Hydraulic Oil Supply for Gas and Steam Turbines

Technical Information

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Tailor-made, reliable, low-maintainance –
Hydraulic Oil Supply for Gas and Steam Turbines

Introduction

A gas or steam turbine utilizes two types of hydraulic systems: a cooling & lubrication unit and a control oil unit. They differ in the physical sizes, pressure and flow. The cooling & lubrication unit operates at low pressure and supplies oil to reduce friction and wear on mechanical rotating elements of the turbine and generator. While lubricating, the oil also absorbs heat produced by bearing friction and heat conduction along the turbine shaft. This heat energy is carried by the oil and removed from the system via a head exchanger.

The high pressure control oil unit supplies hydraulic power to the gas or steam valve actuators, which controls valve positions and regulates the turbine speed. The valve position controls the flow of gas or steam supplying the turbine. The turbine speed controller provides the command signal to control these valves.

The following description provides an overview of the basic structure and function of these oil supply systems.

When designing hydraulic systems, it is critical to receive the specifications for the turbine and/or project.

System Overview

The turbine oil hydraulic system consists of one or two designs: two independent hydraulic systems or a single central system.

Independent systems differ from central systems in the following ways:

▶ Two separate oil tanks
▶ Use of different types of hydraulic fluids
▶ Return flow and filtration loop systems in the control oil circuit
▶ Possible differing locations of the hydraulic tanks

Often the hydraulic units are designed with the top plate of the oil tank used as a mounting surface for most, if not all of the components including piping (see cover picture). Other designs may mount key components on a separate frame which is mounted separately with other equipment. To achieve high availability, wear-critical and serviceable components are installed with redundant backups, generally consisting of pumps and filtration.

The description covers a central hydraulic unit with a single tank and an electrically driven main oil pump – not by the turbine. Redundant components are not shown for simplicity.

Circuit Description

![Circuit Diagram](image-url)
Function

During startup of a gas or steam turbine, proper sequencing of the pumps is required to ensure operational readiness of the required control, regulating and safety devices, and to also prevent damage of the installed equipment.

The hydraulic fluid (18) in the tank (4) can be preheated using heater elements (6). When the fluid reaches an allowable start temperature, the start-up process of a turbine can begin:

When started, the control oil pump (1) fills the accumulator (2) providing pressure for actuator movement as required.

Operation of the main oil pump (11), driven by an AC motor, supplies lubricating fluid for all connected consumers.

An auxiliary oil pump (12) is activated in the event of a failure of the main oil pump.

The emergency oil pump (13) is automatically started when the lubrication pressure drops below a specified limit.

The jacking oil pump (3) is used to pressurize the bearings with high pressure and causes the turbine shaft slightly the bearing race. In doing so, a thin film of lubricating oil provides a low friction layer between the bearing and the shaft. At this point, the hydraulic turning gear starts to accelerate the turbine rotor. After a stable oil layer has built up in the bearings, and ignition speed is reached in gas turbine, the turning gear is decoupled from the turbine shaft and the jacking oil pump (3) is switched off. The turbine then accelerates under its own power of gas or steam, until the desired speed is reached. As the lubricating oil is sent to the consumers, it passes through a three-way valve (15) which, with its temperature dependent control function, modulates the amount of fluid that flows through the oil cooler (14). This is required to maintain oil temperature in its desired range. Because cleanliness of the oil has a large influence on the life of the turbine shaft bearings, the oil is drawn through a wide-mesh suction strainer (not shown) at the inlet side the pump forced through a fine-mesh line-filter (8) before reaching the bearings.

When using a fixed displacement lubricating oil pump, a relief valve (16) is connected to the system at the filter outlet to maintain the required bearing lubrication pressure. The difference between the pump flow and the oil flow used for lubrication returns through the relief valve to the oil reservoir.

After the oil has passed through the oil channels, it flows via gravity through a return pipe to the reservoir, which is located below the turbine axis.

Main Components

Main Oil Pump (11)

During normal operation, the main oil pump provides the total lubricating oil requirements for the turbine system. General centrifugal pumps, as well as positive displacement pumps are used, which can be either gear or screw type pumps.

The main oil pump can be driven from an AC electric motor or directly from the turbine using mechanical coupling.

Auxiliary Oil Pump (12)

The auxiliary oil pump is identical to the main oil pump. It is able to deliver the total lubricating oil requirements in case of a failure of the main oil pump. This pump is driven by an AC electric motor, and switches on when the system pressure of the main oil pump drops below a defined value.

When the main oil pump is driven directly from the turbine shaft, the pump speed is not high enough to produce a sufficient flow and pressure during start-up and shutdown of the turbine. In these cases, the auxiliary oil pump is switched on to supplement the main oil pump.

Emergency Oil Pump (13)

The emergency oil pump is typically the same pump as the auxiliary oil pump, but with a reduced input power. It is sized so that in the event of a failure, sufficient oil is supplied to the bearings to allow the rotor to coast down to a stop.

To allow for operation in the case of loss in the power grid, this pump is driven by a DC electric motor, the power is supplied by a battery.

The emergency oil pump is not intended for continuous operation.

Jacking Oil Pump (3)

The jacking oil pump is used in large turbine systems to prevent metal-to-metal contact in the bearings during turbine start-up. This is accomplished by applying high-pressure oil to the turbine shaft bearings, raising the shaft with the high-pressure oil.

If a hydraulic turning gear system is used, the turning gear motor is supplied by oil from the jacking oil pump. Gear or piston pumps are typically used in this circuit.

Control Oil Pump (1)

The use of pressure compensated piston pumps is recommended to supply high-pressure oil to the actuators. These pumps deliver the required flow and minimize power requirements.

Hydraulic Accumulator (2)

A hydraulic accumulator is used to provide peak flow for fast actuator motion as required by the processes. The accumulator is sized so that in event of a power failure the “Emergency Shutdown Program” can be utilized without external power, to bring the turbine to a stop.
A mist separator is located on the closed tank and generates vacuum in the tank, which continues along the main return line from the bearings. Oil mist, which is formed by turbulent flow in the bearings is aspirated, and prevents the formation of explosive oil vapor.

**Tank (4)**
The capacity of lubricating oil tank can be up to one thousand gallons, or more and depends on the volume of circulated oil. Sensors for oil level and temperature are mounted in the tank. The installation of tank baffles increases the dwell time of the oil in the tank and promotes deaeration of the oil. The manhole covers are provided to allow access to the tank interior for cleaning and inspection.

**Oil Containment Tray (5)**
An oil containment tray is mounted below the power unit to prevent oil leakage into the environment. The containment tray is present to contain accidental loss of oil as well as loss resulting from repairs and maintenance.

**Oil Cooler (14)**
Oil-water coolers can be “shell and tube” type or plate-type design, and are used to remove heat from the hydraulic fluid. Air over oil coolers are also available.

**Relief Valve (16)**
A relief valve is recommended when fixed displacement pumps are used. Flow in excess of the current demand is returned to the tank via the relief valve, which maintains constant pressure in the circuit.

**Duplex Low-Pressure Filter (8)**
Low-pressure filters with high nominal flow rates are used to remove particulate contamination from the lubricating oil circuit. During turbine operation the filter elements can be changed as required by switching the flow to the other filter element. A contamination indicator provides indication of the filter’s condition.

**Duplex High-Pressure Filter (9)**
The switchable double filters are designed for high pressure and are required for the actuator servo controls. They remove particulate contamination from the high-pressure control circuit and are designed to allow for continuous usage during a filter element change.

**High Pressure Filter (10)**
A single high-pressure filter is used in the jacking oil circuit. Duplex filters are not required since this function only operates intermittently. Replacement of the filter element can be performed when this circuit is not used.

**Oil Mist Separator (7)**
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