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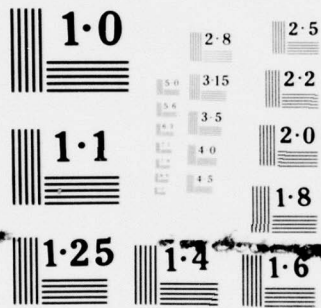
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PROJECT SQUID

TECHNICAL REPORT MICH-18-PU

SUMMARY OF THE PROJECT SQUID WORKSHOP ON TRANSONIC FLOW PROBLEMS IN TURBOMACHINERY

by

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CONTRACT N00014-75-C-1143 NR-098-038

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ABSTRACT

A Workshop on Transonic Flow Problems in Turbomachinery was held at the Naval Postgraduate School, Monterey, California, February 11-12, 1976. Because of the growing need to improve engine performance characteristics, the interest in internal transonic flows has greatly increased. This workshop was held to inform the various workers in the field about the latest work being done and to provide a number of opinions of what important work remains. A volume has been assembled consisting of the thirty-eight papers presented, the discussion following each paper, and the review and discussion sessions at the end of the workshop; this volume, ⁸⁵entitled Transonic Flow Problems in Turbomachinery, edited by T.C. Adamson, Jr. and M.F. Platzer, will be published soon by Hemisphere Publishing Company, Washington, D.C.

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SUMMARY OF THE PROJECT SQUID WORKSHOP ON
TRANSONIC FLOW PROBLEMS IN TURBOMACHINERY

The University of Michigan
Ann Arbor, Michigan
Subcontract No. 8960-22

T.C. Adamson, Jr.

I. INTRODUCTION

The purposes of the meeting described in this report were, first, to assess the current advances in transonic flow analyses and experiments and their applicability in predicting the flow in transonic turbomachines, and, second, to ascertain what work should be done in the future to improve these techniques. The speakers included external and internal aerodynamicists, analytical and computational experts, and experimentalists and theoreticians. The subject matter was only slightly constrained by rather general session subject headings, with the exception that it was decided to limit unsteady flow considerations to the assessment of the effects of unsteady flow on performance. The authors were representative of industry, government laboratories, and universities. A list of authors and their papers for each session is given in the Appendix. These papers, the discussion following each paper, and the reproduction of the review and discussion sessions held at the end of the workshop are contained in a volume entitled, Transonic Flow Problems in Turbomachinery, editors, T.C. Adamson, Jr. and M.F. Platzer, which will be published by Hemisphere Publishing Company in September 1977.

II. DELINEATION OF PROBLEM AREAS: STRUCTURE OF THE WORKSHOP

The general problems associated with transonic flows have been discussed with varying intensity for many years. With the advent of high subsonic Mach number transport aircraft, there has been a great resurgence of effort on transonic airfoil analysis and design. However, the need for high performance jet engines, in both the high subsonic Mach number and supersonic Mach number flight regimes, has also resulted in a great deal of work in internal transonic flows, i.e., transonic flows in rotors and channels. In many respects these internal flows are more demanding than external flows; for example, it is generally necessary to consider three dimensional internal flows, and it is necessary to be much more precise insofar as shock wave position and strength is concerned because of shock reflections off channel or rotor walls. Nevertheless, the fundamental problems are similar, and improvements developed in either area of work are often useful in the other. Hence, in the workshop there was no effort made to group talks having to do with internal or external aerodynamics.

Because of the very complex geometries and upstream flow conditions inherent in flows in turbomachinery, by far the greatest amount of analysis of the transonic flow fields is carried out by computers. Nevertheless, there are many cases where analytical work is of critical importance insofar as understanding of specific flow phenomena is concerned. Moreover, before any numerical computations can be made, it is necessary to

formulate the problem considered. Therefore, in the workshop, there were two sessions on analysis; the first was concerned with the formulation of transonic flow problems to various orders of approximation, and the second with computational methods of solution.

Again, because of geometric and upstream flow condition complexities, most computations are carried out under the assumption that the flow is inviscid. However, there are certain regions in a flow field, where so-called viscous effects are of primary importance; they may, for example, cause flow separation and thus negate the possibility that an inviscid flow field calculation is valid. Hence, the third session of the workshop was on viscous effects on transonic flows, these effects including both those due to boundary layers alone, and those due to shock wave boundary layer interactions.

It is generally agreed that, in general, two dimensional flow fields are not representative of transonic flows in rotors and channels. As a result, a great deal of effort has recently been expended in doing experimental work in three dimensional channels, and in fact in the blade passages of actual rotors. The laser is being employed in the form of a nonintrusive diagnostic tool to make measurements in these passages. In the fourth session of the workshop, which was concerned with experiment and included a review of experimental work in progress, these new diagnostic methods were emphasized.

The fifth and final session of the workshop consisted of a review and discussion in which each of the session chairmen presented a brief review of his session.

III. DEVELOPMENT OF THE WORKSHOP

The Project SQUID Workshop was cosponsored by the Air Force Office of Scientific Research (Lt. Col. R.C. Smith), Naval Air Systems Command (Dr. H.J. Mueller) and the Office of Naval Research (Mr. J.R. Patton, Jr.). It took place at the Naval Postgraduate School, Monterey, California, February 11-12, 1976, and was attended by sixty-seven people from both the U.S. and foreign institutions. The co-organizers and co-chairmen of the meeting were Professors T.C. Adamson, Jr. of the University of Michigan and M.F. Platzer of the Naval Postgraduate School.

The format of the meeting was such that at the beginning of each session there were two or three invited papers of 20 to 25 minutes duration followed by a number of 5 to 10 minute talks covering work in progress. After each presentation, there was a discussion which was recorded. A panel discussion (Session V) was held at the end of the Workshop. These discussions were then transcribed. The formal papers submitted by the authors along with the transcription of all of the discussions form the body of a report of the proceedings⁽¹⁾, and also a bound volume to be published by Hemisphere Publishing Company in September 1977.

IV. OUTCOME

The organization of the Workshop and thus the proceedings was carried out with emphasis on the two goals mentioned previously; thus, the first goal was to assess the current status of analytical and experimental work

(1) Transonic Flow Problems in Turbomachinery, Eds. T.C. Adamson, Jr. and M.F. Platzer, Project SQUID Report MICH-16-PU, 1976, 660 pp. DDC/NTIS ADA-037060.

in transonic flows in turbomachinery, and the second was to attempt to judge what work should be done in the future. In the attempt to reach these goals, participants representing different schools of thought were invited so as to elicit constructive criticisms. This led to discussions, in the area of computational methods in particular, which should prove very useful both to newcomers in the field and to those experts wishing to assess the work of others. Also, many speakers were invited to discuss their work; this, unfortunately, meant long sessions. However, it also meant that more subject material is included in the proceedings; hopefully the trade-off was worthwhile to the participants, who were most patient and cooperative. In any event, it appears that perhaps the first goal was realized. Insofar as the second goal is concerned, the various opinions on research which should be carried out in the future can be found by reading the discussions, in particular the general discussion in Session V. Some specific ideas on this subject are contained also in the editors' concluding remarks. More general comments are given in special remarks by Professor K. Oswatitsch.

The table of contents for the proceedings, attached as an appendix to this report, indicates the overall scope of the Workshop.

Copies of the Proceedings may be obtained from

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Washington, D.C. 20005

and also

- 2) DDC/NTIS
U.S. Department of Commerce
5285 Port Royal Road
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Project SQUID Workshop
on Transonic Flow Problems
in Turbomachinery

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K. Oswatitsch

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