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Bi-velocity fluid mechanics HOWARD BRENNER, MIT — Four physically-different velocities appear in the mass, momentum, and energy equations governing single-component fluid mechanics prior to making any constitutive assumptions regarding the stress tensor and heat flux vector appearing therein: (i) the "mass velocity" $\mathbf{v}_m$ appearing in the continuity equation; (i) the "momentum velocity" $\hat{\mathbf{m}}$ representing the fluid's specific momentum density (momentum per unit mass) appearing in the linear momentum equation; (iii) the "kinetic-energy velocity" $\mathbf{v}_k$ embedded in the fluids scalar specific kinetic-energy density $\hat{e}_k = (1/2)\mathbf{v}_k \bullet \mathbf{v}_k$ appearing in the energy equation; and (iv) the "work velocity" $\mathbf{v}_w$ whose scalar product $\mathbf{P} \bullet \mathbf{v}_w$ with the pressure tensor $\mathbf{P}$ constitutes the power vector (related to the rate working) appearing in the energy equation. Contrary to the current tenets of fluid mechanics, which arbitrarily assumes (without proof) all four velocities to be the same, it is theoretically demonstrated in the case of non-isothermal fluids that the mass velocity $\mathbf{v}_m$ is different from the other three velocities (whose members prove to be identical to one another), with the disparity in velocities being proportional to the temperature gradient. The concomitant need for two independent velocities is noted to have major theoretical consequences, not only for fluid mechanics per se but also for peripheral subjects such as irreversible thermodynamics.

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