THE POWER STATIONS OF STEAM TURBINE IN PERSPECTIVE

F.I. Kelbaliev

Azerbaijan State Oil Academy, Baku, Azerbaijan

ABSTRACT

In article the data about perspective using of the steam turbines in the power stations are discussed.

Keywords: thermal power station, steam turbine, electrical energy, energy block, temperature regime.

I. INTRODUCTION

The necessity of electrical energy for modern production and housekeeping of the man is well known. Electrical energy is manufactured at power stations. Basic, from which one the thermal power stations (TPS) on organic propellant manufacturing about 75 % electrical powers in the world are.

TPS have received prompt development, since 20 years of past century. And from this moment before the explorers there was a problem of pinch of profitability of these stations. By one of the basic methods of pinch of an efficiency of station became pinch of initial parameters of a steam in front of the turbine. Influencing initial parameters of a steam on efficiency of a cycle of water steam was revealed. So with pinch of initial pressure and temperature of a fresh steam the difference in the turbine is incremented available warmly, that is thermodynamic by most effective.

Since 60 years of past century, in TPS are operated turbine installations with super critical pressure steam. So the pressure of a fresh steam in front of the turbine compounds 24 MPa, and temperature about 540-550^{o}C. The exploitation by the turbine with these parameters has allowed to increase efficiency of station approximately up to η = 40 %, what in turn has diminished a specific consumption of conditional propellant up to $b_{c.p.} \approx$ 307 gr / (kW h). For natural propellants the specific consumption "b" depends on value of combustion heat of propellant Q. So, for example medium value of combustion heat for furnace boiler oils is inflected in limits from 40000 up to 41000 кJ/kg, i.e. Q ≈ 40 - 41 кJ/gr. And at η = 0,40, Q = 41 кJ/gr b ≈ 219 gr/(kW h).

TPS is operated with these parameters of a steam to this time. However since 1999 the pinch of the prices on propellant has raised the question, about pinch of efficiency of station. The events running presently, speak about necessity to move in a direction of making bull the energy block on supercritical pressure (SCP) of a steam, which one will exchange the energy block, working with middle 80 years.

II. MAIN TEXT

In references [1] the information on the aggregated European design is given, it is aimed at pinch of efficiency new the energy block for a steam of water cycles with supercritical parameters P = 30 MPa and temperature of a steam approximately 700^{o}C.

So a specific consumption of propellant on manufacture of 1 kW · hour of an electrical power for these the energy block, which one has following parameters:

Pressure of a fresh steam, MPa	30
Temperature of a fresh steam, ^{o}C	580
Temperature of intermediate overheat, ^{o}C	600
Temperature of feed-water, ^{o}C	310
efficiency, %	50

Will be for conditional propellant $b_{c.p.} \approx$ 245 gr/ (kW h), for natural propellant b ≈ 175 gr / (kW h).

For embodying the given design it is required to view some factors. One of which is the examination of heat transfer and temperature regimes a steam of generating surfaces of inventory.

For improvement of legitimacy of heat transfer at SCP of matter expedient the experimental examination of a temperature regimes of a wall is at various temperatures and modes of a motion. As a model fluid the toluene was chosen, which one has found wide applying in technique and the thermal properties are well learnt.

The temperature regimes of a wall are explored at a stationary thermal mode on experimental installation working by a principle of an opened circuital contour. Circulation and making of fluid pressure in a contour come true by the pump. For heating an experimental tube and preliminary heating of a fluid the electric current of low tension will be utilized. During carrying out of experience the temperatures of a fluid and wall, rate of flux and fluid pressure, voltage and current intensity are measured. The measuring of all quantities comes true by known methods. The experiences are spent in a following succession. At stationary values of the rate of flux, temperature and fluid pressure on a going into a tube the electrical heating of an experimental tube is included. The thermal loading is supported by a stationary value for each experience. At transferring from one experience to another a heat flux gradually pinch. The specification statement of experimental installation, procedure of carrying out of experience and the measuring of separate quantities are introduced in [2].

Process of heat transfer at SCP of a fluid can be divided into 3 groups:

- A normal mode of heat transfer
- The improved mode of heat transfer
- The worsened mode of heat transfer.

Let's note, that as a normal mode of heat transfer at SCP it is accepted to term modes, at which one the coefficients of heat transfer are featured of usual measure by the equations supplemented corrections.

Characteristic attribute of the improved mode of heat transfer is the inappreciable temperature variation of a wall with magnification of a heat flux.

The worsened mode is characterized by sharp ascending of temperature of a wall on a particular lease of a tube.

The allocation of temperature of a wall on length of a tube at the improved mode of heat transfer differs from allocation of temperature at normal and worsened modes of heat transfer.

Among these modes of heat transfer the greatest practical and scientific concern, from the point of view of reliability of operation of equipments, introduces the worsened mode of heat transfer, at originating which one temperature of metal grows abruptly. In result the walls of the equipment can be shattered. The complication of the mechanism of the phenomena does not yield an opportunity to one valued definition of this process, and in the literature there is a uniform equation for calculation of the worsened mode of heat emission. At designing and operation of thermal power equipments beforehand it is necessary to know:

1. There will be a worsened mode of heat transfer under viewed requirements of operation of the equipment.
2. What values of temperature will have walls of equipments at the worsened mode of heat transfer.

For eliciting legitimacy of influencing of pressure and mass rate on heat emission at SCP of a fluid the experiments were spent at various values of pressure and mass velocity of the heat-transfer medium. On leases of a tube with the worsened mode of heat transfer at different pressures the unmixing of temperature of a wall is observed. From the graphs follows, that the beginning of propagation of temperature of a wall corresponds to enthalpy of a stream $h_l \approx 980 - 1020$ кJ/kg (fig. 1).

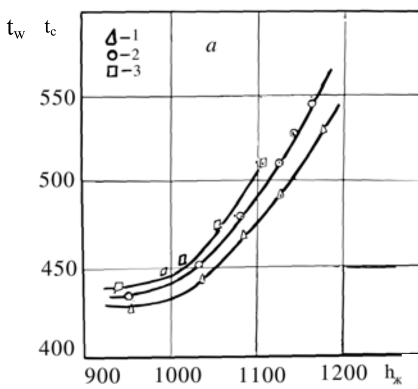

Fig.1. Temperature variation of a wall of a vertical tube depending on enthalpy of a stream: h_l

a) 1- P = 4.5 MPa; ρu = 91.9 kg / (m^2s); $t_{l,in}$= 265°C; $q/\rho u$ = 1.58 кJ/kg; 2 - 5.0; 89.7; 266; 1.60; 3 - 5.5; 94; 270; 1.64.

The experimental data obtained for water, the carbon dioxides and toluene, demonstrate, that the impairment of heat transfer at elevating flow of liquid in a vertical tube takes place at $h_{l.b.}/h_m \approx 0.85$ -1.00 (here $h_{l,b.}$ and h_m - boundary values of enthalpy of the stream relevant to a start of a worsened mode of heat transfer, and medium mass enthalpy of a stream at various pressures and critical temperature).

Data interpretation on heat transfer as dependence $Nu_e/Nu_o = f\,(Gr_{l,d}\,Re_{l.d}^2)$ have shown, that at SCP $Gr_{l,d}/\,Re_{l.d}^2 < 0.2$ - corresponds worsened, $Gr_{l,d}/\,Re_{l.d}^2 > 0.6$ - improved and $0.2 < Gr_{l,d}/\,Re_{l.d}^2 < 0.6$ - to a normal mode of heat transfer (fig. 2).

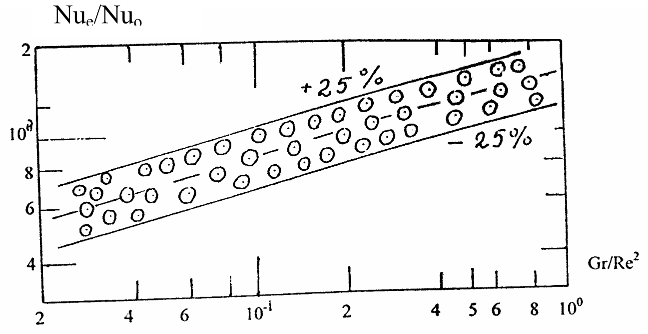

Fig. 2. Dependence $Nu_e/Nu_o = f\,(Gr/Re^2)$

$$Nu_o = 0.021 \mathrm{Re}_{f,d}^{0.8} \mathrm{Pr}_{f,d}^{0.43}$$

Use of intensification of heat transfer at applying tubes with turbulators allows to increase reliability of heat transfer equipments. The pinch of coefficient of heat transfer a in the shaped tubes (fig. 3) will allow to augment power of the turbine equipment and to diminish a specific consumption of propellant by manufactures of an electrical power.

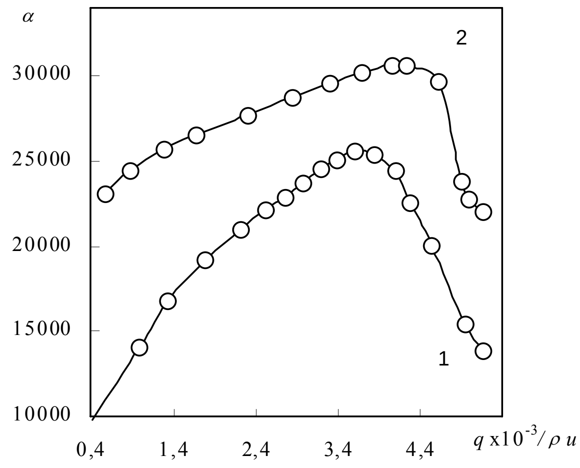

Fig. 3. Dependence of change of coefficient heat transfers from $q/\rho u$ at $P/P_{cr} = 1.08$, 1 - sleek tube; 2 - shaped tube.

III. CONCLUSION

The intensification of heat transfer at SCP of a fluid enables to shun originating the worsened mode of heat transfer and plusly displays itself, incrementing reliability of operation of the boiler. In steam generators of supercritical pressure the impairment of heat transfer is observed in the inferior radiative part. The synthetic intensification of heat emission in the inferior radiative part (IRP) of the boiler meliorates a temperature schedule of metal.

From all said follows, that in the long term IRP of the boiler it is expedient to make of the shaped tubes.

IV. NOMENCLATURE

t- temperature,^{o}C; *P*- pressure, MPa; *q*-heat flux, W/m^2; *u*- velocity, m/sec; ρ- density, kg/m^3; ρ*u*- mass velocity, kg/(m^{2}s); *h* - enthalpy, kJ/kg; h_m- enthalpy corresponding to the maximum of the heat capacity of a substance at supercritical pressures; *d*- diameter, mm; *x* – distance from the inlet of the tube, mm; Re, Gr, Nu – Reynolds, Grashof and Nusselt number; η - efficiency; $b_{у.т}$ - a specific consumption of conditional propellant.

Subscripts and superscripts: w — wall; *l* — liquid; in — inlet; out — outlet; cr – critical; b – boundary.

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