Readers' Forum

Brief discussions of previous investigations in the aerospace sciences and technical comments on papers published in the AIAA Journal *are presented in this special department. Entries must be restricted to a maximum of 1000 words, or the equivalent of one* Journal *page including formulas and figures. A discussion will be published as quickly as possible after receipt of the manuscript. Neither the AIAA nor its editors are responsible for the opinions expressed by the correspondents. Authors will be invited to reply promptly.*

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Addendum to "Potential Application of Piston Generated Unsteady Expansion Waves"

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SOME of the analysis in Ref. 1, most importantly the variation of stagnation conditions within an unsteady rarefaction wave, can be found in Ref. 2, for shock tube flow. Reference 2 also discusses experimental verification of flow conditions within and across the rarefaction. Agreement with theory is sometimes poor, for reasons associated with nonideal shock tube behavior. I wish to thank Professor Glass for pointing out this earlier work.

References

[1]Emanuel, G., "Potential Application of Piston Generated Unsteady Expansion Waves," *AIAA Journal*, Vol. 19, Aug. 1981, pp. 1015-1018.

[2]Glass, I. I. and Hall, J. G., *Handbook of Supersonic Aerodynamics*, Sec. 18, Shock Tubes, NAVORD, Rept. 1988, Vol. 6, Dec. 1959.

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Comment on "Spreads of Oil Slicks on a Natural Body of Water"

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IN a recent paper, Sundaram[1] has developed similarity relations for the spread of oil slicks from a continuous source of constant strength into a two-dimensional channel. It is asserted that previous analyses concerning the spread of oil on water are based on two restrictive assumptions. The first of these is that "all of the oil is spilled 'instantaneously,' so that the total volume of the slick is conserved during the spread"; the second that "it is assumed that the viscous retarding force exerted on the underside of the slick by the underlying water layers can be predicted based upon concepts of laminar boundary-layer theory."

It is the purpose of this Comment to point out that the problem of oil slicks spreading from continuous sources has been considered in the past and that the solutions obtained have proved useful in applications both to time-dependent leaks (damaged tankers, broken pipelines) and to continuous sources (blowouts). Similarity solutions of the thin layer equations governing the spread of oil slicks were published many years ago by Waldman et al.[2] The solutions include both radial flow and channel flow and are restricted only to power-law source-strength variations with time. In this early paper, the problem of spreading from a continuous source with superimposed drift was also considered and the role of ocean turbulence assessed. Further details are available in a Contractor's Report to the U.S. Coast Guard.[3] The solutions in this early paper appear to be more general as well as more complete than the recent contribution by Sundaram.[1]

References

[1]Sundaram, T. R., "Spread of Oil Slicks on a Natural Body of Water," T. N., *Journal of Hydronautics*, Vol. 14, No. 4, 1980, pp. 124-126.

[2]Waldman, G. D., Fannelop, T. K., and Johnson, R. A., "Spreading and Transport of Oil Slicks on the Open Ocean," Offshore Technology Conference, Paper No. OTC 1548, 1972.

[3]Waldman, G. D., Johnson, R. A., and Smith, P. C., "The Spreading and Transport of Oil Slicks on the Open Ocean in the Presence of Wind, Waves and Currents," Avco Systems Division, Report No. AVSD-0068-73-RR; also, U.S. Coast Guard Report No. CG-D-17-73, 1973.

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Reply by Author to G. D. Waldman and T. K. Fannelop

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DURING the last decade a number of studies on the behavior of oil pools spilled on to a body of water have been carried out, and several excellent review articles on the subject also exist in the literature. One class of theoretical studies that exists is concerned with obtaining similarity solutions for the slick spread on a quiescent body of water, and Ref. 1 represents a pioneering contribution in this class of studies. The purpose of our Note[2] was merely to point out that power-law expressions for slick spread can be obtained by making very simple order-of-magnitude estimates for the various forces involved, the virtue of the latter approach being that the consequences of various assumptions and

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approximations become readily apparent. The validity of the assumptions has to be checked by, and the empirical constants appearing in the expressions have to be determined through, controlled laboratory experiments. Comprehensive experiments of the aforementioned type are indeed currently being sponsored by the U.S. Government. It is relevant to point out herein that in a companion Note[3] we have pointed out how order-of-magnitude analyses can also be used to describe the spread of *low viscosity chemicals* (rather than the high viscosity oils of concern herein) on water.

In a short Note such as ours, it is clearly not possible to reference all of the important publications in the literature. Waldman and Fannelop are justified, however, in noting that Ref. 4 should have been included in our Note, since it is pointed out in an appendix of Ref. 4 that the similarity theory given in Ref. 1 can be extended to time-varying oil leaks. A second point made by Comment concerns the influence on slick spread of the ambient turbulence in the waterbody. A brief discussion of a procedure to include the effects of ambient turbulence on slick spread at large times has indeed been given in Ref. 4. In the procedure suggested in Ref. 4, it is assumed that the growth of the pool radius can be calculatd using semi-empirical expressions that have been derived in the literature from oceanic dye-dispersion experiments. It is far from clear that the dispersion of an oil pool, which is immiscible with the surrounding water layers, will have any correspondence, even at large times, to the passive dispersion of tracer dyes.

In any case, the problem that was addressed in our Note was *not* that of the influence of ambient turbulence on pool spread at large times, but rather that of the influence of ambient turbulence on the viscous retarding force exerted on the slick at early times. It was pointed out in the Note that the developing water boundary layer below the spreading pool in a realistic environment is likely to be turbulent rather than laminar, and that, therefore, the skin friction at the interface between the spreading oil layers and the underlying water should be calculated using turbulent boundary layer theory. Although the use of a turbulent skin friction does not appear to change the power-law-growth indices greatly, the dependence of the growth on oil and water properties is indeed affected significantly.

As mentioned in our Note, only the results for slick spread in a channel were given because of limitations of space; results for axisymmetric spills readily follow from the results given. We do not believe that the results contained in Ref. 4 are either more general or more complete than those given in our Note.

References

[1] Fannelop, T. K. and Waldman, G. D., "Dynamics of Oil Slicks," *AIAA Journal*, Vol. 10, April 1972, pp. 506-510.

[2] Sundaram, T. R., "Spread of Oil Slicks on a Natural Body of Water," *Journal of Hydronautics*, Vol. 14, Oct. 1980, pp. 124-126.

[3] Sundaram, T. R., "The Spread of High- and Low-Viscosity Chemicals on Water," *Journal of Hydronautics*, Vol. 15, Jan.-Dec. 1981, pp. 100-102.

[4] Waldman, G. A., Johnson, R. A., and Smith, P. C., "The Spreading and Transport of Oil Slicks on the Open Ocean in the Presence of Wind, Waves, and Currents," U.S. Coast Guard Rept. CG-D-17-73, 1973.

EDITOR'S NOTE: This Technical Comment and Reply are based on a paper that originally appeared in the *Journal of Hydronautics*, which has ceased publication.