AIAA 81-4027

# Effect of Rear Stagnation Point Position and Trailing Edge Bluntness on Airfoil Characteristics

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## Introduction

CALCULATION of the pressure distribution over an airfoil plays an important role in predicting its aerodynamic characteristics. Airfoils with a blunt trailing edge are important because of the practical difficulties in fabricating a sharp trailing edge. During the process of calculating the pressure distribution, it is customary to fix the rear stagnation point by satisfying the Kutta hypothesis at the trailing edge, while the actual position of the rear stagnation point is unknown. In the present study, the rear stagnation point is varied over the trailing edge and the respective pressure distributions are calculated.

The Hess and Smith method[1] is used to calculate the pressure distribution. In this method, the profile is divided into several straight line elements. Sources of unknown strengths, each constant over a given element, are distributed arbitrarily. An unknown constant circulation is superimposed on the profile. The boundary condition is satisfied by equating the normal velocity component to zero. The Kutta condition is satisfied by equating tangential velocities on the two elements on either side of the rear stagnation point. With these two conditions the tangential velocity over each element and hence the pressure coefficient is calculated for a given angle of attack and unit freestream velocity. In the present work, the computer program from Ref. 2 is used. The RAE 101 profile was chosen for the study as experimental results are available for this profile. It is a symmetrical profile with a thickness-to-chord ratio of 10%.

## Results and Discussion

The basic RAE 101 profile was divided into 104 straight line elements. The rear stagnation point is moved on either side of the trailing edge up to 0.02 c in steps of 0.01 c.

The basic profile was then flattened at 0.94 c and the trailing edge rounded at 0.995 c (Fig. 1). This blunt trailing edge is divided into 118 elements. The rear stagnation point is moved on either side of the trailing edge up to 0.003 c in steps of 0.0005 c. The value of the angle of attack used was 4.09 deg, as the experimental results are available for this angle of attack.

As the rear stagnation point is moved on the upper surface away from the trailing edge, the static pressure on the upper surface increases due to the deceleration of the flow, while on the lower surface it decreases (Fig. 2). The reverse holds true for rear stagnation point on the lower surface. The envelope of the pressure coefficient curve changes, resulting in a change of lift and moment coefficients depending on how far the rear stagnation point is moved from the trailing edge. Figure 3 shows the plot of the lift coefficient and the quarter chord of moment coefficient for different stagnation point locations on both profiles. The change in the value of lift coefficient for a given stagnation point location is relatively greater for the blunt trailing-edge profile than for the sharp trailing-edge

Received Jan. 21, 1980. 

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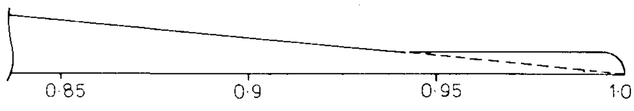


Fig. 1 RAE 101 profile with sharp and blunt trailing edge.

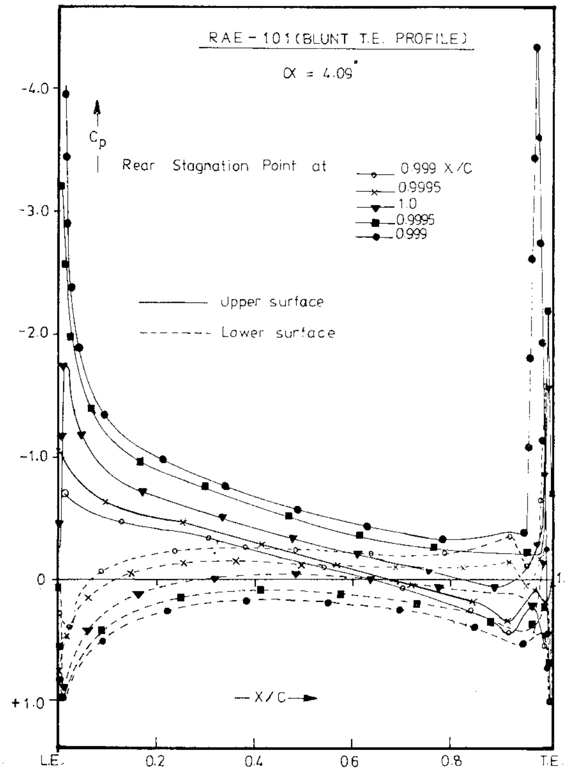


Fig. 2 Effect on pressure distribution.

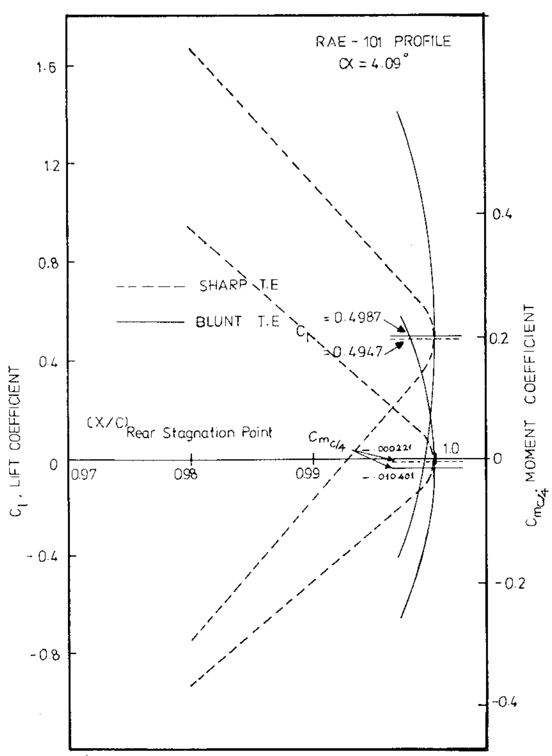


Fig. 3 Effect on lift and moment coefficient.

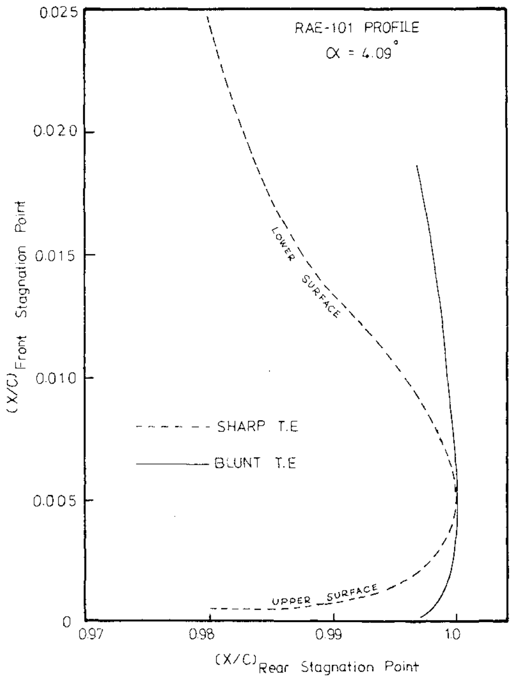


**Fig. 4 Effect on the location of front stagnation point.**

profile. This behavior can be attributed to the bluntness of the profile due to a drastic change in local slope. The same trend is observed with the moment coefficient behavior; also, the location of the rear stagnation point dictates the sense of the moment. When the rear stagnation point is on the upper surface, the sense of the moment is positive (nose up) and vice versa.

The front stagnation point lies on the lower surface for both the profiles regardless of the location of rear stagnation point, but the movement of front stagnation point is relatively larger for the blunt trailing edge profile (Fig. 4).

When the rear stagnation point is at the trailing edge, the bluntness affects the moment coefficient more than the lift coefficient (Fig. 3).

## Summary

Pressure distribution is calculated on the basic RAE 101 profile and on the RAE 101 profile with a blunt trailing edge using the method of Hess and Smith.[1] The flow is assumed to be steady, incompressible, and two dimensional. Results are obtained for different stagnation point locations near the trailing edge satisfying the Kutta hypothesis. The effect of the rear stagnation point position and the trailing-edge bluntness on the pressure distribution, lift coefficient, quarter chord moment coefficient, and the front stagnation point are studied. The results indicate that the location of the rear stagnation point and bluntness have a strong effect on all of the preceding quantities.

## Conclusions

1) The rear stagnation points position has a strong influence on the basic characteristics when it moves away from the trailing edge.

2) The characteristics change drastically due to the presence of bluntness in comparison with the sharp trailing-edge profile.

## References

[1] Hess, J.L. and Smith, A.M.O., "Potential Flow About Arbitrary Bodies," *Progress in Aeronautical Science*, Vol. 8, pp. 1-138.

[2] Narasimha Prasad, S., "Two Studies in Airfoil Design," Project Report, Dept. of Aero. Eng., Indian Institute of Science, Bangalore, 1973.