(NASA-CR-153914) LOW SPEED AIRFOIL STUDY Final Report (Illinois Univ.) 4 p HC A02/MF A01 CSCL 01A
N77-27074
Unclas
G3/02 39190

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AERONAUTICAL AND ASTRONAUTICAL ENGINEERING DEPARTMENT

Allen I. O
Principal

ENGINEERING EXPERIMENT STATION, COLLEGE OF ENGINEERING, UNIVERSITY OF ILLINOIS, URBANA

AERONAUTICAL AND ASTRONAUTICAL ENGINEERING DEPT.

UNIVERSITY OF ILLINOIS URBANA, ILLINOIS

Technical Report AAE 77-11

UILU-Eng. 77 0511

NASA Grant NGR 14-005-144
Allen I. Ormsbee, Principal Investigator

FINAL REPORT
LOW SPEED AIRFOIL STUDY

by

Allen I. Ormsbee

University of Illinois
Urbana, Illinois
July 1, 1977

LOW SPEED AIRFOIL STUDY

This study, initiated in February, 1970, has had as its purpose the development of airfoil geometries for low speed high lift applications, such as general aviation aircraft, propellers and helicopter rotors. The primary effort was to determine the extent to which the application of turbulent boundary layer separation criteria, primarily that of Stratford, plus manipulation of other input parameters, specifically trailing edging velocity ratio, could be utilized to achieve high C_{Lmax} airfoils with relatively low drag at C_{Lmax}. Both single-element and double-element airfoils were considered. This activity also included wind tunnel testing of some airfoils, derived from the theoretical development, in the University of Illinois of Two Dimensional Wind Tunnel.

For the single element airfoil, the primary approach was the adaptation of an inversion procedure due to Eppler allowing tranformation of a prescribed pressure distribution into an airfoil geometry. For the multi-element case a similar procedure was used employing an inversion technique developed during the course of the study, based upon a single element scheme due to Oeller. In both cases, computer codes have been written which successfully accomplish the design process.

The single-element program has been documented in References 1 and 2, and the multiple element program has been transmitted to Langley Research Center by Dr. Allen W. Chen, who, after completing his Ph.D. studies here, served as an NSF Fellow at Langley Research Center for two years. A paper discussing the multi-element analysis was published in the AIAA Journal (Reference 3).

Two single-element airfoil models were tested in the University of Illinois Two Dimensional Wind Tunnel. Results for the first of these models, the UI-1720 airfoil, have been documented in Reference 4, copies of which have been previously transmitted to NASA. The results of the second model tested, the UI-1640-20 is in the process of being documented. Copies of this report will be provided to NASA upon completion, expected in the next month or two. The UI-1720 test results supported the theoretical analysis. A model of this airfoil was tested independently by Professor F. X. Wortmann in the Stuttgart two-dimensional tunnel, and his results substantiated the results obtained in the UI tunnel.

The maximum measured lift coefficient for this airfoil was 1.96, at Reynold's number 1.8×10^6. The drag coefficient associated with this value of C_L was .028. The minimum drag coefficient for the airfoil was .009 at a C_L of 0.48.

The UI-1640-20 airfoil did not achieve the theoretical design lift coefficient of 4.0. The detailed reasons for this are not yet clear. However, oil film flow visualization tests showed three dimensional flow effects, including separation near the trailing edge-wind tunnel side wall junction, at almost all angles of attack. This was in spite of the presence of side-wall blowing over the upper surface, designed to prevent this separation. The primary difference between the 1720 and the 1640-20 airfoils was the specification of a substantially lower trailing edge pressure for the 1640-20 airfoil. In both cases, the specified trailing pressure was below free stream static pressure.

References:

1. Thomson, W. G., Design of High Lift Airfoil with a Stratford Distribution by the Eppler Method., Technical Report AAE 75-5, Aero & Astro Eng. Dept., U. of Ill., Urbana, 1975.

2. Thomson, W. G., Program Manual for the Eppler Airfoil Inversion Program. Technical Report AAE 75-4, Aero & Astro Eng. Dept., U. of Ill., Urbana, 1975.

3. Ormsbee, A. I., and Chen, A. W., Multiple Element Airfoil Optimized for Maximum Lift Coefficient., AIAA Journal, V. 10, No. 12, Dec. 1972, pp. 1620-1624.

4. Sivier, K. R., Ormsbee, A. I., and Awker, R. W., Low Speed Aerodynamic Characteristion of a 13.1 percent Thick, High Lift Airfoil., SAE Paper 740366, Presented at National Business Aircraft Meeting, Wichita, April 1974.