

TANDEM COMPOUND, CONDENSING TURBINE

The steam turbine, like any other high grade machine, requires for sustained efficiency and continuity of operation a reasonable minimum of care and attention on the part of the operator. In order that the unit may receive such care and attention it is necessary that the operators become thoroughly familiar, not only with the mechanical structure of the turbine parts, but also with their purpose, and, in a general way, with the reasons why they are so designed. The following brief instructions for the care and operation of the turbine have been prepared as an aid to the attainment of this desired information and it is hoped that they may be found to be broad enough in scope for that purpose.

General Description

This unit consists of a two cylinder, tandem compound, condensing turbine, designed for high operating efficiencies and maximum reliability. The steam conditions with which it is intended to operate, the normal speed, and the maximum load, are given on the Title Page of the Instruction Book.

The construction of the entire turbine is shown in the longitudinal section photograph. This illustration is arranged to show a side view below the horizontal centerline and a longitudinal section above the centerline.

The high pressure turbine is of the combination impulse and reaction type. The exhaust opening is at the top of the cylinder and the steam passes into the low pressure turbine through a single cross-over pipe. The low pressure turbine is a straight reaction, double flow machine with steam entering at the center of the blade path and flowing toward an exhaust opening at each end.

Openings are provided in the cylinders through which steam may be extracted for feed water heating. The size and location of these openings are given on the "Outline" Drawing.

Cylinders

The structural shapes of the cylinders and their methods of support are carefully designed to obtain free but symmetrical movements resulting from thermal changes, and thereby reduce to a minimum the possibility of distortion. A feature of major importance in the accomplishment of this desired condition under conditions of warming and starting is the provision for an annular belt of steam extending around the entire high pressure cylinder at the inlet end which maintains equal temperatures in the base and cover. This chamber serves as a steam passage between one of the governing valves and its nozzles which are located in the base. Until synchronous speed has been reached, it therefore is filled with high temperature steam as soon as the throttle valve is opened. The flow through the balance piston maintains the condition after the machine has been warmed up and placed on the line.

The high pressure cylinder is made of cast steel (or a suitable alloy when the steam temperatures are unusually high) and is split on the horizontal centerplane to form a base and cover. Separate blade rings are provided, while the balance piston rings are formed integrally in the cylinder castings.

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This cylinder is supported by four arms (or lugs) which are cast integrally at the top of the base, thus locating the point of support as closely as possible to the horizontal centerline. At the exhaust end, these arms rest on a pedestal, formed by the low pressure turbine cylinder base. Transverse keys, one attached to the bottom of each arm by a single sleeve type dowel and free to slide in its keyway cut in the pedestal, maintain the correct axial position of the cylinder with respect to the pedestal, but allow free expansion in a transverse direction. At the thrust end, the cylinder arms rest on a separate pedestal and likewise are free to expand transversely from the longitudinal centerline. At each end, the cylinder is connected to the adjacent pedestal by a single vertical key placed on the longitudinal centerline, thus maintaining the correct transverse position of the cylinder with relation to the pedestals. The exhaust end pedestal, being integral with the low pressure cylinder, definitely locates the axial position of the high pressure cylinder with relation to the low pressure. The thrust end pedestal is free to slide axially on its base, but is held against transverse movement by an axial key placed on the longitudinal centerline between it and the base. Any tendency to tilt or lift is limited by side gibs which are fitted with ample clearance to allow free movement axially. Any tendency of the cylinder to rise off the pedestals is limited by a stud bolt through each arm. These bolts are placed inside the sleeve type dowels and are fitted with ample clearance under the nut and around the bolt to allow free movement of the cylinder arms in response to temperature changes.

The low pressure cylinder is divided vertically into two sections, each being split in the horizontal plane to form a base and cover. At the time of installation, the vertical joint is made up permanently and thereafter the cover is handled as a single piece. With the double flow arrangement, steam enters at the center, flowing toward each end and thence downward into a combined exhaust into the condenser. Hence the blading is identical in both ends, with the exception that one side is right hand and the other is left hand. The blades are carried in a separate blade ring which is supported in the cylinder by lugs just below the horizontal centerline.

The complete low pressure element is supported by a continuous foot or skirt which is cast integrally and extends around the cylinder base. This foot rests on seating plates which are grouted to the foundation. Its location is maintained by four keys between the cylinder foot and the seating plates, located as follows: Two keys, one at each end, placed axially on the longitudinal centerline, definitely locate the cylinder in a transverse direction but permit free expansion in an axial direction. The other two keys, one on each side, placed transversely on the transverse centerline, definitely locate the cylinder in an axial direction but permit free expansion in a transverse direction. Therefore, from a point at the center of the exhaust opening the cylinder can expand freely in any direction in the horizontal plane, at the top of the foundation seating plates. The low pressure cylinder forms the housing for its own bearings and also for the exhaust end bearing of the high pressure turbine and the inboard bearing of the generator.

The base and cover of the high pressure section of the cylinder are bolted together by large stud bolts (or studs). In order to obtain the proper stress in each of these bolts, they must be initially tightened to set up a definite stress. The correct method to obtain this stress is described in the Supplement on Bolt Tightening. The cylinder joint faces are finished to make a tight joint under the standard hydrostatic and steam tests with the faces dry and metal to metal. When assembling the machine for operation, triple boiled linseed oil should be used on the joint faces.

Rotors

The high pressure turbine rotor is machined from a solid forging of steel (or a suitable alloy for the higher temperatures). A separate stub shaft is bolted to the inlet end to form the thrust bearing collar and to carry the oil impellers and the overspeed trip.

The main body of the low pressure rotor is likewise machined from a solid forging of alloy steel. If considered necessary by design conditions, the blades of one or more of the exhaust rows are carried on separate alloy steel discs which are shrunk onto the main body. In addition to the heavy shrink fits, these discs are further secured by split dowel rings which are, in turn, held by solid rings shrunk on them.

The entire rotors are finish machined and, after being completely bladed, are given a running test at 20% overspeed and an accurate dynamic balance.

A flanged rigid type coupling is used between the high pressure and low pressure rotors and the low pressure is located axially by the high pressure turbine thrust bearing. The low pressure rotor is, in turn, connected to the generator field by a rigid coupling and the main rotating element thus formed (consisting of high pressure turbine rotor, low pressure turbine rotor and generator rotor) is carried in six bearings.

Blading

The blade path includes an impulse element (either Curtis or Rateau) operating with partial admission control, followed by reaction blading in the high pressure turbine and double flow reaction blading in the low pressure turbine. The exact blade arrangement and the number of stages or rows are given on the Title Page of the Instruction Book. Throughout the blade path, the massive rotating and stationary parts are separated by relatively large clearances and the reduced clearances and the reduced clearances necessary to control steam leakage are maintained by thin seal strips. These strips are made of an alloy steel with excellent wearing qualities so that contacts may occur under abnormal conditions and the strips will rub away without resulting in any damage to major parts.

Balance Pistons

The inlet end of the high pressure rotor is machined to form a two stage balance piston (or dummy) which is designed to overbalance the thrust on the blading and thus produce a thrust toward the inlet end of the machine under all operating conditions. With this arrangement, any floating of the rotor, such as is possible in case of loss of load, can occur toward the exhaust end only, thus temporarily increasing the axial running clearance by the amount of clearance in the thrust bearing but maintaining at least the desired minimum clearance at all times.

The steam leakage past the balance piston seals is led through external pipes and is returned to the cylinder at lower pressure zones.

The balance piston labyrinth seals are of the axial and radial clearance type and are described in a separate leaflet. During starting and stopping periods, in the first month of supervised operation of the unit, the rotor can be moved (by means of the thrust bearing adjusting mechanism) to change the axial clearance throughout the whole unit. During this time measurements will be taken to determine the maximum relative movements of the turbine cylinder and rotor. After these movements have been established the thrust bearing cage stops will be set (as described in the thrust bearing supplement) and no further adjustment of the mechanism will be required.

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Control

The control and oil system diagram shows the various parts of the control system and their relation to one another. The detail operation of each particular part is described in its respective leaflet.

Sufficient oil should be provided so that when the turbine is running at full speed the oil level in the reservoir, as shown by the gauge, is within the limits given on the indicator plate. Although there is a permanent filter in the oil system, it is desirable as a precaution to strain the oil through a fine mesh screen or cloth just before putting it into the reservoir.

The amount of water circulated through the oil cooler should be regulated to maintain the temperature of the oil leaving the cooler between 100 and 110° F. The correct criterion of oil cooler water supply is, of course, the temperature of the oil leaving the hottest bearing. This temperature will vary with different units and operating conditions. However, in general, oil return temperatures of 140 to 160° F. are considered good practice. When starting a turbine, the oil cooler water should not be turned on until the oil temperature has increased to the approximate limits given above.

Operation and Maintenance

A recommended procedure for operating the turbine is given in a separate leaflet. While these instructions are quite specific it is impossible to cover all details. Hence, they do not in any way relieve the operator of using sound judgment and exercising due caution.

Likewise, it is impossible to give any detailed procedure for maintenance work. It is believed that the illustrations and descriptions of the detail parts as given in the Instruction Book should enable the Maintenance Engineer to care for the apparatus properly.