THE PROBLEM OF PARTICLE COAGULATION IN THE CONVERGING SECTIONS OF VENTURI TUBES

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An attempt is made here to evaluate the role of inertial particle coagulation in the converging section of a Venturi tube. Bearing in mind that converging sections with angles of $\alpha \leq 30°$ are usually used in Venturi tubes, we regard the normal velocity component as negligibly small in comparison with the longitudinal component. The motion of the particle in the converging section, in the case of a steady-state gas flow ($Re \lesssim 1$), is determined on the basis of the Stokes resistance law.

From the condition of continuity for a stream of dust we have derived the law governing the variation in particle concentration in the converging section, and it follows from this (neglecting the coagulation of the particles) that the concentration of the particles along the converging section gradually increases, and this increase is the more pronounced for the larger particles.

To determine the effect of particle coagulation in the converging section, we determine the variation in the particle-distribution function along the converging section. The condition of conservation of mass for the coagulating particles is fundamental.

After having determined the path over which particle coagulation occurs (evidently this path is a function of the dimensions of the interacting particles), we can derive a formula to evaluate the coagulation.

As a result of this investigation of the degree of particle coagulation with the particles of various sizes, we have found the condition for the onset of pronounced coagulation in the converging section, i.e.,

$$r_{\min} \lesssim \bar{r}, \tag{1}$$

where $r_{\min}$ is the minimum radius of particles interacting within the limits of the converging section; $\bar{r}$ is the radius at which the particle distribution function assumes its maximum value.

We then proceeded with an approximate solution of the original equations for the initial segment of the converging section and we derived a formula to find

$$r_{\min} \approx \left[\frac{1.1\,\eta r_0}{N^{1/3} B v_0 \rho}\right]^{1/2}, \tag{2}$$

where η is the gas viscosity; r_0 and v_0 are, respectively, the initial radius of the converging section and the gas velocity at the inlet to that section; ρ is the density of the solid particle; N is the particle concentration; $B = \tan\alpha$.

As an example it is demonstrated that when $v_0 = 20$ m/sec, $\alpha = 30°$, $\rho = 4.5 \cdot 10^3$ kg/m^3, $r_0 = 0.5$ m, $N = 10^6$ 1/m^3, $\eta = 2 \cdot 10^{-5}$ N·sec/m^2, coagulation begins to appear at the segment of the converging section that is equal to the radius, provided $r_{\min} \gtrsim 2.2$ μm.

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