1.0 Introduction

Considerable care is taken in the design and construction of wings to ensure that the shape provides the required combination of lift and drag over the flight cycle and that the surface is aerodynamically smooth. The presence of rain, insect deposits or ice can change the shape of the wing and its surface finish and this paper examines the magnitude of the effects on lift and drag and describes the status of calculation methods which can provide a basic tool for their prediction.

The problems associated with flying airplanes through heavy rain include those associated with aerodynamic performance. It is difficult to quantify these effects from flight experience since they occur usually together with other effects such as wind shear and downdraft. It is known, however, that heavy rain can increase the effective thickness of a wing and cause roughness which stems from drop impingement and from waviness of the liquid film. These effects can, in turn, influence the transition from laminar to turbulent flow and increase drag while decreasing lift. They are significant at all angles of attack and can be important at the higher angles associated with landing configurations. More will be said of this topic later in the course by Dunham.

Knowledge of insect contamination is less, mainly because the likely consequences are small. It is assumed that the contamination acts as distributed roughness with maximum height in the region of the leading edge. The contamination tends to be removed at high speeds or in the presence of rain.

The formation of ice is usually confined to the leading-edge region and again has maximum importance at the high angles of attack associated with landing and takeoff. Deicing is carried out where possible and can avoid or reduce the problem but, as is known from recent accidents, ice can form rapidly on the leading edge of wings and intakes with considerable consequences for aerodynamic properties. Ice formation can also occur at cruise conditions and to an extent that lift is reduced by an important amount. It can be considered in two ways, the first where the effective shape is changed and the second where the ice acts as an equivalent sand-grain roughness although both can be important in many circumstances.