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OPERATION OF STEAM TURBINES

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This invention relates to a process of operating steam turbines, especially those which are operated with steam from water which has been pre-treated.

Great disadvantages are caused in steam turbines, especially those which are operated with high pressure steam, say at 500° C. and below, in that salt incrustations are formed at the turbine blades originating from the salt from the treated boiler water. Because of the incrustation upon the blades caused thereby the efficacy of the turbine is strongly reduced, for instance by the reduction of the steam passage. The salt incrustation may even cause the destruction of the turbine and frequent stoppages of the turbine for purification purposes, for instance, rinsing out with water, become necessary.

In accordance with the present invention these salt incrustations upon the turbine can either completely or considerably be avoided by employing steam which contains only such salts, the crystallization interval of which is either completely or to the greatest part outside the working temperature of the turbine. This crystallization interval may be above as well as below the working temperature of the turbine.

When using steam having a salt content the crystallization interval of which is beyond the working temperature of the turbine, the salt is passed through the turbine in a solid crystallized state, if the crystallization interval is below the working temperature of the turbine, the salt passes through the turbine in the molten state. A separation of salt upon the turbine blades does not take place in either case. The composition of the salt in the steam depends on the composition of the salt in the boiler water, since the salt in the steam is mechanically carried over from the boiler water. It is understood that the treatment of the boiler water must be so that the crystallization interval of the salt particles is outside the working temperature of the turbine. The simplest way would be to neutralize the free alkali of the boiler water completely or almost completely by the addition of acids or acid salts, preferably inorganic acid or salts thereof. For this purpose all known treatments may be used. For reducing the oxygen content, if desired sulfurous acid or bisulfite or the like, or for removing the residual hardness phosphoric acid or phosphorous acid or salts thereof, or for reducing the corrosion chromates may be added to the boiler water. The addition of the said substances must naturally be made in so large a quantity that the crystallization interval of the salts is brought to temperatures being outside the operating temperature of the turbine.

In the following examples it is understood that the salt content of the boiler water changes in accordance with the evaporation. Therefore, only the proportion by weight of the single salts to one another has been indicated.

Example 1.—When starting with a water containing calcium sulfate, sodium chloride and calcium bicarbonate, which after treatment with a base exchanger and splitting up by heating of the bicarbonate formed, contains about equal quantities of sodium chloride, sodium sulfate and sodium hydroxide, incrustation of the blades occurs in a high pressure turbine the working temperature of which is between about 500 and about 150° C., since this salt mixture absolutely uniformly crystallizes at about 300° C. However, on removing the salts causing hardness from the water by precipitating the SO_4-ions by treatment with barium hydroxide and by removing the calcium bicarbonate by the addition of calcium hydroxide, and by transforming the calcium salts still remaining by means of a base exchanger into the corresponding sodium salts, so that the boiler water contains only 4.4 parts by weight of sodium hydroxide upon 120 parts by weight of sodium chloride, no salt incrustation occurs in the same turbine, since the latter salt mixture already at 600° C. has crystallized to 90%, so that the salt passes through the turbine in a solid form.

Example 2.—On carrying out the treatment of the boiler water in such a manner that besides 100 parts of NaCl,10 parts of Na_2SO_4 and 10 parts of SiO_2 no sodium carbonate or sodium hydroxide, but 6 parts of tri-sodium phosphate are contained therein, no salt incrustation of the turbine occurs, since this salt mixture already crystallizes to 25% at 620° C. and completely at 550° C. Also in this case the salt is passed through the turbine in the solid state.

Example 3.—A boiler water containing sodium hydroxide or bicarbonate is treated with the chemically equivalent quantity of sulfuric acid. The salt mixture carried over with the steam is passed through the turbine in the solid state without forming incrustations on the blades of the turbine, since the melting point of the eutectic of NaCl and Na_2SO_4 is at 623° C.

The same result is obtained when adding a quantity of sulfurous acid corresponding to the oxygen content of the water in order to avoid oxygen corrosion and neutralizing the remaining sodium hydroxide in the solution or the $NaHCO_3$ by means of sulfuric acid.

Example 4.—When carrying out the treatment of a boiler water in such a manner that upon 50 parts by weight of sodium sulfate and 50 parts by weight of sodium chloride in the first case 2.94% of sodium hydroxide are present, and in the second case the sodium hydroxide is converted into tri-sodium phosphate by the addition of bisodium phosphate, the salt mixture crystallizes at the following temperatures:

	First case 2.94% of NaOH	Second case Na_3PO_4
	Percent	*Percent*
550° C. about	35	80
500° C. about	43	90
450° C. about	45	100
440° C. about	100	

It follows that by the neutralization of sodium hydroxide solution by means of bisodium phosphate an incrustation of the turbine cannot take place, whereas without the neutralization the blades are liable to be incrusted.

The addition of phosphoric acid or phosphate to the boiler water is known per se, however, the additions heretofore were only made in such quantities that the calcium still present in the water was precipitated as calcium phosphate, whereas according to the process of the present invention such as a quantity of phosphoric acid or phosphate are added that in the above example the addition is increased to such an extent that all the sodium hydroxide is neutralized, whereby the effect above specified is attained.

Example 5.—Incrustation of the blades of the turbine can be avoided when neutralizing the sodium hydroxide persent in the boiler water by sodium chromate or chromic acid.

We claim:

1. In a steam turbine-boiler plant, the method of minimizing deposits in the turbine of solids carried over in the steam generated from water containing salts which comprises treating the boiler water with substances interacting with substantially all the alkaline compounds contained in the water to form neutral compounds which have a crystallizing range outside the temperature interval 150° C. to 500° C.

2. In a steam turbine-boiler plant, the method of minimizing deposits in the turbine of solids carried over in the steam generated from water containing salts which comprises treating the boiler water with substances interacting with substantially all the alkaline compounds contained in the water to form neutral salts of inorganic acids which have a crystallizing range outside the temperature interval 150° C. to 500° C.

3. In a steam turbine-boiler plant, the method of minimizing deposits in the turbine of solids carried over in the steam generated from water containing salts which comprises treating the boiler water with substances interacting with substantially all the alkaline compounds contained in the water to form neutral salts of sulfurous acid which have a crystallizing range outside the temperature interval 150° C. to 500° C.

4. In a steam turbine-boiler plant, the method of minimizing deposits in the turbine of solids carried over in the steam generated from water containing salts which comprises treating the boiler water with substances interacting with substantially all the alkaline compounds contained in the water to form neutral salts of sulfuric acid which have a crystallizing range outside the temperature interval 150° C. to 500° C.

5. In a steam turbine boiler plant, the method of minimizing deposits in the turbine of salts carried over in the steam generated from water containing salts which comprises treating the boiler water with a substance selected from the group consisting of sulfuric acid, sulfurous acid, phosphoric acid, chromic acid and salts thereof in such proportion as to react with substantially all the alkaline compounds contained in the water to form neutral salts which have a crystallizing range outside the temperature interval 150° C. to 500° C.

6. In a steam turbine boiler plant, the method of minimizing deposits in the turbine of salts carried over in the steam generated from water containing salts which comprises treating the boiler water with phosphoric acid or a salt thereof in such proportion as to react with substantially all the alkaline compounds contained in the water to form neutral phosphate salts which have a crystallizing range outside the temperature interval 150° C. to 500° C.

7. In a steam turbine boiler plant, the method of minimizing deposits in the turbine of salts carried over in the steam generated from water containing salts which comprises treating the boiler water with sulfuric acid or a salt thereof in such proportion as to react with substantially all the alkaline compounds contained in the water to form neutral sulfate salts which have a crystallizing range outside the temperature interval 150° C. to 500° C.

8. In a steam turbine boiler plant, the method of minimizing deposits in the turbine of salts carried over in the steam generated from water containing salts which comprises treating the boiler water with sulfurous acid or a salt thereof in such proportion as to react with substantially all the alkaline compounds contained in the water to form neutral sulfite salts which have a crystallizing range outside the temperature interval 150° C. to 500° C.

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