On the Determination and Combination of Loss Coefficients for Compressible Fluid Flows[1]

H. S. Hillbrath[2]

I would like to compliment the author on a valuable and useful paper. Similar techniques have been used for the determination of loss coefficients in the testing of Saturn S-IC components and the Fanno loss factor has been found to be the best method of data correlation. However, I know of no other adequate treatment generally available which substantiates the validity of this method for cases other than that of a straight pipe.

The author discusses and gives data for the case in which the nozzle in Fig. 2(*a*) or 2(*b*) is choked; however, he does not point out the greatly increased control of the test condition which this affords relative to the unchoked case. Note that for this case the specimen outlet Mach number is determined solely by the nozzle area ratio, and that the Reynolds number is a direct function of nozzle inlet pressure, and is only slightly affected by temperature. If, as is often the case, it is desired to have an approximately uniform distribution of test points over a region of Mach and Reynolds numbers, this method can result in great reductions of test time. The objection may be raised that the nozzle discharge coefficients are not accurately known at this condition; however, this uncertainty is generally less than 1.0 percent which is usually not significant.

An interesting point which the author does not discuss, but that seems to warrant experimental investigation, is the effect of the isentropic exponent and whether results obtained with air, for example, are valid for other gases such as steam or helium.

It may be helpful to those not familiar with the author's previous work to point out that equation (1) is equivalent to the relation:

$$4f\,\frac{L_{\max}}{D} = \frac{1 - M^2}{\gamma M^2} + \frac{\gamma + 1}{2\gamma}\ln\frac{(\gamma + 1)M^2}{2\left(1 + \dfrac{\gamma - 1}{2}\,M^2\right)}$$

where M is the Mach number.[3]

Author's Closure

Mr. Hillbrath's remarks are appreciated. It is interesting to note that others also find the Fanno-type loss coefficients useful in correlating data. The use of nozzles operating in the choked regime for controlling test conditions is well known. However, an additional unchoked nozzle should be used to meter the flow, to avoid the unnecessary uncertainties which would be introduced by the undetermined choked nozzle discharge coefficients. The question of model testing and similitude is one which must be considered carefully. Professor Kline's book[4] presents a recent approach to this problem. The equation given in the discussion concerning $4fL_{\max}/D$ represents the loss coefficient from a given plane of interest to the critical state, while equation (1) of the paper represents the loss coefficient from a given plane of interest to *any other* plane of interest, directly. Thus, while these two equations are related, they are clearly not identical. Again, the author would like to thank Mr. Hillbrath for his useful comments.

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[1] The discussion to the paper by R. P. Benedict, published in the January issue of the JOURNAL OF ENGINEERING FOR POWER, TRANS. ASME, Series A, vol. 88, 1966, p. 67, was received at ASME Headquarters after the paper was published.

[2] The Boeing Company, Launch Systems Branch, New Orleans, La. Assoc. Mem. ASME.

[3] A. H. Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow*, The Ronald Press, New York, N. Y., vol. 1, 1953, p. 167.

[4] S. J. Kline, *Similitude and Approximation Theory*, McGraw-Hill Book Company, Inc., New York, N. Y., 1965.

Cycles for Supplying Steam to Desalting Evaporators of Dual-Purpose Power-Generation Plants[1]

E. D. Howe[2]

This paper presents an interesting collection of possible cycles for combination plants. The figures given in Table 1 would be more significant if the "Water to Power Ratio" involved both commodities on similar bases. It is noted that both commodities may be regarded as given in rates of production, water in gallons per day, and power in MW hr per hr. By dividing the numbers in the last column of Table 1 by 24,000, the result will be in terms of gallons of water per kwhr of electrical energy. Since the demands for water and power are usually expressed in gallons per capita per day and kwhr per day, respectively, the quotient would be gallons of water per kwhr. In urban U.S.A. the demand ratio of these two quantities is about 25 to 30 gallons of water per kwhr. On this basis, the figures in Table 1 vary from a minimum of 1.3 for Cycle F-6 to a maximum of 18 for Cycle F-2. Thus all the cycles proposed would tend to increase electrical capacity at a rate greater than water capacity. This suggests that consideration should be given to the utilization of off-peak power for water production and possibly to distillation systems in which steam heat can be used at two different pressures—a low pressure during periods of peak electrical demand and a higher pressure during off-peak periods. The objective would be to keep the water production essentially constant while the electrical output was changed from full load to a lesser load, say, half-load. If cycles could be developed to accomplish this result, a significant saving in equipment and cost of water could result.

Authors' Closure

The authors wish to thank Professor Howe for his fine comments and suggestions. His suggestions should be considered for certain dual-purpose plant application where considerable flexibility is required between water and electrical production.

However, the added capital expenditure incurred for the variable pressure operation of the water plant should be carefully evaluated.

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[1] The discussion of this paper by P. Leung and R. E. Moore, published in the January issue of the JOURNAL OF ENGINEERING FOR POWER, TRANS. ASME, Series A, vol. 88, 1966, p. 22, was received at ASME Headquarters after the paper was published.

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Flow Losses in Abrupt Enlargements and Contractions[1]

J. R. Turner[2]

The discusser would like to call the attention of the authors to the article by Hall and Orme[3] in which the writers have described the compressible flow through a sudden enlargement by a straightforward analysis. By combining continuity, momen-

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[1] The discussion to this paper by R. P. Benedict, N. A. Carlucci, and S. D. Swetz, published in the January issue of the JOURNAL OF ENGINEERING FOR POWER, TRANS. ASME, Series A, vol. 88, 1966, p. 73, was received at ASME Headquarters after the paper was published.

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[3] W. B. Hall and E. M. Orme, "Flow of a Compressible Fluid Through a Sudden Enlargement in Pipe," *Proc. of Inst. of Mech. Eng.*, vol. 169, no. 49, 1955.