

THERMODYNAMICAL POTENTIALS AND MATHEMATICAL SIMULATION OF THE PROCESS OF FLOW OF VISCOUS MEDIA

I.G. Teregulov

A generalization of classical thermodynamics to the case of irreversible multiparametric processes is suggested. It is shown that the classical phenomenological thermodynamics in its strict statement is valid for reversible two-parametric processes. It is proved that the increment of interior energy in irreversible processes is the complete differential with respect to the increments of process parameters, and the complete heat income in the general case may fail to have an integrating divisor for multiparametric processes. By these reasons the increments of the interior energy and heat in a system are considered as linear differential (Pfaffian) forms with respect to the increments of process parameters which are included in the system of state's parameters. Into the latter system there enter reactions of environment to the change of the process parameters and parameters of medium properties. The reactions are considered as generalized forces which produce a work on the increments of process parameters as on generalized translations. We use known results on possible representations of Pfaffian forms via systems of independent functions of the parameters of process. We consider some partial cases, which cannot be reduced to the classical (traditional) version of thermodynamics.

1. Concluded in a volume V at the current moment t viscous medium will be considered as a closed thermodynamic system, i. e., in absence of mass interchange with outer environment. In this situation, every small volume dV of the medium with the mass dm on the time segment $\tau = t - t_0$ for small $\tau > 0$ (τ is sufficiently small) represents also a closed system. Here t_0 is the moment of time at which there have been formed dV_0 with non-selfintersecting boundary ds_0 and the mass of medium dm_0 included in there. Through the boundary Σ of volume V with the exterior normal n in the current state there can be present a heat flow determined by the vector \mathbf{q} , i. e., the vector of the heat flow. Let us introduce in the medium the Lagrange frame of reference x^i ($i = 1, 2, 3$) and a vector $\mathbf{r}(x^i, t_0)$, which defines the position of material points of the medium at a certain instant t_0 with respect to the laboratory coordinate system y^i ($i = 1, 2, 3$). At the current moment $t = t_0 + \tau$ the position of these material points with respect to laboratory coordinate axes y_i is determined by the vector $\mathbf{r}(x^i, t_0) + \mathbf{u}(x^i, t)$, where \mathbf{u} is the translation vector corresponding to the time τ . We introduce parameters of the medium state and include in these ones: the parameters of the process α_i ($i = 1, 2, \dots, n$, e. g., deformations, temperature); those of the reaction of medium β_j ($j = 1, 2, \dots, m$, e. g., stresses) to the change of process parameters, which produce a work on increments of process parameters as generalized forces on generalized translations; the parameters of medium's properties γ_k ($k = 1, 2, \dots, l$, e. g., the viscosity coefficient, elasticity modules, etc.). A process is said to be reversible if in this process the complete set of state parameters can return to the values which took place earlier. Otherwise a process is said to be irreversible.

Supported by the Russian Foundation for Basic Research, project no. 96-01-00518, and by the Republic of Tatarstan Academy of Sciences.

©1997 by Allerton Press, Inc.

Authorization to photocopy individual items for internal or personal use, or the internal or personal use of specific clients, is granted by Allerton Press, Inc. for libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$ 50.00 per copy is paid directly to CCC, 222 Rosewood Drive, Danvers, MA 01923.