RESEARCH PAPER ON STUDY OF STEAM TURBINE

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Abstract:

TURBINE:

The turbine consists of three casings, high, medium and low pressure. HP part consists of two horizontally split casings-inner is placed inside, outer casing with scope for expansion in all direction. Fixed point of inner casing in the axial directions is between the nozzle chambers.

Medium low pressure casing is split horizontally and comprise of 3 parts connected by vertical flanges. The outlet branches are connected rigidly with condenser which is supported on springs. In the middle casing, tube nests of 1st and 2nd LP heaters are mounted.

The casings are inter connected by guide keys and fixed points in the axial direction is at the central part of the LP casing. Total thermal expansion of the casings is indicated at front bearing pedestal and is approximately 25mm when casings are fully stretched at rated steam parameters and at full load. The displacement of the bearing pedestal; between HP & MP parts is about 15mm. Relative expansion of rotors also are measured at 3 points.

Steam Turbine Theory:

A turbine, being a form of engine, requires in order functioning a suitable working fluid, a source of high-grade energy. When the fluid flows through the turbine, apart of the energy content is continuously extracted and converted into useful mechanical work. Steam and gas turbines use heat energy. While water turbines use pressure energy.

1. Steam Turbine as a Prime mover:

(a) The steam turbine offers many advantages over other prime movers both thermodynamically and mechanically. From a thermodynamic point of view the main advantage of the steam turbine over, say a reciprocating steam engine is that in the turbine the steam can be expanded down to a lower backpressure, thereby making available a greater heat drop. The same amount of heat drop in the case of a reciprocating engine would require very large cylinder, which would be impractical and uneconomic.

(b) From a mechanical point of view the turbine is ideal because the
propelling force is applied directly to the rotating element of the machine.

(c) Another advantage of the turbine is the absence of internal lubrication. This means that the exhaust steam is not contaminated with oil vapour and can be condensed and fed back to the boiler.

(d) A final advantage of the steam turbine and a very important one is the fact that, size for size, a turbine can develop many times the power compared to a reciprocating engine whether steam or oil.

2. Operating Principle:

(a) A steam turbines two main parts are the cylinder and the rotor. The cylinder containers fixed blades, vanes and nozzles that direct the steam into the moving blades carried by the rotor. The rotor is a rotating shaft that carries the moving blades.

(b) In a multiple stage turbine, steam at a high pressure and high temperature enters the first row of fixed blades through an inlet valves. As the steam passes trough the fixed blades, it expands and its velocity increases. The high velocity jet of steam the first set of moving blades. The kinetic energy of the steam changes into mechanical energy, causing the shaft to rotate. The steam then enters the next set of fixed blades and strikes the next row of moving blades.

(c) As the steam flows through the turbine, its pressure and temperature decreases, while its volume increases. The decreases in the pressure and temperature occur as the steam transmits energy to the shaft and performs work. After passing through the last turbine stage, the steam exhausts into the condenser or process steam system.

(d) The kinetic energy of the steam changes into mechanical energy through the impact or reaction of the steam against the blades. Many large turbines use both impulse and reaction blading. Blade rows require seals to prevent steam leakage where the pressure drops.

3. Steam Cycle:

(a) The Thermal (steam) Power Plant uses a dual phase cycle. It is closed to enable the working liquid (water) to be used again and again. The cycle used is 'Rankine cycle' modified to include super heating of steam, regenerative feed water heating and reheating of steam.
Rankine cycle

TURBINE SPECIFICATIONS 110MW

(i) Make
BHEL
(ii) Rated Speed
3000 RPM
(iii) Rated Power
110 MW
(iv) Weight of HP rotor
5500 Kg.
(v) Weight of MP rotor
11000 kg.
(vi) Weight of LP rotor
24000 Kg.
(vii) Steam Pr.(Rated)

(a) Initial Steam
130 ata
(b) Before MP casing
31.63 ata
(viii) Stem Temp.(Rated)
(a) Initial Steam
535ºC
(b) IP Cylinder Stop Valve Inlet
535ºC
(c) HP Cylinder Exhaust
343ºC
(d) LP Cylinder Exhaust
49ºC
(ix) Turning Gear Speed
62 rpm

(x) Type of Turbine

(i) HP cylinder
- Regulating stage
  Two rows Curtis wheel
- Other impulse stage
  8 Nos.

(ii) MP cylinder
- Impulse stage
  12 Nos.

(iii) LP body
- Impulse stage
  4 Nos.

(xi) Oil Supply

(a) Oil Tank rated Capacity
12500Lt.
(b) For oil system of generator
4400 Lt.

<u>GLAND SEAL & LEAK-OFF:</u>

Turbine glands are sealed by steam at fixed pressure. Seal-steam, during starting and on low load period, is supplied from either cold R/H lines after N/R valves or from 11/6 ata header.

<u>ROTORS, BEARING AND TURNING GEAR:</u>

All the rotors including the rotor of the generator are mutually connected by means of rigid coupling.

The critical speed of the turbine rotors is best noticed between 1900-2350rpm. Double sided axial thrust bearing is located in between HP & MP casings. Two protections, one hydro-mechanical and one electro-magnetic are mounted near the axial bearing to trip the machine, in case the rotor movement crosses the prohibited limit on either side.

Differential expansions are measured at 3 points:-

- on the front bearing pedestal
- on the pedestal between MP & HP parts
- and between LP & Generator

to access relative expansion of stator and rotor.

There are seven radial bearings on which rotor is supported. With proper expansion of all turbine parts, the load sharing is equal in all bearings. The bearings are placed in:

- HP front standard
- between HP & MP at MP end
- both side of LP
- both side of generator

The journals are lifted by high pressure oil supplied by jacking oil pump at the time of putting machine on turning gear.

TURNING GEAR:

This equipment is located on the bearing pedestal between LP and generator and turns the rotor after shutdown or before start-up, at 62 RPM by an electric motor of 30KW. The motor starting is possible only when lubricating. oil pressure is available. The oil pressure required to put the swinging gear to engage with the coupling gear is 50 ata, supplied from jacking oil pump to a servomotor through an electro magnet.

TURBINE OIL SYSTEM

It supplies oil for the lubrication of the turbine and generator bearings, for actuation of various components of governing and control system and seal oil to generator seals in the event of any emergency. It also supplies oil for the jacking and hydraulic turning gear during start-up and shut down of the set.

Oil Supply During Operation:

During normal operation, the main oil pump supplied oil to the lubrication and governing system. The oil is drawn through injector from the oil tank to provide necessary suction head to the main oil pump. The normal supply of oil for generator seals is through a separate AC driven oil pumps.

The oil for lubrication is reconditioned in oil coolers. The amount of oil required for each bearing is adjusted on start-up, by means of variable orifices.

a) Oil Supply During Start-up and Shut Down

During start-up and shutdown the oil requirement of the TG set is met by 2x100% auxiliary oil pumps. They draw oil directly from the oil tank and discharge into the pressure oil line and continue in operation till main oil pump takes over the oil supply, which is at approximately 90-95% of rated speed. The pressure switches in pressure oil line give the signal for switching off and switching on during shutdown.

The jacking oil pump is mounted on the oil tank and discharges oil in a header whose pressure is maintained by a pr. limit valve. The jacking oil pressure required for its regulating globe valve adjusts each bearing. Opening by-pass valve can trip the pr. limit valve. Non-return valves provided down stream of the respective regulating globe valves prevent back flow of oil into the header.

b) Oil Supply During Disturbances

When pressure in the pr. oil line falls below a set point the auxiliary oil pumps are automatically started.

In case main and auxiliary oil pumps cease to operate simultaneously. A pressure switch in the lubricating line starts D.C. emergency oil pump. It by passes the oil coolers and discharges oil directly into the lubricating oil lines thereby ensuring oil supply to bearings during run down of the TG set.

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OIL PUMPS:

There are 4 oil pumps. These are

a) Main Oil Pump:

The main oil pump is sized for supplying the whole requirements of governing system, lubrication system and seal oil system during operation of the turbo set at rated speed. The pump is located in the front bearing pedestal and is directly driven by the turbine shaft through the coupling.

b) Auxiliary Oil Pump

2x100% A.C. auxiliary oil pumps supply the oil during start-up and shut down of the turbo set the pumps can either be switched on manually or automatically through pr. switches. The setting of pr.

switches are staggered so that one pump comes into operation before the other one with the second one remaining in reserve.

c) D.C. Emergency Oil Pump

This pump is a standby pump which can be started manually or automatically through a pr. switch when the lube oil pr. drops to 50% of the normal value in case main and auxiliary oil pumps cease to operate or there is breakdown the electricity supply system to the pumps.

d) Jacking Oil Pump

When the set is stationary the shafts come into metallic contact with the bottom bearing lining. The normal bearing oil supply at low speeds is unable to generate to these surfaces and considerable force is required to rotate the shaft from rest. This is overcome by forcing high pr. oil through bottom bearing sheets thereby lifting the shafts in the bearings and allowing an oil film to form thus facilitating rotation of shafts by turning gear. Jacking oil pump is high-pressure low discharge pump.