THE NEED FOR AN OPTICAL TRANSITION DETECTION SYSTEM IN THE NTF

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TRANSITION DETECTION IN THE NTF

The very high test and model costs which will be associated with the NTF as well as the limited access of commercial transport aircraft manufacturers to the facililty will necessitate testing of any new configuration over a range of Reynolds numbers for correlation with data obtained in conventional tunnels, where most development testing will continue to be done. These Reynolds number variations will be carried out at constant dynamic pressure, i.e., constant aeroelastic condition, by varying test temperature. Boundary-layer transition cannot be expected to occur at the full-scale location at significantly less than full-scale Reynolds numbers, and transition patterns will change with varying Reynolds number. Knowledge of the location of transition on model surfaces is essential for correct interpretation of drag data, however, so that a means of determining transition location in the NTF is essential if the testing requirements of transport manufacturers are to be satisfied. The importance of transition, the limitations of artificial transition fixing, and their relation to the NTF are further reviewed in Reference 1.

Transition detection techniques used on model transport configurations in conventional tunnels are restricted to surface flow visualization methods such as oil flow and sublimation. Even if problems associated with very low temperatures are overcome, adaptation of these methods for transition detection in the NTF is not practical because of the very small critical roughness heights encountered. Figure 1 shows the calculated minimum roughness height to instantaneously trip transition on a model transport wing over a range of Reynolds numbers of interest in the NTF. Clearly, any material placed on a model surface would be very likely to affect transition at many important conditions. A nonintrusive method of transition detection is required.

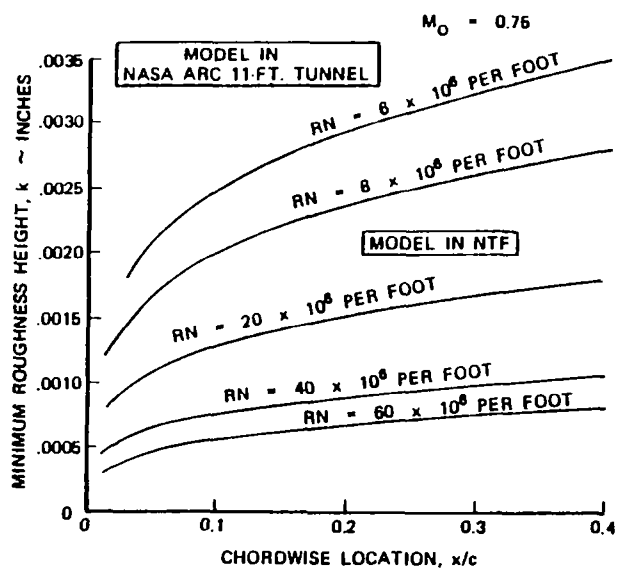

Figure 1

THE NEED FOR A NEW OPTICAL METHOD

To date, no fully satisfactory method for transition detection in the NTF has been identified. A uniquely nonintrusive configuration of hot-film gages described in Reference 2 appears to at least partially satisfy the firm requirement for transition detection on transport models in the NTF. However, only an optical method offering nonintrusive and total coverage of model surfaces will be completely satisfactory. One such approach is infrared thermography. However, both fundamental and practical limitations appear to prevent its use for transition detection in the NTF. Figure 2 shows the calculated range of temperature change across the transition region on a model transport wing over the Mach number range of interest. It is seen that the temperature changes associated with transition in conventional wind tunnels, in which only marginal results have been obtained, are far larger than those at conditions of interest in the NTF. This consideration and other complications of low temperature infrared measurement eliminate these methods from consideration. An innovative alternative is needed, perhaps based on properties of coherent light reflected from model surfaces or transmitted through the model boundary layer from sources in the model surface.

In summary, a method for boundary-layer transition detection on models tested on the NTF is necessary if the requirements of transport aircraft manufacturers are to be satisfied. Current methods are not applicable, and the only workable approach proposed to date, the hot-film system of Reference 2, is not ideal. Identification and development of a nonintrusive method, preferably optical, must be given high priority now if this critical capability is to be on hand when the NTF becomes available to industrial users.

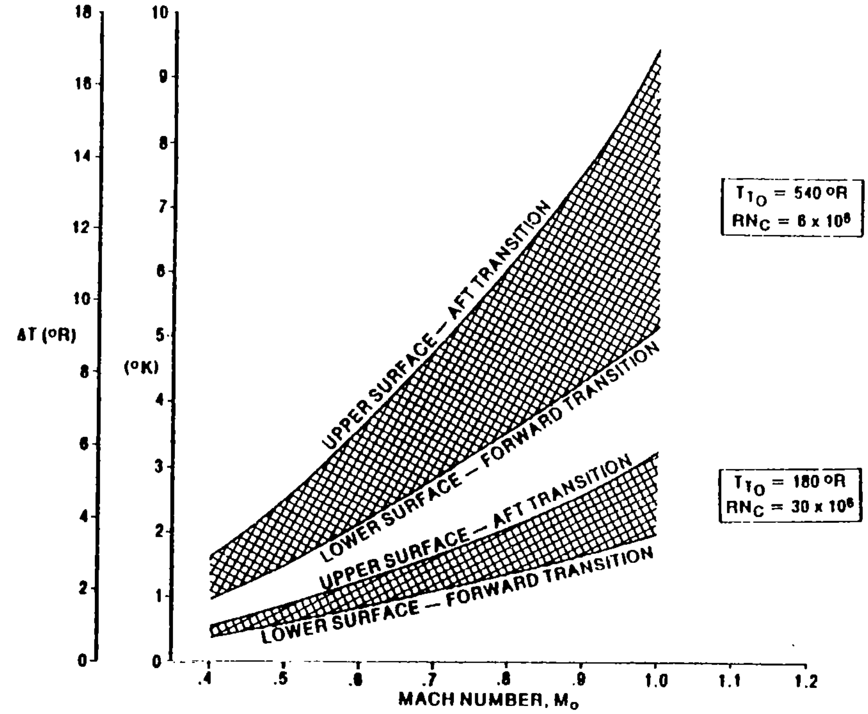

Figure 2

REFERENCES

1. Lynch, F. T. and Patel, D. R.: Some Important New Instrumentation Needs and Testing Requirements for Testing in a Cryogenic Wind Tunnel Such as the NTF. AIAA Paper No. 82-0605, presented at AIAA 12th Aerodynamic Testing Conference, Williamsburg, VA, March 1982.

2. Fancher, M. F.: Aspects of Cryogenic Wind Tunnel Testing Technology at Douglas. AIAA Paper No. 82-0606, presented at AIAA 12th Aerodynamic Testing Conference, Williamburg, VA, March 1982.