Moreover, we have not only determined the form of the diffusion combustion "peninsula," but have also calculated the combustion temperatures within that region.

Externally, the $Da(Pe)$ curve resembles the analogous curve obtained for the combustion limits of premixed gas mixtures in pipes [5]. Fundamentally, however, the curves are different. For the premixed gases, combustion corresponds only to the upper branch of the curve, and for the diffusion flame it corresponds to the region enclosed by the curve; the total extinction condition is common to the two curves. In both cases this condition is described by the point $Da = Da(Pe^*)$.

A particularly important aspect of the theory of diffusion-flame limits is the question of the intensity of combustion at the leading edge of the flame and at the combustion limits. According to our calculations, in the absence of heat losses at the leading edge of the flame, the rate of conversion of the reactants in the reaction zone depends on the combustion kinetics and may be two to three times greater than the intensity of combustion of the equivalent gas mixture. Near the total limit of diffusion burning, the reactant conversion rate is reduced by approximately $e$ times as compared with the rate at the leading edge of the flame in the absence of heat losses.

**LITERATURE CITED**


**APPLICATION OF ELECTROPHYSICAL EFFECTS FOR THE MONITORING AND CONTROL OF HEAT-ENGINEERING AND TECHNOLOGICAL PROCESSES**

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Solving the problems of improving the productivity of heat-engineering and technological facilities, fuel economy, and environmental protection requires the design of facilities to monitor fuel combustion, which must have a fast response, be reliable, and provide objective data. It is particularly urgent to find an easily and reliably measured parameter that mirrors the internal laws governing the evolution of the process taking place in a given plant or system. Considerable promise is offered in this respect by application of the "electrical noise" of flames and combustion zones [1], whose constant component has been shown [2] to depend on the oxygen excess coefficient, the composition of the fuel, etc.

Industrial-experimental studies and in-plant operations have been carried out on various facilities of the Karaganda Metallurgical Combine. The oxygen excess coefficient, the degree of burnup of carbon in steel, and the calorific value of the fuel were monitored in open-hearth furnaces, soaking pits, and cupolas fired by (respectively) cold coke-oven gas, black oil, and mixtures of coke-oven and blast-furnace gases in various proportions. Cooled and uncooled probes [1] (depending on the general thermal regime of the equipment) were mounted — in the neck region of the open-hearth furnaces, above the recuperators in the soaking pits, and in the burner tunnel of the cupolas. The combustion products were analyzed simultaneously with the measurements of the flame potential or, strictly speaking, the constant component of the "electrical noise," and a carbon analysis of the steel was also carried out in the open-hearth furnaces.

The results of the investigations (Fig. 1) indicate a fairly representative behavior on the part of the variation of the signal with variation of the oxygen-excess coefficient (air and oxygen). As this has also been observed in laboratory experiments [2], the corresponding dependence has an extremal character. The difference
in the positions of the extremum for the investigated facilities is associated with the composition of the particular fuel, the organization of the combustion process, and the locations of the monitored points relative to the flame zones. Investigations in large-charge open-hearth furnaces indicated the existence of a relationship between the carbon content of the metal and the value of the potential (for a constant fuel/oxidant ratio) with a correlation coefficient of about 0.86 in the range of carbon concentrations 0.1-2%. (The existence of this relationship is attributable to the ingress of CO from the bath into the flame during the burnup of carbon and the proportionality of that ingress to the residual C content.). This fact also provides a means for monitoring the melting periods, making it possible to increase the furnace output and the quality of the metal; a reduction in the specific consumption of reference fuel by 2.34 kg per metric ton of steel has been achieved. Regulation of the fuel combustion process has been implemented in the soaking pits, and the nonuniformity of the temperature field has been eliminated by redistributing the air as a function of the signals from probes mounted above the recuperators, and the total air flow has been optimized. These measures have significantly increased the uniformity of heating of the ingots, eliminated the fusion of cinder, and lowered the gas consumption by 10-14%. The feasibility of monitoring and, what is particularly important, automatically controlling the calorific value of the gas mixture has been demonstrated (Fig. 2).

In the sintering of iron-ore materials on agglomeration machines, sensors were mounted in the vacuum chamber beneath the fire grate, and the signal from them was used to monitor the end of sintering, the quantity of fuel in the charge, and its moisture content. These parameters exhibited an intimate relationship with the signal amplitude. The end of sintering was monitored according to the disappearance of the signal from the corresponding probe, and the rate of the machine was controlled by holding this time above a specified vacuum chamber. The output was increased by 4 metric tons/h, the quantity of agglomerate was increased, and the fuel consumption in the process was lowered.

The control of the sintering process by the application of electric fields was tested on an industrial-experimental sintering pan. A voltage was applied to a grid electrode placed on the charge. The body of the sintering pan was grounded. The parameters of the sintering process were shown to depend on the value and sign of the grid potential and its distance from the charge. For example, with the application of a negative potential of 5 kV, the temperature of the spent gases increased by 60°, and the sintering time decreased by 18%. With a change in polarity, the sintering time was increased 10% in comparison with the usual conditions, and the temperature of the spent gases was lowered by 40°. Removing the grid electrode from the surface of the charge diminished the observed effects. The reported experiments showed that the application of an electric field makes it possible to intensify the sintering process and to reduce the fuel consumption in sintering.

The efficiency of using the feedback principle to control combustion (in connection with the turbulent combustion of gases and liquid fuels and the burning of solid fuel in the circulatory regime) was demonstrated, in which case the oscillations generated by the combustion process, in particular the low-frequency component of the "electrical noise," are amplified and fed back into the combustion zone with a phase shift relative to the primary signal, after transformation. Laboratory and industrial-experimental tests have shown that appreciable variations, consistent in sign with the phase shift, take place in every case in the dimensions of the combustion zones (± 10-18%) and the temperature (2.5-4.5%). If the transmitted signal has the opposite phase, the oscillations radiated from the combustion zone are effectively suppressed.