FOURTH AUSTRALASIAN CONFERENCE
on
HYDRAULICS AND FLUID MECHANICS
at
Monash University, Melbourne, Australia
1971 November 29 to December 3

# FLOW AROUND LEADING EDGES OF AEROFOILS

by

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SUMMARY

The leading edge of an aerofoil plays an important role in giving the section a capability to accept flow over a range in incidence without marked increases in drag. At incidences away from the design value the distribution of velocity around the leading edge can peak: as a consequence there is an adverse pressure gradient behind the peaking that causes thickening of the boundary layer leading to separation and the drag increase.

The purpose of this paper is to describe the effect of leading edge shape on the flow: to do this conformal mapping is used to generate aerofoils having leading edges of a practical shape. The two-dimensional, inviscid, incompressible flow around the leading edges is then examined for a range in incidence. The movement of the stagnation point around the leading edge is examined and two sets of characteristic points defined. These correspond respectively to the incidences at which peaking of the velocity distribution commences and at which peaking becomes very pronounced and beyond which local flow separation would generally be expected, so invalidating the model being used. The ranges of incidence between the characteristic points are related to the leading edge thickness.

The significance of these results in practical applications is then examined. To do this the influence of real flow effects is discussed and the use of the two-dimensional, inviscid flow is justified under particular circumstances. As an example, the design of an aerofoil to have high maximum-lift without a laminar separation bubble is examined and it is shown that this may be achieved with a range in designs from low leading-edge thickness and high camber to high leading-edge thickness and low camber. The former gives the highest value of lift but a low range in incidence for low loss, as the velocity distribution over the pressure surface has marked adverse gradients for lower incidences. On the other hand, the thick, low-camber aerofoil has a lower maximum lift but a large range of low-loss operation.

The method is extended to show that under specific circumstances a leading edge superior to the general type examined may be devised.

The conformal mapping method is applicable to incompressible flows only and there is no method for compressible flows that yield equivalent trends in a parametric form. However, some results from an A.R.L. computer programme that calculates numerically the compressible flow around aerofoils are examined to indicate the trend of the influence of compressibility on the low-loss operating range of an aerofoil and, in particular, on the change in the ideal incidence of the section.

The application of this approach to aerofoil design is discussed. It is suggested that there is a need to be able to prescribe the type of boundary layer development required, including the desirability or otherwise of laminar separation, before the above results yield improvements in aerofoil design.

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