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THE BASICS OF STEAM TURBINES

A **steam turbine** is a rotary type of steam engine, having a rotating wheel to which is secured a series of buckets, blades or vanes, uniformly spaced on its periphery. Steam from nozzles or guide passages is directed continuously against these buckets, blades or vanes, thus causing their rotation. **Expansion** of steam in the nozzles or buckets converts its heat energy into energy of motion and gives it a high velocity which is expended on the moving wheel or buckets. The difference in the various types of steam turbines is due to different methods of using the steam. depending upon the construction and arrangement of the nozzles, steam passages and buckets.

The steam turbine is essentially a high speed machine. It is used to advantage with direct connection to electric generators, centrifugal pumps and compressors and with geared connections to rolling mills, fans and other machinery which are run at low speed.

The **advantages** of steam turbines are: comparatively low initial cost, low expense for maintenance, small floor space, large overload capacity, exhaust steam is free of oil contamination as no internal lubrication is needed and high efficiency over a wide range of load conditions. The steam turbine can be built in a unit of much greater capacity than is practical with the reciprocating steam engines.

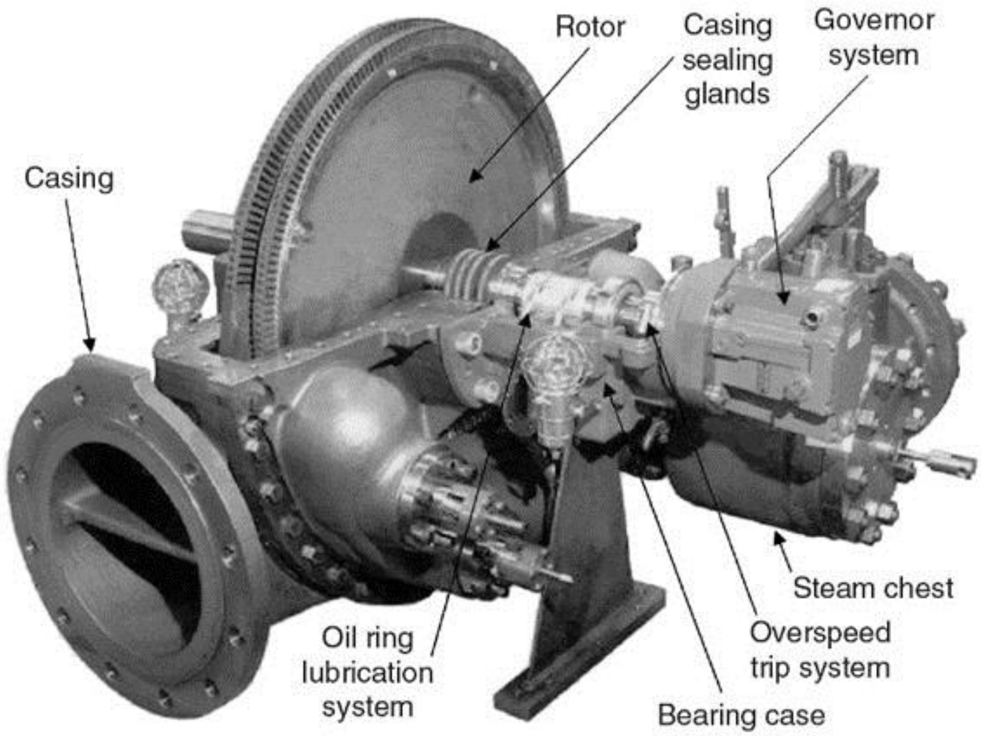
CLASSIFICATION OF STEAM TURBINES	
Shaft Position	Horizontal or vertical
Method of Drive	Direct connected or geared
Action of the Steam	Impulse or reaction
Exhaust Pressure	Non-condensing, condensing, extraction

THE IMPULSE TYPE STEAM TURBINE

In the **impulse type steam turbine**, the expansion and consequent change in the pressure of the steam occurs entirely within the nozzles which direct the steam in jets against the moving buckets. In as much as the expansion of steam takes place in the nozzles, the **clearance** between the rotating and stationary surfaces is **greater** than in the reaction type steam turbine.

THE REACTION TYPE STEAM TURBINE

In the **reaction type steam turbine**, the expansion and consequent change in pressure of the steam occurs entirely in the blading where the steam is directed against the moving buckets or blading by guide valves or orifices. The expansion of the steam takes place through both the stationary and moving guide vanes, and therefore the **clearance** space between the stationary and moving surfaces is very **small,** to cut down on the pressure drop by leakage between stages, to a minimum.



Single Stage Impulse Steam Turbine Cutaway

THE STEAM STRAINER

A steam **strainer** should be installed in the main steam line to the turbine to prevent foreign particles from being carried into the turbine with the steam. It is therefore an important accessory. Steam strainers are normally installed **ahead** of and close to the throttle valve.

Some are an integral part of the governor/throttle valve assembly. When installed as a separate part of the unit, the grid is usually accessible for cleaning without breaking any piping connections.

STEAM SEPARATOR AND DRAINS

It is unsafe to permit water to enter the steam passages of a turbine. The steam supplied to a turbine should be reasonably dry at all times. A **separator** of the receiver type and having ample drains should be installed in the steam supply line near the turbine. The drains should be located on the boiler side of the throttle valve. In addition it is necessary to drain all portions of the turbine casing where water from condensation may collect. Water in any pocket in a turbine casing may cause a slug of water to be carried over in the turbine during operation, with very serious results.

THE THROTTLE VALVE

The **throttle valve** performs the functions of controlling the quantity of steam admitted to the turbine by throttling and acting as a quick-closing emergency valve (on some governors). It should always be closed by means of the manual trip device. The throttle valve should receive careful attention and all moving parts should be kept well lubricated.

At dismantled inspections the throttle valve should be examined for leakage at the disc, under the seat and through the threads. A careful check should be made to see that no dirt, grit or metallic particles are imbedded in the valve seat or disc and no corrosion or pitting is taking place in these parts or in the valve body. It is important that proper repairs or replacement be made when required for tightness and free operation.

There are various **tripping mechanisms** that may be used with a throttle valve. These include a hand trip lever on the valve, a solenoid trip, a pressure trip, and a differential pressure trip. These specially designed trips usually have separate hydraulic operating and emergency cylinders. Certain older types of throttle valves have a steam actuated cylinder for operating the quick closing emergency valve. In this type, steam leakage around the piston may cause rusting and sticking of the valve so that it becomes necessary to jar the valve to close it.

THE OPERATING GOVERNOR

All turbine governors, regardless of their design operate off of one specific principle: **centrifugal force** from the main shaft acting to overcome spring tension.

Except on smaller size auxiliary turbines, where shaft governors are used, very little work is done by the governor. It normally operates as a relay, and the mechanism upon which the governor acts must be given the same consideration as the governor. Proper lubrication of the parts of the governor should be carefully maintained. Any lost motion in this mechanism is of primary importance and should be given immediate attention.

The typical **shaft governor** employs weights held in place by a stationary spring. Centrifugal force tends to move the weights outward. This motion is transmitted to the governor slide and in turn through levers, to the valve regulating admission of steam to the turbine. The weights have knife edges that contact knife edge seats on the stationary spring, causing it to move. It is essential that the knife edges and seats be kept in good condition.

Practically the same type governor is used on larger units, except that the motion transmitted to the governor slide moves only a pilot valve which controls the flow of oil to an operating piston directly attached to the steam admission valve. These governors are called **oil relay governors**. It takes oil pressure, usually shaft driven off the main turbine shaft, to actuate the governor and open the throttle valve. In this sense, they will "fail safe" on loss of the oil pump or oil pressure.

Hydraulic governors are an older type of oil relay governor taking oil pressure directly from the main oil pump, instead of through a pilot valve, with excess oil pressure bled off back to the main oil sump. The main drawback to this type governor is that unlike the oil relay governor that takes oil pressure to open the throttle valve, the hydraulic governor requires oil pressure to close the throttle valve, and therefore do not "fail safe" on loss of the main oil pump or pressure.

THE EMERGENCY GOVERNOR

Only a relatively short period of time is required to dangerously accelerate the rotor of a steam turbine. Therefore, when the governor fails, the rotor is subject to the danger of a "run away", or in other words, instant over speeding. To guard against this hazard, the turbine is provided with an **emergency governor** which shuts off the steam to the turbine when normal speed is exceeded by 10%.

Most emergency governors (also referred to as overspeed trip) consist of a small piston located in a recessed opening in a collar mounted on the main shaft of the turbine. Centrifugal force of the turbine over speeding causes the piston to move outward where it contacts a trip lever as it emerges from the recess, which in turn, actuates the quick closing emergency valve, shutting off the steam supply to the turbine. Movement of the piston is opposed by a spring, the tension of which is adjustable to obtain the desired tripping speed.

AUXILIARY OIL PUMP

The auxiliary oil pump provides oil pressure necessary to operate the governor control valves and to supply sufficient lubricating oil to the bearings when the turbine is being started, shutdown or in the event of failure of the main oil pump. Older auxiliary oil pumps had to be manually actuated by the turbine operator and for obvious reasons of the possibility of human error, the auxiliary oil pump is now actuated by a pressure switch on drop in oil pressure.

Most auxiliary oil pumps are electric motor driven, but they can also be steam turbine driven, hence the term, "steam auxiliary oil pump". On steam turbine driven generator sets the auxiliary oil pump is most always steam turbine driven, because in the event of a turbine trip, for whatever reason, there would be no electricity to operate the auxiliary oil pump.

OILING SYSTEM

Fire hazard in connection with the lubricating oil system became an important concern as steam turbine operating pressures and superheat temperatures increased over the years. With steam temperatures up to 600 deg. F there is little or no fire hazard caused by lubricating oil coming into contact with a steam pipe. At a steam temperature of 700 deg. F however, oil will flash into flame should contact with a steam pipe be longer than one minute.

At 800 deg. F the time is about 2 seconds and at 900 deg. F fire follows contact almost instantaneously. Therefore it is necessary that leakage of oil be eliminated on machines using high temperature steam, or switch to a di-ester synthetic oil which will not flash even at temperatures as high as 1,000 deg. F. However, there are drawbacks to di-ester synthetics.

They will attack and dissolve any rubber based binder in gasket material. The only products impervious to di-ester synthetics are Teflon and piton. So, many times it is easier to cope with the problem of oil leakage than to change to another oil.

At the time of a dismantled inspection the oiling system should be checked, the oil drained out, the oil strainer examined for sources of trouble such as dirt, sediment, chips of babbitt or brass, and grit or other abrasive or corrosive deposits. If sludge is found in the oil or the sump, there will be sludge in the oil lines and all parts of the oiling system.

Oil cooler tubes should be carefully cleaned. Normally the oil pressure is in excess of water pressure to prevent water entering the oiling system in case of a cooler leak.

THRUST BEARINGS AND SQUEALER RINGS

Thrust bearings should be checked for wear and clearance. The smaller impulse turbines have roller thrust bearings with specially hardened steel washers. These should be very carefully inspected as the clearance is close. Any bearings of this type which show even minute pitting or roughness of the rollers or any cutting or galling on the hardened washers should be replaced. In reality these are not thrust bearings, but only serve to maintain shaft position since there is not axial thrust transmitted to the shaft on impulse turbines.

The most commonly used type of thrust bearing used on reaction turbines has babbitt faced stationary plates. In many cases these are spring-backed or self-aligning to allow for a slight amount of misalignment. The condition of the hardened steel runner plates should be carefully noted and the faces should be kept true to within .001 inch.

Reaction turbines utilize either a parallel plate or a Kingsbury type thrust bearing. On a **parallel plate** thrust bearing pressure is applied to the plates but because they are solid shoes, the pressure may only touch a portion of the shoes resulting in uneven wear. The shoes of the **Kingsbury** thrust bearing are made of segments which permit equal pressure throughout the bearing resulting in more total surface area contact. Because the plates are segmented they also receive more lubrication and this type of bearing can handle larger thrust loads.

It is the practice of certain manufacturers of the impulse type steam turbine to build into the machine so-called squealer rings. The purpose of these rings is to give warning before a dangerous degree of wear occurs at the thrust bearing.

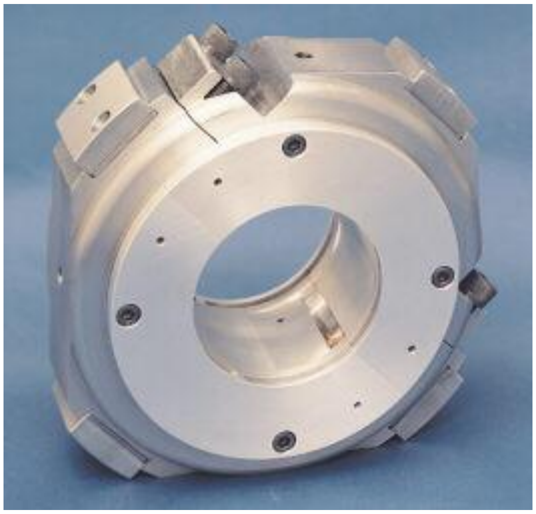
They are usually either placed close to or made a part of the thrust bearing and consist of a rotating ring mounted on the shaft and stationary rings mounted on a stationary part close thereto. The rings are spaced with a clearance less than the clearance at the bucket wheels so as to make contact and give warning before the wheels begin to rub, hence the squeal is easily detected.

MAIN BEARINGS

Various types of bearings are used by the different manufacturers. The older type bearings were babbitt lined in cast iron shells and had water coils imbedded in the babbitt for cooling purposes. This type used a relatively small quantity of oil, the oil being drawn under the bearings to form the oil film. Modern bearings are generally of the oil-cooled type, where large quantities of oil are fed into the top half of the bearing and distributed it's full length by special cut oil grooving. The oil acts as the cooling medium as well as the lubricant. On the latest types of steam turbines, in the larger units there are no valves in the oil lines, with the oil flow being regulated by orifices provided at the factory before shipment. Bearing pressures per square inch of projected area have been greatly increased in the new designs.

Babbitt bearing

Bearing clearances allowed when a turbine leaves the factory are generally from .001 to .002 inch per inch of shaft diameter, with a minimum clearance of .010 inch. In most cases this amount may be doubled before replacement is necessary, although the running condition and load on the bearing should be considered. When the bearings of a steam turbine need to be re-babbitted, they should be returned to the manufacturer as the babbitt is of a special composition and have special grooving.



Complete babbit bearing assembly

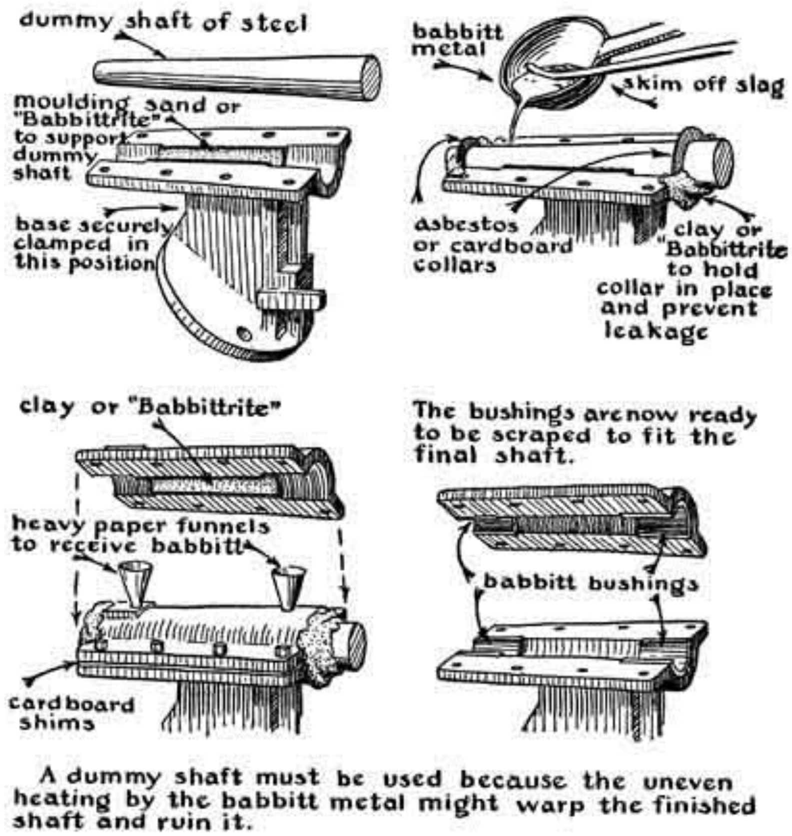
Packing glands used on steam turbine

SHAFT PACKING

The function of the shaft packing is to prevent excessive steam leakage. The water seal method is used in combination with packing rings of **carbon or labyrinth** type, affords a positive seal when functioning properly. Where this type of seal is used careful check should be made for cracking of blading and erosion of the stationary casings. Clearances also should be checked.

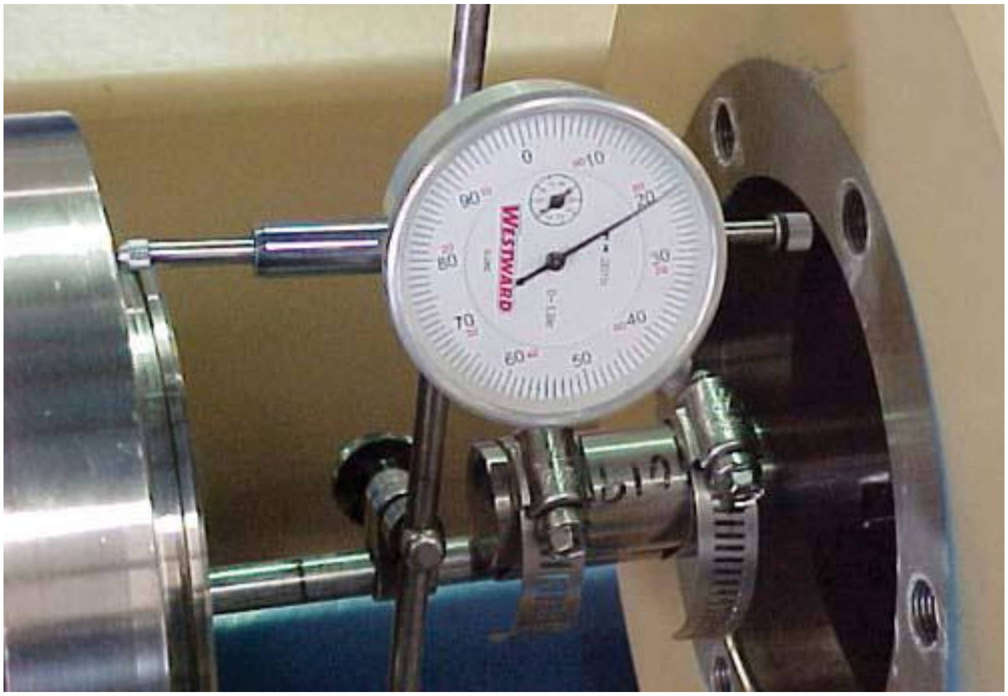
Other types of shaft packing are made in three or four segments held together by springs called garter springs, and are self-aligning, to some extent. These types should be checked for clearance, flexibility of springs, joint openings between sections and overall general condition. Carbon packing will be found to have smaller clearances than most other types. Another type used is the bronze lead alloy, which has good wearing-in qualities without excessive overheating, so that small clearances may be used. The diaphragm packing in the impulse type turbine usually has only one ring of packing per diaphragm, because of the limited space and small pressure drop. Wear on diaphragm packings is an indication of diaphragm misalignment. As the packing controls leakage of steam between stages, wear of the packing will have a definite effect on turbine efficiency.

Segmented carbon packing rings.



Pouring a new babbitt bearing

Misalignment of diaphragms may cause localized heating, due to excessive friction, which tends to bow the shaft. This, in turn, will result in shaft vibrations.



Coupling alignment using dial indicator method.

SHAFT COUPLINGS

Shaft couplings connecting steam turbines to driven machines are usually of the flexible type. Turbine manufacturers use several designs of flexible couplings, usually of the jaw, pin or gear type. Lubrication is a matter of extreme importance with all flexible couplings, as lack of sufficient and proper lubricant will cause excessive wear. Wear and the lubrication of couplings should be checked at each inspection, and in no case less than once each year.

BUCKETS AND BLADES

The term buckets and blades are often used synonymously. Although the shape and appearance are similar, it has usually been considered that buckets are used in the impulse type turbine and blades, both stationary and rotating, are used in the reaction type steam turbine. Buckets of impulse turbines and blades of some reaction turbines have a shroud band, either continuous or in sections, either welded, brazed or riveted to the blade tip, which acts as a bracing to the blades and maintains radial clearance with the turbine casing. One of the principal causes of blade failure is shocks due to water being carried over with the steam. This may be due to priming of the boiler, poor arrangement of the steam piping, resulting in pockets in the line which are insufficiently drained, of failure of the drains to operate.

At light loads a considerable quantity of water may accumulate in these pockets and when the load increases, the higher velocity of the steam will carry this water over into the turbine in the form of slugs. The impact of this mass of water at the comparatively high velocity may cause serious damage to the blading.

WHEEL AND BUCKET VIBRATION

Sometimes the wheels or discs on turbines tend o vibrate under certain conditions. In the majority of cases an exciting force is required to start the wheel to vibrate and in many cases it is necessary for the exciting force to continue it's action to maintain the wheel vibration. The exciting force may be small, such as quick changes in load or governor hunting, or vibration of the turbine itself, caused by poor foundation or rigid construction between the turbine and the building structure or other machines, or from the vibration from other machines transmitted to the foundation through the foundation.

DUMMY PISTONS IN REACTION TURBINES

The **dummy or balance piston** in a reaction type turbine is designed to counteract the end thrust on the blading and thus produce a thrust of the rotor towards the high pressure end of the machine under all operating conditions.

With this arrangement any floating of the rotor, such as is possible in the event of loss of load, can occur only towards the coupling end and thus will temporarily increase the running clearance by the amount of play in the thrust bearing.

Dummy pistons may be either integral with the solid rotor or shrunk and keyed into position. When the dummy pistons are not integral with the shaft or rotor, but are shrunk and keyed on, a gradual loosening of the pistons from the shaft causes vibration at certain loads and sometimes it will attain sufficient magnitude to strip the high pressure blading. The grinding in and setting of the clearances of the dummy piston packing should never be undertaken except by a representative of the manufacturer.

TURBINE WHEELS

The wheels on a turbine shaft should be checked carefully at a dismantled inspection for possible defects such as looseness on the shaft. A loose wheel is often difficult to locate as it may appear tight when the turbine is stationary and be loose when the rotor is at normal speed.

Evidence of this is that the wheel will run untrue and can be detected by indicating the side of the wheel at the rim. A close examination of the shaft or key may disclose traces of iron oxide deposits adjacent to the wheel.

Cracks are sometimes difficult to discover in some parts of a wheel or disc, particularly at the bucket or blade attachments. The majority of impulse wheels have so-called steam balance holes drilled through them to equalize the steam pressure on both sides of the wheel. Cracks in the wheel disc frequently start at these holes. The manufacturers carefully grind and round off all corners of these holes to reduce the possibility of cracks starting at the holes. Where there is any suspicion whatsoever that a wheel may be cracked, the entire wheel should be given a magnaflux test or be x-rayed.

EXTRACTION OR BLEEDER TURBINES

For industrial applications, steam turbines are often designed to extract steam at definite pressures from one or more points along the expansion cycle. This is done on either the impulse or the reaction machine, with the turbine acting as a reducing valve and at the same time driving a machine.

Where steam is taken off from the turbine for process work, non-return valves are required at the turbine, just in case that there may be a live steam connection somewhere in the plant, to prevent a backup of steam into the turbine, which would allow it to overspeed, and being beyond the main steam inlet, the governor would have no control over the speed and a runaway would result.

The only difference between a bleeder turbine and an extraction turbine is that the **extraction turbine** has rotating grid valves at each extraction point to maintain a constant pressure on the low pressure system being supplied. A **bleeder turbine** has no grid valves, so it uses un-controlled extraction of the steam to supply the lower pressure system. If it is not critical that the low pressure steam be kept exactly at its desired pressure, there is no need to incur the added expense of grid valves.

The turbine casing and exhaust hood are designed by the manufacturers with a liberal margin of safety for the steam pressure under normal operating conditions. These parts are not designed for the steam pressure which may accumulate should the exhaust passage be closed at any time while steam is being admitted to the turbine.

For this reason suitable relief valves must be installed on the exhaust piping on the turbine side of the first stop valve, and it must be of ample size to prevent the build-up of excessive exhaust pressure in the turbine casing. A relief valve or rupture disc is also placed on the turbine exhaust casing.

VIBRATION

Dependable and safe operation of a steam turbine requires that it run smoothly. Vibration is consequently a matter of great importance in turbine design and operation. The importance of good balance and smooth operation may be fully realized when it is considered that excessive vibration may result in a serious accident to the machine. Turbines have been completely wrecked by excessive vibration. Vibration will also produce severe stresses in the rotating parts which will ultimately lead to their failure.

Continued vibration which may not be serious enough to cause failure except after a considerable length of time will result in increased wear of the bearings and couplings, loosening of joints, damage to the foundation and loss in efficiency.

When taking shaft vibrations with a shaft stick vibration of the shaft is likely to be greater in amplitude than the vibration found on the bearing caps. This is due to the dampening effect of the oil in the bearings which reduces the transmission of shaft or rotor vibration to the bearings. Vibration readings may be irregular due to fluctuating loads or varying steam pressure.

Vibrations taken from the shaft are considered of great importance in determining the running conditions of the turbine. Such readings will generally give better indications of internal conditions or changes than will readings taken on the bearing caps. Special instruments are necessary in order to check vibration of steam turbines.

OPERATING A TURBINE AS A SYNCHRONOUS CONDENSER

It is sometimes the practice in power plants to operate a turbine-generator set as a synchronous condenser to improve the power factor of the system. In doing this certain precautions are necessary to protect the turbine from damage. The heat generated by the windage load in the low pressure end of the turbine is high and a flow of steam is required to carry away the heat and keep the turbine cool. When a turbine-generator is operated as a synchronous condenser, the electric generator is being run as a synchronous motor and it is turning the steam turbine, and for that reason live steam at 3 to 5 pounds pressure is admitted to the turbine to keep it cool, otherwise the effect would be much the same as operating a centrifugal pump without water.

PRESSURE AND TEMPERATURE GAUGES

Pressure and temperature gauges installed on a steam turbine can be used to foretell pending troubles. Thermometers on the oil inlet and discharge lines from a bearing will indicate a rise in temperature caused by a bearing that is dirty or out of adjustment, by an insufficient flow of oil. The normal temperature of a steam turbine bearing usually should not exceed 150 degrees. Fahrenheit.

The pressure gauges on the shaft seal by comparison with previous readings will indicate whether the clearances have changed or if wear is taking place.

An increase in steam pressure at the first stage or at other stages of the turbine, over the pressure shown by previous readings at the same load and with the same vacuum, is a reasonably good indication that something is wrong with the blading or nozzles of the machine.

A gradual increase in pressure is frequently caused by deposits forming on the buckets, blades and nozzles, or it may be due to corrosion or erosion of these parts. A sudden increase in pressure is indicative of damage to blades by some foreign body that has passed through the turbine or of blade failure.

When a steam turbine is operating condensing, an increase in the exhaust pressure means an increase in the steam rate. This increase in steam rate may be from 2 to 5% for each decrease in vacuum of one half inch of mercury, depending upon the load and turbine design. It is obvious therefore, that the highest possible vacuum is essential to obtaining maximum efficiency from the machine.

Practically all circulating water contains solids and dirt. These settle out in the condenser tubes and retard the transfer of heat from the steam to the cooling water, resulting in higher steam temperature and lower vacuum at the turbine exhaust. Checking temperature readings, the frequency at which cleaning can be determines form consideration of the cost of cleaning, the loss due to outage of the turbine during the cleaning period, and the saving to be effected by an increase in vacuum.

A simple but adequate method for determining the amount of fouling can be set up by plotting the difference between the temperatures of the circulating water at the inlet an at the outlet, and the difference between the condensate temperature and the temperature corresponding to the vacuum at the time the data is taken. These temperature differences should be plotted against months of the year as the abscissa.

As the condenser becomes dirty the curves of the two temperature differences become further apart. The distance between these curves at which it is advisable to clean the condenser can be readily established. Load conditions on the turbine should be approximately the same each time data is taken for the curves of this type.

SYNCHRONIZING A TURBINE GENERATOR

Steam or gas turbine-driven generators operating in parallel with other generators or with incoming power from the local utility require that the following conditions be satisfied:
1) Both machines must have the same frequency and wave form.
2) Their terminal voltages must be equal.
3) Their sequence of maximum potential values must be the same.

There are two types of generator synchronization: indicator synchronizing and lamp synchronizing.

LAMP SYNCHRONIZING

Machine #1 is running and supplying the load. Its oil circuit breaker is closed, the running plug inserted. Bring machine #2 up to voltage by slowly increasing the speed of the turbine. As the speed of machine #2 increases, insert the running plug. Then when the machines are running at nearly the same speed, the synchronizing light up, then go out, light up again etc. If the machines are in step with the lamps out or lamps in, (depending upon whether light or dark lamp connections are used) wait until they go out for a few seconds then close the oil circuit breaker on machine #2. Now the machines are in parallel.

In the case of a generator operating in a co-generation mode, the frequency of the incoming power from the local utility would represent machine #1.

INDICATOR SYNCHRONIZING

Proceed same as before: The rotary motion of the pointer on the indicator (called a synchroscope) indicates whether the generator to be synchronized is running too slow or too fast. When the pointer remains stationary in the vertical position, the two machines are in synchronism and the oil circuit breaker on the machine being synchronized can be closed.

Again, in a co-generating mode, the frequency of the incoming power from the local utility would have to be synchronized with.

Syncroscope indicator.

After paralleling the two machines, adjust the mechanical power input and the generated EMF (electromagnetic force) until each machine supplies its share of the total load, and the power factor of each machine is the same and equal to that of the total load. If this procedure is not done to balance the load, a lightly loaded machine is prone to slow down and fall out of synchronization in the even of a drop in demand. Should this happen, a directional relay called a reverse current trip will open the oil circuit breaker of the slower machine to protect it from being motorized by other machines on line.

GLAND SEAL CONDENSER OPERATION

Regardless of whether a steam turbine utilizes carbon rings or the labyrinth metallic packing to seal the shaft there is going to be some degree of leakage past these seals, depending upon the clearance between the shaft and the seal.

On a condensing turbine, this gland seal leak-off is piped to the condenser during normal operation and vented to atmosphere during startups and shutdowns, to prevent it from escaping into the turbine room.

Non-condensing impulse turbines normally have very little steam seal leak-off, so it is usually allowed to emit from the carbon packing cases and into the turbine room. This is usually only a wisp of steam and allows the turbine operator to visually determine the degree of wear on the carbon rings. This is the usual mode with an impulse type turbine exhausting into very low pressures such as a deaerator or low pressure heating system.

With non-condensing turbines using high pressure and sometimes superheated steam exhausting into another high pressure system, gland seal leak-off can pose several problems, including human safety.

With these type of "step-down" turbines, it is sometimes necessary to condense the gland seal leak-off in a small surface condenser called a **gland seal condenser** and either sewer it or recover it for re-use. Condensing it will both prevent it from leaking out into the turbine room and possibly injuring someone and also, with the vacuum on the condenser, pull it away from the carbon seals as fast as it leaks by. Carbon rings will crack and break if condensate from the steam leak-off builds up on one side with steam on the other, thus shortening the life of the carbon rings.

BRIDGE GAUGES

The **bridge gauge** is a type of micrometer supplied with steam turbines and other rotating machinery designed to indicate main bearing wear as referenced by a lowering of the shaft or a lateral movement of the shaft. Bridge gauges should give cold readings. The bearing caps are removed and the bridge gauge is fitted into position straddling the shaft. Two fingers project radially in towards the shaft from the bridge gauge.

The distance between the top of the shaft and the gauge finger which projects down will give an indication of the wear as it influences the vertical position of the shaft if this reading is compared with the design or previous readings. Horizontal shifting of the shaft will be indicated by the distance between the side of the shaft and the horizontal gauge finger.

As the main bearing wears, the shaft will drop in the bearing and radial clearance will decrease on the bottom half of the turbine casing bringing the blading shroud closer to rubbing the casing. Bearing wear will also cause lateral movement of the shaft affecting sideways radial clearances.

Many large reaction turbines have places along the rotor shaft where a plate may be removed, exposing the shaft, where the bridge gauge can be placed to take a measurement. Thus, the entire top half of the casing does not have to be removed.

Correcting pins are used with bridge gauges for the purpose of checking the accuracy of the bridge gauge itself. This is done by setting the bridge gauge on a known flat surface and inserting the pin under or between the top gauge finger and the table. The correcting pin is stamped with it’s length and the same reading should be indicated on the bridge gauge. The test should be made under design conditions of temperature.

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