shown for a channel cross section 2 m from two diametrically positioned direct-flow nozzles, orthogonal to the flow. The channel diameter is 1 cm, the velocity of disperse-phase injection is the same for both nozzles (35 m/sec); all the other parameters of the nozzles and the gas flow are "standard." The dashed lines in Fig. 4b show the distributions given by each nozzle and the continuous curve shows the total mass distribution function of drops over the channel cross section. It follows from the resulting calculations that the correct choice of parameters of the injection system may ensure a very homogeneous distribution of the disperse phase even with a small number of nozzles.

LITERATURE CITED

PROPAGATION OF SMALL DISTURBANCES IN CONCENTRATED DISPERSED SYSTEMS

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The mechanism of elastic pressure waves in concentrated dispersed systems is discussed. It is shown that the continuously relaxing medium model is valid for describing acoustic effects in a fluidized vibrating layer.

Concentrated dispersed systems of the "fluidized layer" (FL) type are characterized by the essential nonstationarity of all hydrodynamic processes due to the nonlinear properties in the particle bulk concentration. The propagation laws of dynamic disturbances play an important role. The dynamic FL characteristics earlier considered were usually related to propagation of comparatively slow plastic isolated waves during spontaneous or induced change of flow of a fluidized agent [1, 2]. Their appearance was related to quasielastic relaxation processes due to the nonlinear dependence of the aerodynamic particle resistance on their spacing density, earlier found by Roy [3]. In this case the analysis included only low layers, with pressure waves propagating along them practically instantaneously [4, 5]. One of the most interesting effects, explained within the concepts of incompressibility of the fluidized agent in an FL, is the effect of ordered oscillations of the gas pressure and of the dispersed phase density (in the form of self-oscillations in boiling [6] and induced oscillations in pulsating [1] and vibrating-boiling [5] layers), characterizing the law of expansion cycle, precipitation at each period of oscillation, occurring with a completely determined "zero-order" frequency $f_0 \sim \sqrt{g/H_0}$.

Imposing on an FL induced oscillations with a frequency larger than the zero-order frequency ($f_B > f_0$), the action of the relaxation oscillations is restricted by the surface and bottom portions of the layer, and their contribution to the formation of the internal portions of the FL is diminished. At the same time the passage of a pressure wave through a high FL is compatible with an oscillation period $T_B$. Under these conditions one must expect the appearance of gas compressibility (elasticity), which would lead to resonance effects of higher than "zero" order.

At present the model of interacting, mutually penetrating continua is most widely used to describe the behavior of dispersed systems. This model is valid when the characteristic
scale of the effect exceeds the size of the microinhomogeneity of the dispersed medium. To
this belongs propagation of elastic oscillations in a dispersed medium with a wavelength
significantly exceeding the particle diameter and the mean distance between them. For tenu-
ous fluidized beds and "gas" or moist vapor type media the presence of a mechanism of propa-
gation of elastic oscillations in the form of acoustic waves was proved (see, for example,
[7]), while an analytic description of sound propagation in these media results from a justi-
fied assumption on particle interaction with each other through the supporting phase only.
This a priori simplification is too crude in concentrated dispersed media. Therefore, sev-
eral investigators have doubted the very possibility of existence of elastic waves in concen-
trated dispersed systems of the FL type, where the mean distance between the centers of the
dispersed particles is on the order of their diameter [2]. This doubt is fully justified
due to the nonlinearity of the object and the presence of significant dissipative effects.
Only experiments can indicate the presence of elastic properties in FLs, implying the possi-
bility of propagation of elastic oscillations in concentrated dispersed systems, considered
as homogeneous media with effective characteristics.

The problem of studying the dynamic properties of FL is complicated by the difficulty of
creating a stable, macroscopically uniform fluid (without bubbles) with properties assigned
ahead of time. At this stage the most suitable is the layer of finely dispersed particles,
oscillating as a quasifluid (VL). For certain combinations of oscillation parameters (fB and
Ag), properties of the dispersing medium, and its elements (H, ρ1, d1, μ0, p0) there occur
expansion and fluidization of solid particles in the oscillating bulk of the gas, accompanied
by relatively slow secondary phase transformations. In this case the expansion is maintained
at a high level, and the aggregate of solid particles never separates at the bottom of the
cavity. This is proved by the well-known fact of immobility of the upper boundaries of the
expanding VL for practically nonselecting motion (from the bottom) of the lower parts of the
layer with the relation ΔH/Ag ~ 104.*

Thus, the separation pulsation (occurring with frequency fB) does not exceed the mean by
more than 5-7%, exceeding the separation of the precipitated layer by 30-50%. Taking into
account that in a slightly dispersed fluidized filling the pulsations of gas pressure p0 and
of particles p1 are of the same order (for example, for maximum expansion p0 > 2p1 [10, p.
186]), we reach a conclusion of continuous stress redistribution between the gas and the sus-
pended particles and the possibility of "freezing" of solid particles in the variable contin-
uous phase.† It is natural to expect that momentum transfer from the vibrating bottom will
be realized (to a large extent) by elastic pressure sound waves.

We discuss a possible mechanism of sound wave propagation in a primarily expanding dis-
persed mixture. Clearly, in a fluidized gas the speed of sound has the value α0, depending
on its temperature only. Let a cluster of particles, suspended in the gas, border with a pure
gas, in which sound waves propagate with speed α0 and angular frequency ω. If the wavelength
corresponding to this frequency is comparable and larger than the mean distance between par-
ticles, the latter can be considered as a bulk diffraction lattice, where due to diffraction
and interference, the incident sound wave will be almost completely absorbed. And since par-
ticles in the gas are not fixed, the incident wave reduces to oscillating motion of the ex-
ternal gas layer and particles, which becomes in turn an emitter of acoustic waves, prop-
gagating into the depth of the particle cluster. The velocity of propagating waves can be
estimated from the thermodynamic relation

\[ a^2 = -\alpha^2 \left( \frac{\partial p}{\partial \nu} \right)_S = \left( \frac{\partial p}{\partial \nu} \right)_S \]  

whose validity for a dispersed medium is verified if the region of periodic medium compres-
sion and expansion (wavelength) is much larger than the distance between particles. The
pressure p of the gas mixture and of the particles differs in most cases quite little from

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*The topic here is not dynamic particle interaction with the bottom [8], but kinematic con-
tact of small particles, "frozen" in the gas and not tearing away more than 0.2Ag, which is
easily observed, for example, by photography with stroboscopic illumination [9].
†A reliable indication of "soft" shockless fluidization under these conditions by the widely
used fact in VL practice of the absence of noticeable wear and small particle cracking in opti-
timal regimes of vibrating machines.