Experimental Investigation of a Stationary Cascade of Aerodynamic Profiles

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APPROVED DISSERTATION

SUBMITTED BY

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VII. Summary and Conclusions

A. Cascade Testing in General

The practicability of direct measurement of cascade blade forces by use of a suitably accurate balance was demonstrated. A valid and practical "blade efficiency" for a cascade in terms of force components was defined and used to reflect the practical influences of flow variables. Various means of observation of boundary layer separation and transition were discussed and their indications shown to be consistent among one another. Accuracy of measurement of flow conditions was substantiated by means of the continuity equation applied to three-dimensional observations.

B. Turbulence and Reynolds-Number Effects Upon Blade Performance

The existence of a minimum Reynolds number, below which the cascade may not be satisfactorily operated, has been recognized. This limit is more pronounced when it is identified with the lift breakdown. It is less distinct and occurs at somewhat higher Reynolds numbers, if defined in terms of losses. This critical minimum Reynolds number decreases with increase in turbulence intensity of the incident flow. Creation of high local turbulence intensity on the blade suction side by physical surface irregularities serves to decrease the critical Reynolds number in the same manner as increasing general stream turbulence. Within certain limits, the separate influences of turbulence *intensity* and of turbulence *scale* were investigated, yielding the conclusion that the effect of intensity far outweighed that of scale. In fact, for the restricted limits between which it was possible to vary the scale of turbulence, no definite influence of this parameter could be established, due probably to the "laminar" nature of the blade profile.

C. Continuum Theory of Cascades

The *Ackeret* theory for the prediction of flow through a two-dimensional cascade of closely-spaced airfoils of finite thickness has been shown to yield a satisfactory approximation to the experimental conditions for a single cascade arrangement tested. The theory produced a blade form which, in cascade, yielded a tangential force (work) component within 1.5 % of the theoretical (*Euler* equation) component, and a pressure drop within 3 % of the theoretical. Also of practical interest to the designing engineer, the cascade constructed according to the theory produced, with better than 97 % maximum efficiency, an actual mean angle of turn of the air flow within 1.7 % of the turning angle desired (desired turning angle $= 30^0$; actual mean turning angle $= 29^0.5$). Using supplementary curves presented herein, a complete solution by the theory, giving the resultant blade profile and associated pressure distribution, may be obtained in approximately 40 hours.