Technical Note

A CFD evaluation of three prominent World War II fighter aircraft

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ABSTRACT

The results of a computational fluid dynamics analysis of three prominent World War II fighter aircraft, the Supermarine Spitfire, North American P-51 Mustang and Focke Wulf Fw190 are presented. The goal of this analysis was to learn the strengths and weaknesses inherent in the aerodynamics of these aircraft. Design features covered include comparisons of the wing designs and calculated total wetted areas along with a look at specific details of the aerodynamics of each aircraft. This information, while historical, still has relevance in today's world of aircraft design.

INTRODUCTION

As time progresses, many of the valuable lessons learned in the original design of vintage aircraft are being lost. It is the purpose of this study to use modern aerodynamic analysis tools to recover some of this lost knowledge. Great strides in aircraft design were made in the 1935–1945 era, and this is most evident in the design of fighter aircraft of this period. For this reason, an evaluation of three prominent fighter aircraft of this era, the Supermarine Spitfire, the North American P-51 Mustang and the Focke Wulf Fw190, is presented here.

ANALYSIS METHOD

All three aircraft have been analysed with the VSAERO panel code. VSAERO[1] is a full-configuration, aerodynamic analysis method which solves the linearised potential flow equations. The basis of the computer program is a surface singularity panel method using quadrilateral panels on which doublet and source singularities are distributed in a piecewise form. Effects of wake shape are treated in an iterative wake relaxation procedure, while the effects of viscosity are added in an iterative loop coupling potential flow and integral boundary layer methods. Boundary layer displacement is modelled by transpiration through the body surface in succeeding solutions. The laminar boundary layer calculation is an adaptation by Curle[2] of a method developed by Thwaites[3]. Boundary layer transition is calculated by Granville's method[4], while the turbulent boundary layer calculation uses the method of Nash and Hicks[5]. Turbulent boundary layer separation is predicted when the skin friction vanishes. Compressible flow can be modelled by applying a Karman–Tsien or Lieblein–Stockman correction of the incompressible flow or a Prandtl–Glauert linearisation to the compressible flow. Validation of the VSAERO code has been shown in many studies, Ref. 6 being a typical example.

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GEOMETRY DEFINITION

In all three cases, the VSAERO panel models were prepared using original manufacturers' drawings. It was found that models of the P-51B/C (Fig. 1) and P-51D/K (Fig. 2) were relatively easy to prepare, as the drawings contained surface coordinates, in a familiar fuselage station–buttline–waterline system. The Spitfire drawing set contained definition for various models, ranging from the Spitfire I to the Seafire 47. It was decided to build the panel

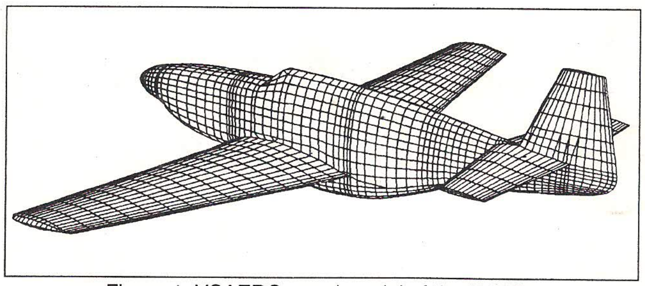

Figure 1. VSAERO panel model of the P-51B.

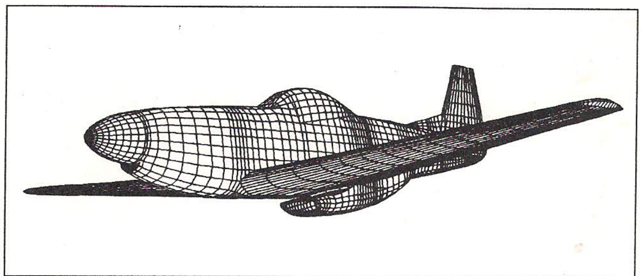

Figure 2. VSAERO panel model of the P-51D.