CONDENSING, EXTRACTION TURBINE

INTRODUCTION

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 familiar, not only with the mechanical structure of the various parts of the turbine, but also with their purpose, and, in a general way, with the reasons why they are so designed. The following brief instructions 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 is a combination impulse and reaction turbine designed for high operating efficiencies. It is arranged for automatically controlled extraction to supply steam at the desired pressure for heating or process work. The exact 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. It should be noted that this illustration shows a side view below the horizontal centerline and a longitudinal section above the centerline.

The blade path includes impulse elements and groups of reaction blading, the exact combination for each turbine being determined by the steam conditions and capacity required. The exact blade arrangement and the number of stages or rows of each type are given on the Title Page. Steam is admitted through the main nozzles and passes through the high pressure section of blading to the extraction zone where a part is led out of the cylinder to supply the extraction system. The remainder, which is not used in the extraction system, passes through the extraction valve steam chest to the low pressure section of blading and exhausts into the condenser.

Depending on the size of the machine, one or more openings may be provided in the cylinder through which steam can be extracted non-automatically, if desired, for additional feed water heating or process work. The sizes of these openings, when provided, are given on the outline drawing. Since extraction at these points is not controlled automatically, the pressures and quantities available are determined by the load being carried by the turbine and the quantity of steam being extracted automatically.

Cylinder

The structural shape of the cylinder and the method of support are carefully designed to obtain 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 is the provision for an annular belt of steam extending around the entire cylinder at the high pressure end which maintains equal temperatures in the base and cover. This chamber serves as the steam passage between the No. 1 governing valve located in the cylinder cover, and its nozzles which are located in the base. It, therefore, is filled with high temperature steam as soon as the first valve opens and remains filled until this valve closes.

The complete cylinder is made in either two or three sections, depending on the size of the machine. The high pressure sections are of cast steel (or a suitable alloy when the steam temperatures are unusually high) and the low pressure is of cast iron. Each section is split in the horizontal plane through the axis to form a base and cover. During the installation, the vertical joints are made up permanently and thereafter the cover is handled as a single piece. The balance piston rings are formed integrally in the cylinder castings. All blade rings, with the exception of the last one in the low pressure end are separate elements supported in the cylinder at the horizontal joint and guided at the top and bottom by dowel pins so as to maintain the correct position with respect to the turbine axis, but to allow the parts to expand and contract freely in response to temperature changes.

The low pressure end of the cylinder is supported by feet, projecting from the exhaust chamber, which extend along each side and along a portion of the exhaust end. These supporting feet rest on seating plates which are grouted to the foundation. The position of the cylinder at this end is maintained by three keys placed between the supporting feet and the seating plates. Two of these keys, one on each side, placed transversely on the transverse centerline of the exhaust, definitely locate the cylinder in an axial direction but permit free expansion in a transverse direction. The third key, placed axially on the longitudinal centerline just below the No. 3 bearing, definitely locates this end of the cylinder in a transverse direction but permits free expansion in an axial 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.

At the high pressure end, the cylinder is supported by two 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. These arms rest on tapered, split keys placed between them and the pedestal. The correct axial position of the cylinder with respect to the pedestal is maintained by sleeve type dowels which extend through both halves of the split keys. These dowels are fitted with clearance in a transverse direction and each cylinder arm is thus connected to the pedestal by a pivot arrangement which gives the desired flexibility to reduce distortion to a minimum. A vertical key between the cylinder and the pedestal definitely locates the cylinder in a transverse direction. The pedestal, in turn, 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 is limited by side gibs which are fitted with ample clearance to allow free movement axially.

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 tightened sufficiently to stretch them a definite amount. 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. In addition, a sealing groove is provided in the joint face, into which sealing compound can be injected in case leaks develop after periods of operation.

Rotor

The main body of the turbine rotor is machined from a solid forging of steel (or suitable alloy for the higher temperatures) with a central inspection hole drilled through its entire length. A separate stub shaft is bolted to the inlet end to form the thrust bearing collar and to carry the oil impellers and overspeed trip. The entire rotor is finish-machined and, after being completely bladed, is given a running test at 20% overspeed and an accurate dynamic balance. The exhaust end is connected to the generator field by a rigid coupling and the main rotating element thus formed is carried in four bearings.

Balance Piston

The inlet end of the rotor is machined to form a two stage balance piston (or dummy) which is designed to over-balance 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, as determined by the steam conditions and design of the machine. The balance piston labyrinth seals are of the radial clearance type and are described in a separate leaflet.

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.

Enough 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 strainer 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 Books should enable the Maintenance Engineer to care for the apparatus properly.