~~S E C R E T~~ C-105

S1038CF105-180
(AMTS/DAEng)

REPORT ON A VISIT TO AMES AERONAUTICAL LABORATORY MOFFETT FIELD CALIFORNIA TO DISCUSS AERODYNAMIC PROBLEMS OF THE CF105 AIRCRAFT ON THE 9 AND 10 DEC 1954

SUMMARY

1 The following is a summary of the comments made by the staff of the NACA Ames Laboratory on the CF105 design:

(a) The subsonic drag estimate is probably correct.

(b) The supersonic drag estimate is optimistic. Ames considered that the supersonic $C_{D_{Min}}$ would be between .025 and .030 instead of the .016 as estimated by AV Roe.

(c) A $C_{D_{Min}}$ of .020 may be achieved for aircraft similar to the CF105 but will represent somewhat of an optimum figure for this class of aircraft.

(d) The area rule will over estimate the drag of the CF105 because of the low fineness ratio and large bumps.

(e) The CF105 should be modified at intakes and jetpipes to reduce the slope of the area distribution to reduce wave drag.

(f) Conical distribution positive camber will reduce the drag due to lift below the speed of sound but will increase it supersonically.

(g) There is some evidence that conical distribution positive camber may delay the pitch up tendency to a higher angle of attack.

(h) The leading edge notch and extended leading edge as advocated by AV Roe to prevent pitch up may cause a supersonic drag increment of .001.

(i) A continuous increase in wing leading edge radius from root to tip may do the same job as the notch and leading edge extension without the increase in drag

(j) The use of suction to prevent separation of the boundary layer by the normal shock ahead of the intake has been successfully tried by Ames. Design data may be obtained from recent tests carried out by NACA Lewis Laboratory, Cleveland.

(k) The intake lips should be modified to be sharp on the outside and elleptical on the inside to reduce supersonic drag.

(l) The internal intake ducting should be of constant cross sectional area for a distance of two duct diameters before being gradually diverged to allow any separated boundary layer to re-attach.

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tending to cancel the benefit of the staggered inlets. However the idea may be worth considering). The NACA had no design data on staggered inlets.

9 Limitations on the Application of the Area Rule. The area rule can only be used in estimating the drag of slender bodies (large fineness ratio) with small bumps. As the body departs and becomes more blunt and has large bumps the area rule over-estimates the drag. The NACA stated that the area rule would definitely over-estimate the drag of the CF105. However, the area rule can be used to indicate the general areas where the aircraft can be improved on.

10 Drag Due to Lift. The use of positive camber of conical distribution, the type recommended by the NACA Langley Laboratories to reduce the drag due to lift was discussed. Mr. Frick stated that at Mach .9 positive camber did reduce the drag due to lift to that given by theory. At Mach 1.5 it gave a drag penalty of .001. Thus from a drag due to lift point of view, the use of positive camber depends on the mission of the aircraft. It is of value for subsonic missions and a detriment for supersonic missions.

PITCH UP

11 The Ames Laboratories have found that the use of positive camber at Mach .9 delays pitch up to a higher C_L i.e. a higher angle of attack. This was because the increased leading edge suction prevented flow break-away until a higher angle of attack.

12 With regard to the leading edge notch and extended leading edge as advocated by AV Roe, Mr. Frick felt that at Mach 1.5 the drag may be increased as much as .001. He felt that a continuous increase in leading edge radius of the wing from root to tip would do the same job without the same increase in drag but could produce no data on this.

13 Mr. Frick stated that since pitch up was a viscosity effect, wind tunnel tests of means to cure the tendency should be carried out at a high Reynolds number in order to obtain reliable design information.

INTAKES

14 Mr. Frick stated that he had carried out wind tunnel tests on intakes similar to those of the CF105 and had found that the use of suction to prevent separation of the boundary layer by the normal shock ahead of the intake was very successful. The mass flow could be reduced away below the design value without incurring instability. Data on these tests were proprietary and could not be released. However, the NACA Lewis Laboratories had done some recent tests on this type of intake and it was suggested that AV Roe contact them for design information.

15 Mr. Davis felt that the diverter (i.e. the wedge shaped structure between the intake ramp and the fuselage) was too blunt and should be sharpened if structural considerations allowed.

16 Intake Lips. Mr. Davis recommended an intake lip design that he had been experimenting with. This lip was sharp on the outside to reduce external drag and elleptical on the inside to prevent separation at high angles of attack. To avoid confusion this lip should not be considered a sharp or a blunt one in the usual sense but as a new type. The outside surface of the intake was a straight conical taper, approximately 3° while the internal contour was an ellipse of major to minor axis ratio of 3.6 to 1. The use of this lip on an aircraft similar to the CF105 had saved approximately .001 in drag.

17 **Internal Ducting**. The NACA commented on the intake ducting of the CF105 by saying that the duct should run at constant cross sectional area (not necessarily circular) for a distance of two duct diameters to allow any detached boundary layer to re-attach before being diffused by a gradual divergence.

18 **Artificial Damping**. Mr. Robinson stated upon being asked of the NACA's opinion the dependence of artificial stability devices that he could not comment since this was entirely a matter for the "user" to determine based on an assessment of reliability.

Commercial Tests in NACA Tunnels

19 The NACA resists doing development wind tunnel tests because their prime job is research. However, the procedure leading up to such tests is as follows:

(a) The contractor discusses his problem with the laboratory most directly concerned who carry out a technical assessment of the problem to determine if design data already exists in the literature and if the contractor has done everything possible on his own.

(b) If the Laboratory decides that the test is needed then the recommendation is forwarded to NACA Headquarters who decide on the overall priority for carrying out the test.

20 Mr. Robinson recommended that USAF facilities be considered for any work that we may require since their tunnels are intended for development testing.

Concluding NACA Statement

21 At the end of the discussion Mr. Robinson, Assistant Director of the Aimes Laboratory, stated that while they could point out those things that individually were desirable it was only the designer of the aircraft that could make the final design compromises.

IS McLeish

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Initial

~~SECRET~~

INTRODUCTION

1 Members of the staffs of AV Roe and AFHQ visited Ames Laboratory, Moffett Field to discuss aerodynamic problems connected with the design of the CF105 aircraft, in particular the modification of the aircraft as dictated by the Area Rule.

2 The members of the Canadian group were as follows:

F/L I.S.	McLeish	DAEng/AEng4-2
Mr. J.	Chamberlin	AV Roe
Mr. J.	Morris	AV Roe
Mr. F.	Woodward	AV Roe

3 Discussions were held with the following members of the NACA Ames Staff.

Mr. R.G. Robinson	Assistant Director of the Ames Laboratories
Mr. R.T. Jones	
Mr. G. Holdaway	
Mr. C.W. Frick	
Mr. Barrett Baldwin	
Mr. Davis	

DRAG OF THE CF105

4 Drag Estimation. Mr. Robinson stated that American firms estimate drag in various ways - some add the drag of various components similar to AV Roe, some add the drag components and then modify the total according to the area rule if within the limitations of the rule (see paragraph 9), while some use the drag of comparable aircraft. When specifically questioned regarding the validity of contractors estimates, Mr. Robinson stated that the NACA had found some of the drag estimates made by adding the drag of various components ~~had been found~~ to be correct. Further, Mr. Frick stated that the drag as measured in their wind tunnels had subsequently been proven to be correct within the usual experimental error from flight tests.

5 Subsonic Drag of the CF105. After considering the CF105 design the NACA agreed that AV Roe's subsonic drag estimate was probably right. The subsonic zero lift drag is essentially turbulent skin friction which can be estimated the same as always.

6 Supersonic Drag of the CF105. Based on the NACA experience of many aircraft they considered AV Roe's supersonic zero lift drag to be very optimistic since the wave drag has been estimated much too low. It was considered that the zero lift drag of the CF105, as is, will be between .025 and .030. Mr. Frick stated that from measurements made on aircraft similar to the CF105 (not the F102) he considered that a figure of .020 could be obtained for this general class of aircraft but this would represent the very best that could be achieved.

7 The NACA's chief criticism of the CF105 was that the fineness ratio of 7 is far too low. For a Mach 2 aircraft the fineness ratio should be 9 or greater. Increasing the fineness ratio from 7 to 11 halves the wave drag. The CF105 could not be stretched this amount without a complete redesign.

8 Application of the Area Rule to the CF105. From an inspection of the area distribution curve for Mach 1 the NACA pointed out the known criticism that the slope of the curve at the intakes and the rear boattail was far too steep and produces much of the wave drag. It was suggested that the intakes be staggered to reduce the area slope at the front and a plate between the jetpipes to reduce the slope at the rear. Caution must be exercised with the plate between the tailpipes because it may affect the jets and cause more drag than saved. (Subsequent consideration of staggered inlets brought out the disadvantage that the staggered ramps would produce a large moment on the aircraft which would have to be taken out by the rudder and fin. The increase in rudder angle would cause an increase in trimming drag