

# NEW HEAT FLOW METER FOR WATER WALL PIPES FOR PARALLEL – FLOW STEAM GENERATOR OF SUPER - AND HYPERCRITICAL PRESSURES

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## ABSTRACT

It is described new design and methods of the measurement by heat flow meter for determination heat flow, on-giving water wall pipes in firebox parallel flow steam generator of the supercritical pressure. Reliability of the work heat flow meter screen insertion, is provided by breeding hole in wall of the water wall pipe for installing the thermocouples. Heat flow meter is calculated on work at the temperature before 600 °C and pressures 250 bars and above. By heat flow meter allows to define the heat flow as absolute, so and differential method.

Inaccuracy of the determination heat meter flow is range by value 5 - 7%. The first test thread is organized on acting steam generator.

The first test caliber experiences are organized on laboratory stand. New heat flow meter is recommended to use as for steam generator hypercritical pressures.

**Keywords:** water wall piper insert, heat flow meter, steam generator supercritical pressure, water wall pipes, water wall piper supercritical pressure.

## I. INTRODUCTION

The typical particularity modern power steam generator super and in hypercritical pressures is presence of the greater volumes cameras of combustion of the order 5 thousand on m<sup>3</sup> and more. Such of the camera present complex heat technical object парогенератора, in which run simultaneously in close-fitting interaction separate not more complex energy technology processes: combustion fuel, heat temperature radiant-convective heat exchange, thermo – mechanical stress of the metal of water wall, generation steam at supercritical parameter, gas air hydrodynamics (nourishing water, draught and blast), chemical preparation of water and others This far incomplete list of the processes powerfully is whose ambiances steam generator complicated by extreme change thermophysical characteristic main steam - water and water pair in the field of located close to critical state material [3].

Wholly obviously that said circumstance claimed need optimization complex furnace process by equipping furnace process in steam generator supercritical pressure and supercritical pressure corresponding to facility of

control and operation system CAD type "sensor-instrument-computer". For the matter of that it is felt to a certain extent gap [4].

Usually as sensor for determination warm-up state of working water wall in furnace of steam generator with supercritical parameter are used temperature water wall piper insertions and heat flow meter different design [1]. However, as a rule, these sensors were used short time when starting-adjust and researcher test steam generator supercritical of the pressure.

In [2] give of the description new multifunction, differential water wall piper insert of Azerbaijani research and design-survey institute of JSC "Azerenerzhi".

The particularity of this insert consists in that unlike earlier offered she allows carry out alongside with absolute measurements temperature of metal of water wall pipes and differential measurement. She vastly reliability others that is confirmed long-lasting in 3 years by functioning the water wall piper insert in on 3-th steam generator Azerbaijani TES ( Mingechaur city). this appeared the motivated possibility to use these insert not only for short time starting-adjust and exploratory test steam generator supercritical of the pressure, but also for permanent their using in operation conditions of the work steam generator. So, for instance, differential thermocouple water wall piper of the insert "front surface of the water wall piper - nourishing water" has provided checking and regulation of the correct correlation between consumption of nourishing water and presenting fuel under different working state of working steam generator.

However for full control the heat regime of the water wall piper steam generator one only warm-up screen insertion it is not enough. For more exact quantitative checking and calculation of the water wall pipes is required also installation of heat meter, defining supplementary as well as heat stress on surface water wall piper ( $Vt/m^2$ ).

## II. BODY OF THE TEXT

A design of heat flow meter for water wall pipes parallel flow steam generator supercritical critical pressure is complicated series specific heat and technological circumstance:

- measure cell heat flow meter is required place in wall of the water wall pipe by thickness of the whole order 6 mms;
- heat flow meter works in unusual heavy agree-yah, under high thermomechanical stress at the temperature 600 °C and pressures 250 bars, but for steam generator supercritical pressures and that above - 700 °C and 350 bar;
- in that conduction waking of steam generator to fabrications of the cell heat flow meter making of demands specifically high requirements;
- a design heat flow meter in the manner of water wall pipe insertion as far as possible must not contribute distortion in warm-up field of the piper pipe in real condition of her(its) work in firebox steam generator;
- need of the provision to reliability electrical to insulation wire thermocouples in insertion and their conclusion, as well as their capsulation from contact with aggressive furnace gas for protection of corrosions.

Naturally, completely combine these requirements at designing of heat flow meter is technical problem, but reduce many undesirable designing and methodical defect to minimum problem can be decide.

As one such decisions author propose the new variant to designs and methods of the measurement of the heat flow, falling on water wall pipes in firebox steam generator by original heat flow meter, in which complex avoiding the defect earlier described in literature heat flow meter.

On fig. on show the drawing offered author of heat flow meter.

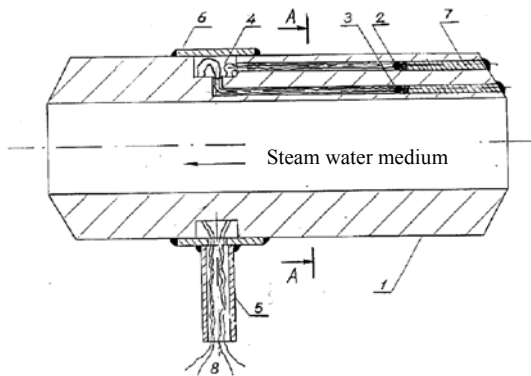


Fig. 1

In length of the screen pipe 1 diameter 32 and length 200 mms with wall, thickness 6 mms, with right and left butt end on depth 60 mms are drilled on two longitude channels by diameter 1,8 mms: one closer to medicine to be taken externally of the surfaces of the screen pipe 2, other - to internal surface 3. thermocouple Of the wire HA diameter 0,3 took seats In these jack and 0,5 mms, insulated bead porcelain by diameter < 0,9 mm. On pipe on circumferences was turned through slot 4 for bring out wire thermocouples 8, through tube 5 in setting at boiler for connection by means of compensation wire to potentiometer or computer. For encapsulating wire thermocouples on water wall piper of heat flow meter was put on and welding by argon the defensive ring 6 for prevention of the influence aggressive furnace gas. The junction of the thermocouples, insulated fine porcelain

beads, were situated in external and internal channel of the thermocouples in one cross-sections. In channels for thermocouples with butt end of the insertion were inserted and weld in the dowels 7 for filling started space. The channels with butt end weld in tightly.

The Main by discriminating constructive particularity heat flow meter unlike earlier offered variant is a breeding two above mentioned longitude channel from vertical axis of the cross-section of the water wall pipe vis-a-vis on a certain corner (ris.2):

$$\alpha = \frac{2 \div 3(r_1 + r_2)}{R_1} \quad (1)$$

where  $r_1, r_2$  - accordingly radiuses of externally and internal channel for wire of the thermocouples, mm;

$R_1$  - a radius of the centre of the drilling the internal channel

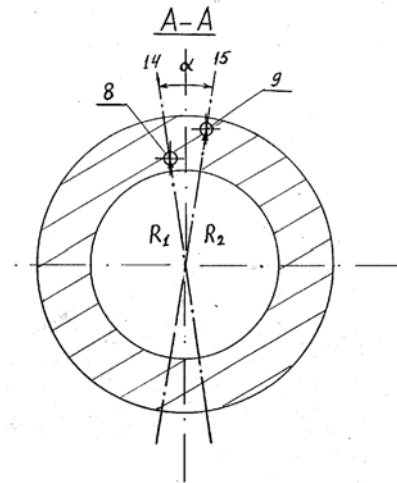


Fig. 2

The breeding channel for thermocouples is reached hardening cross-section of the screen pipe in contrast with variant, when both channels are found on one vertical axis friend under the other.

The special calculation is installed that displace channel to the right and to the left from vertical axis contributes inaccuracy in value of the heat flow not more 1-2% [3] and can be taken into account by accounting way.

Other, discriminating methodical particularity heat flow meter is a possibility as absolute, so and relative ways of the measurement to differences of the temperature in external and internal channel in wall of the pipe  $\Delta T = T_1 - T_2$ .

Under the known importance heat conductivity metal [5] walls of the water wall pipe heat flow is calculated on formula of the cylindrical wall:

$$q = \frac{2\pi\lambda l(T_1 - T_2)}{\ln \frac{R_2}{R_1}} \quad \text{Vt/m}^2 \quad (2)$$

$\lambda$  - heat conductivity metal of the wall of the screen pipe depending on average temperature  $T_1$  and  $T_2$ , °C, [5],  $\text{Vt/m}^0\text{C}$ ;

$R_1$  и  $R_2$  – accordingly radiuses of the drilling medicine to be taken externally and internal channel for thermocouples, m;

$T_1$  и  $T_2$  – accordingly evidences medicine to be taken externally and internal thermocouples,  $^{\circ}\text{C}$ .

Inaccuracy of the determination of the heat flow described above heat flow meter is valued by value of the order  $\pm 5 - 7\%$ .

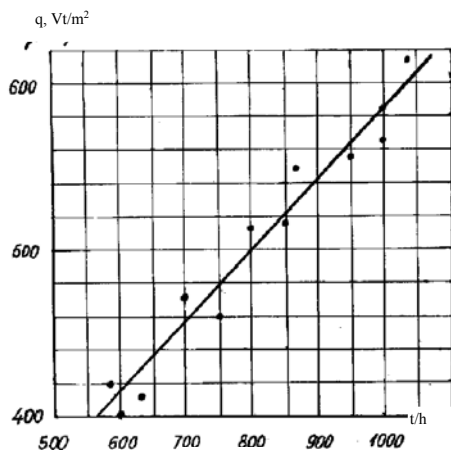


Fig. 3

### III. EXPERIMENT

Functioning the water wall pipe insert heat flow meter is tested in laboratory condition. These are a primary test simultaneously possible to characterize and as preliminary caliber experiences. The measuring stand was collected for undertaking experiment, imitating condition of the functioning the water wall of the water wall pipe in firebox with one-sided radiation by heating. As source of the heating was used ceramic heating stove with tightly put spiral from Cr-Ni alloy surface, where was situated the measuring cell heat flow meter. For prevention of the drain of the hear stove with heat flow meter with side and were from below insulated thick layer the high temperature and high effective insulation from mineral cotton wool.

The measurements heat radiation flow, falling heat flow meter from spirals of the heating stove, were conducted under formed warm-up mode. Was it simultaneously measured and the temperature on frontal surfaces of heat flow meter, turned to spirals at medicine to be taken externally of the thermocouple heat meter cells. Measurements were conducted under different warm-up mode, on measure of the possibility drawn near to real condition in steam generator, with the help of autotransformer accurate to  $\pm 5\%$ .

The Results of the measurements are presented in table.

Table. Experimental data of determination specific heat flow steam generator,  $\text{Vt/m}^2$

Steam prodac. steam generator, t/h	1000	850	705	700	600	800	950	750	630	840	1000	580
Heat flow on water wall pape, $\text{Bt/m}^2$	683	537	470	470	400	515	557	615	460	412	550	565
Power generator,	280	275	180	180	150	200	250	280	200	180	270	260

MW													
Temper. front surfce pape, $^{\circ}\text{C}$	445	440	415	400	430	440	450	435	410	435	432	395	

### IV. CONCLUSION

The results of the measurements of the temperature on front of the surfaces heat flow meter (the table, line 4) were compared with previous our studies on measurement of the temperature on front of the surfaces of the water wall pipe insert [1] one of acting steam generator on Azerbaijani TES JSC "Azerenerji". These comparisons on the temperature front surfaces water wall pipe in both study, in persisting and previous, have allowed to refer got given on specific heat flow to corresponding to productivity steam generator and powers energy block real acting equipment (the table, line 1 and 3).

From fig. 3 are seen that results of the measurements specific heat flow water wall pipe of steam generator are found in direct dependency from capacity on vapor steam generator in broad range of the loads from 0,58 before 1,04 from  $D_{\text{nom}}$ . At scatter experimental measured specific heat flow is found within  $\pm 4-5\%$ .

Described above heat flow meter of the type "sensor and secondary instrument or computer" can be used in system of the hardware check and management furnace process of the combustion and generations steam in steam generator supercritical and hypercritical pressure [4].

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