAGE(B) 115.1 KV
GRID FREQUENCY 50 Hz
11KV CURRENT(R) 889.8 A
11KV CURRENT(Y) 865.5 A
11KV CURRENT(B) 273.7 A
11KV VOLTAGE 10.78 KV
STEAM FLOW
LUBE OIL
GOVERNING
SUPERVISORY
TRIP ALARM
26-Aug-07 12:57:47 VFD BFP2 OFFNRM U 00 BFP2 RUNNING OFF


GR2004 LUBE OIL SYSTEM
COGEN
Previous
LUBE OIL SYSTEM
Next
INDEX
Colour Code
ATM RUNDOWN TANK
LAH402
LAL402
JACKING OIL SYSTEM
PALL201
PI201
PALL202
PALL203
TI308
GEAR BOX
NDE
DE
ALTERNATOR
REAR END
STEAM TURBINE
FRONT END
DPSH363
OIL FILTER
OIL FILTER
TI380
ACCUMULATOR
OIL COOLER
OIL COOLER
PAL301
CNTL.OIL SYSTEM
CNTL.OIL SYSTEM
OMF
FMO
MOP
AOP
EOP
TI390
LAH401
LAL401
PURIFIER