REFERENCES

1. M. V. Lykov, Spray Drying [in Russian], Pishchepromizdat, 1955.
2. J. Dlouhy, W. A. Gauvin, I. Ch. En. J., 6, No. 1, 1961.
3. W. E. Renz, W. R. Marshall, Chem. Eng. Prog., **48**, 141, 1952.
4. O. Lebenspiel, K. B. Bishoff, Ind. Eng. Chem., **51**, No. 12, 1959.
5. G. H. Reman, Chem. and Ind., **3**, 46, 1955.
6. G. D. Kavetskii, A. N. Planovskii and L. A. Akopyan, Khimicheskaya promyshlennost', No. 6, 1963.

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RATE OF BURNING OF PEAT AND PEATY COKE PARTICLES IN AN AIRSTREAM

Yu. A. Finaev

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In actual furnace conditions – in chambers, and especially in cyclone furnaces – fuel particles of various sizes acquire different relative velocities, and thus burn while exposed to a gas and air stream. Then the stream velocity has a great influence on rate of burning of the fuel particles.

Tests have been performed with spherical peat particles [1], pressed from peat dust using a special mold, and also with spherical particles of peaty coke, obtained by prolonged coking of pressed peat particles of diameter 5, 10, and 15 mm in a steel hermetic retort at a heating temperature of up to 800°C; the coke contained residual volatiles equal to 6.01% of the combustible mass.

For comparison, spherical particles of electrode carbon obtained by machining were also used.

The particles were suspended on non-combustible threads, and burned in a vertical tubular electric furnace of diameter 40 mm in an airstream at various flow velocities from 0.2 to 1.35 m/sec and at a furnace temperature of 1270°K. The specific rates of burning of these and other particles were compared.

During burning the peat and coke particles were continuously weighed by means of a specially developed self-balancing photoelectronic recording analytical balance [1].

The burning process for each particle was recorded, using an MPO-2 type oscillograph, on photographic film in the form of a certain curve (oscillogram), analysis of which gave a value of the mass burn-up of the particle; also a time marker was included on the film every second, from which total time of burning of the particle could be determined.

After the test the residue of the burned particle was weighed on an analytical balance, to check the burn-up value recorded on the oscillogram.

From the experimental results, the specific rate of burning was determined as an average curve of the overall burn-up. The specific rate of burning is the mass of fuel burning per unit time per unit area of external surface of the particle, and was calculated with the aid of the expression

$$K_s = \frac{w - w_r}{S_p \tau_b} = \frac{\Delta w}{\pi d^2 \tau_b}$$

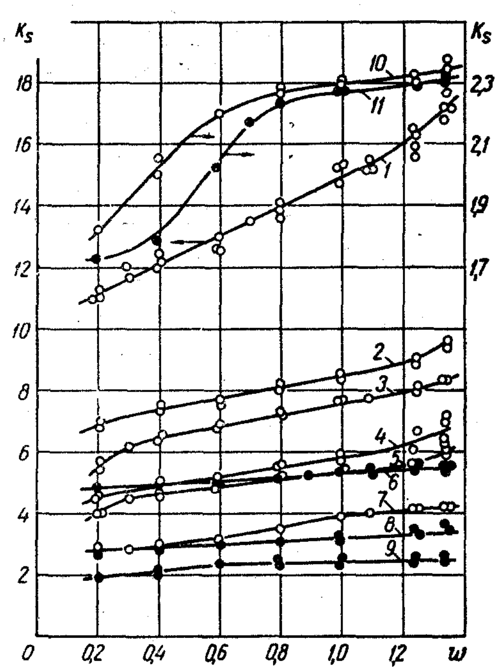

Fig. Dependence of specific burning rate $K_s \cdot 10^3$(kg/m^2 $\cdot$ sec) on flow velocity ω (m/sec) for spherical peat particles of diameter 5.0 mm – 1; 8.0 – 2; 10.0 – 3; 12.0 – 4; 15.0 – 5; for particles of electrode carbon of diameter 5.0 mm – 6; for spherical particles of peaty coke of diameter 4.5 mm – 7; 8.0 – 8; 12.0 – 9, and for particles of peaty coke of diameter 12.0 mm with residual volatiles 6.01% of combustible mass – 10, and 2.55% – 11.

Hence, graphs were plotted of the dependence of the specific burning rate of peat and coke particles on the velocity of flow over the particle (Fig.). They show that as the flow velocity increases the burning rate of the peat and coke particles increases. For peat particles, the burning rate at flow velocities above 1.0 m/sec grows considerably faster than at flow velocities below 1.0 m/sec. This is evidence that as flow velocity increases, there is increased blowing away of the burning layer of volatile material from the front surface of the particle (this is also observed visually), which accelerates burning, since part of the front reaction surface of the particle, where active burn-up of coke residue begins, is still accessible to oxygen up to the end of the phase of visible burning of volatiles [2]. Moreover, as the flow velocity increases, the inhibiting action of diffusion on the heterogeneous reaction is lessened, which also accelerates burning.

The dependence of the specific burning rate on flow velocity is stronger for peat particles than for coke particles.

The burning rate of peat particles is considerably greater than that of coke particles of corresponding size, although the mass of the former averages twice that of the latter. The specific burning rate of 8 mm peat particles is thus 2.5 to 3.0 times that of coke of the same diameter within the range of flow velocities used in the tests. Therefore, on the whole, the volatiles serve to intensify the burning of peat particles (although at the time of emission they inhibit the burning of coke [2]).

Examination of the graphs also shows that as particle size decreases, the specific burning rate increases. This agrees with the fact that mass transfer increases with reduction of particle diameter, while specific burning rate also increases.

NOTATION

w – initial weight of fuel particle; w_r – weight of residue after burning; Δw – weight of fuel particle burned in time τ_b; S_p – external surface area of spherical particle; d – particle diameter.

REFERENCES

1. Yu. A. Finaev, IFZh, No. 10, 1959.
2. Yu. A. Finaev, In: Heat and Mass Transfer [in Russian], 2, Izd. AN BSSR, Minsk, 1962.

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Heat and Mass Transfer Institute AS BSSR, Minsk

THE INFLUENCE OF RE NUMBER ON THE POSITION OF THE SEPARATION POINT OF A BOUNDARY LAYER

A. B. Tsinober, A. G. Shtern, and E. V. Shcherbinin

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The equation of motion of a liquid written in dimensionless form contains the small parameter 1/Re. If the quantities in the equation are expanded in terms of this parameter, the zero-order approximation, not containing the parameter, leads formally to the equation of the boundary layer. Thus, the concept of the boundary layer presupposes that the Reynolds number is sufficiently large, so that in the expansion for velocity, for example,

$$u = u_0 + \frac{1}{\sqrt{\mathrm{Re}}} u_1 + \frac{1}{\mathrm{Re}} u_2 + \ldots$$

all terms after the first may be neglected. Using this concept, it may be shown [1] that, up to a critical Re number, the dimensionless velocity distribution in the boundary layer, and also the location of the point of separation of the boundary layer, do not depend on the Re number.

The position of the separation point of a laminar boundary layer on the surface of a cylinder was first measured by Hiemenz [2]; according to the data of [3], the position of this point is 82° from the front stagnation point, at $\mathrm{Re} = 1.2 \cdot 10^4$, while according to [1] it is 81° at $\mathrm{Re} = 1.85 \cdot 10^4$.

The term "sufficiently large Reynolds number" is somewhat indefinite, it being difficult to point to a range where the concept of the boundary layer starts to be valid, and the position of separation point to be "steady."

At small Re numbers the terms with $1/\sqrt{\mathrm{Re}}$, 1/Re, and so on begin to be important in the expansion of the velocity in negative powers of Re, and so the position of the separation point of the boundary layer begins to depend on the Reynolds number (the concept "boundary layer" is then itself somewhat modified from that mentioned above).