Technical Comments

Comments on "Hydroduct Using a Thermite Fuel"

LEONARD GREINER*
Costa Mesa, Calif.

THE paper by Hacker and Lieberman[1] has been commented upon by Lorber[2] with a subsequent reply by Hacker[3]; in so doing it is easy to overlook the potentially excellent features of the underwater propulsion scheme being discussed and, instead, concentrate only on potential defects. To recap the features, they include operation as an underwater counterpart of the air ramjet, the hydroduct, in which the simple absorption of heat from a thermite-type reaction within a properly ducted stream of ambient water results in thrust without need for moving machinery. The defects, if one is permitted to read between the lines of a technical article, may be a lack of good experimental data on the system and, instead, substitution of paper designs and models—for depending on the hypotheses taken, one can conclude with the original authors that the hydroduct is marginally useful, at best, or with the comentator that such pessimism is not justified. The truth of the matter is that we don't know the truth of the matter.

We do not know, for example, if Hacker and Lieberman's analysis of the combustor and nozzle characteristics are correct, nor which of the three is more nearly correct. Contrarywise, Lorber's neglect of two-phase problems in the combustor may be required to make feasible on paper a process which is not feasible in practice, or it may show up a problem requiring an innovative solution that could be just around the corner.

Considering the embryonic nature of this novel underwater propulsion scheme, one is tempted to suggest that the barest minimum paper studies be made, and these only to uncover problems and unknowns requiring experimental study. Going one step further, it is my normal inclination[4] when first considering a novel scheme to determine only its theoretical performance on perfect-efficiency bases which take into account only absolute thermodynamic limitations on performance. Then, when one compares such results with information computed under similar restrictions for known systems, there is good assurance that a potentially attractive scheme is not rejected prematurely: i.e., before it has had the benefit of experimental evaluation and the courtesy of direct and creative engineering study.

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* Consultant. Associate Fellow AIAA.

References

[1] Hacker, D. S. and Lieberman, P., "Thermodynamic Performance Evaluation of Hydroduct Using a Thermite Fuel," *Journal of Hydronautics*, Vol. 3, No. 3, July 1969, pp. 139–144.

[2] Lorber, A. K. G., "Comment on 'Thermodynamic Performance Evaluation of a Hydroduct Using a Thermite Fuel,'" *Journal of Hydronautics*, Vol. 4, No. 2, April 1970, p. 95.

[3] Hacker, D. S., "Reply by Author to A. K. G. Lorber," *Journal of Hydronautics*, Vol. 4, No. 2, April 1970, pp. 95–96.

[4] Greiner, L., "Theoretical Performance with Hydrogen-Oxygen as Propellant of Perfect Rocket, Heat and Fuel-Cell Engines in Underwater Missiles," *Underwater Missile Propulsion*, edited by L. Greiner, Compass Publications, Arlington, Va., 1967, pp. 31–50.

Erratum: "Analytical Prediction of the Incompressible Turbulent Boundary Layer with Arbitrary Pressure Distribution"

GEORGE S. DEIWERT
NASA Ames Research Center, Moffett Field, Calif.
AND
DOUGLAS E. ABBOTT
Purdue University, Lafayette, Ind.

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G. KRETZSCHMAR of the Office National D'Etudes et de Recherches Aerospatiales has informed the authors of the following error: Eq. (16) should be changed from

$$B_{ij} \equiv \int_0^1 [h_i u - (1 - u^2)\, h'_i]\, \phi_j du = \int_0^1 [(1 + 2u)P_{i-1}\,(2u - 1) - (1 - u^2) \times P'_{i-1}(2u - 1)]P_{j-1}(2u - 1)\phi_0 du$$

to

$$B_{ij} \equiv -\int_0^1 [(1 - u^2)\, h'_i]\phi_j du = -\int_0^1 [(1 - u^2)P'_{i-1}\,(2u - 1)]P_{j-1}\,(2u - 1)\phi_0 du$$

This correction results in a slight change in the momentum thickness results, bringing them in closer agreement with the results of Cebeci and Smith, and McDonald and Camarata.

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