COMPREHENSIVE ANALYSIS OF TRANSFER PROCESSES IN MODERN HEAT EXCHANGERS

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The limiting effect of internal (inside the tubes) heat transfer upon the resulting heat flux within the tubular middle- and high-temperature heat exchangers has been ascertained theoretically by using the CFD modeling, and has been confirmed experimentally with the tests at firing rig.

Mentioned limitations evaluated by examination of an influence of the outward hot temperature of the heating medium on the intensity of heat exchange, as well as upon the thermal resistance of the apparatus, have been eliminated by means of installing the secondary emitters SE inside the tubes. The positive inserts' impact grows as far as increasing the operating temperatures of the heat exchanger.

As a result, under conditions of a recuperative heat exchanger with an internal inserts, the effect of using a hot heat transfer medium (combustion products CP) with a temperature of T_{CP} = 1000 °C can be provided by reducing of T_{CP} by almost 200 °C when achieving the same heating of the a cold (air) heat transfer medium. The average temperature of the tube walls can be reduced by 260 °C compared to the basic design of the heat exchanger.

Four schemes of the vertical tubular heat exchanger with the upper (cold) and lower (hot) collectors have been compared regarding the characteristics (intensity and uniformity, Reynolds analogy factor) of heat exchange processes:

1 – basic (BD) design with the plain hollow tubes; 2 – with the plates– external secondary emitters ESE installed between the longitudinal rows of tubes (BD + ESE); 3 – basic version with the internal secondary emitters ISE – the cruciform inserts inside the tubes (BD + ISE); 4 – combined design (BD + ISE + ESE).

The Table shows the results of computation analysis of influence the secondary emitters: internal and external – on resulting heat flux. It follows from the Table the conclusion regarding the most significant influence of internal SE upon the heat exchange intensity between hot flow of combustion products and an air to be preheated.

Table. Heat transfer enhancement compared to BD, %, depending on the heat exchanger scheme (circuit)

T_{CP}, °C	2 BD+ ESE	3 BD+ISE	4 BD+ISE+ESE
600	4–5	10	15
1000	2–3	36	40

The proposed approach allows us to optimize the design of the heat exchanger from the standpoint of thermal and hydraulic characteristic and to make selection of materials for manufacturing of high-temperature recuperative heat exchangers.