THE INFLUENCE OF "STEALTH" TECHNOLOGY ON FLIGHT-PEFRORMANCE AND MANOEVERING CHARACTERISTICS OF FIGHTER AIRCRAFT

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Abstract

Low Observable technology offers significant benefits for fighter aircraft in terms of aircraft survivability [1]. Different approaches to reduce aircraft radar crossection (RCS) are proposed and investigated [1], [2].

The requirement for aircraft to be stealthy in some case results in performance penalties to be paid [3]. Thus, at designing of an advanced fighter the search of tradeoff between low signature and high performance is possible.

The article presents results of appreciation of "Stealth" technology influence on fighter aircraft flight-performance and maneuvering characteristics.

Introduction

The shaping an aircraft for the purpose of scattering the most radar waves and not reflecting back to the transmitter allows reducing RCS in a broad band of lengths of wave [1].

It is achieved by reduction the number of "bright points" (areas of a surface, the reflected signal from which is directed to the receiver). Most typical examples of "bright points" are:

- Engine compressor faces and turbines
- Engine air inlets
- External weapon stores
- Wing leading edge
- Corner reflectors
- The area, in which normal to a surface is parallel to a direction of propagation of a wave (vertical tail, aerodynamic fence, etc.).

The reduction of number of "bright points " decreasing intensity of a reflected signal is possible with the help of following measures:

- use internal weapon storage,
- curved S-shaped inlet ducts,
- use aligned reflecting surfaces and ages.

The analysis of the influence of these measures on weight and aerodynamics, flight-performance, RCS is performed by going over from initial arrangement to arrangement with reduced level of signature (RLS). The peculiarity of the analysis is that the going over to RLS arrangement is performed at a given engine. The 4-th generation fighter arrangement of MiG-29 type is considered as initial one.

Two possible ways of going over are considered:

1. Basic overall dimensions of an aircraft - wing span, fuselage length, fuselage maximum crossectional area are constant. Geometry proportions of an arrangement – form coefficient *F* [5]

$$F = (36\pi)^{-1/3} \frac{A_{wet}}{V_a^{2/3}}$$

   and relative wetted surface area A_{wet}/S are changing.
2. Proportional resizing of an arrangement at constant form coefficient F and relative wetted surface area A_{wet}/S under specified subsonic range and sustained g-load.

1 Transition to RLS arrangement under constant overall dimensions.

At transformation of initial arrangement with the purpose to create the RLS version following measures were realized:

- The shape of fuselage crossection is changed.
- The "S"-shaped nonadjustable air intakes.
- Internal weapon bay.
- The parallel edges of a wing and tail.

According to the adopted approach the change of an arrangement has resulted in increasing of internal available volume on ~ 10% on a comparison with initial arrangement at a practically constant wetted surface area.

The relative changes of geometric parameters (RLS arrangement parameter value is divided by initial one) at transition from initial arrangement are adduced in table 1.

Table 1

Geometry parameter	Parameter ratio
1. Reference wing area	1.33
2. Wing aspect ratio	0.75
3. Relative wetted surface area	0.76
4. Form coefficient	0.94
5. Aircraft volume	1.11
6. Relative wing profile thickness	0.8
7. Relative fuselage maximum crossectional area	0.75

1.1 Calculation of the aerodynamic and mass characteristics

The estimation of changes of the aerodynamic and mass characteristics at transition to RLS arrangement is performed with use of a program package "JAPAD" for preliminary aerodynamic design of an advanced fighter developed in TsAGI.

The package consists of the set of programs of an expert level based on statistical relations of geometric, weight and aerodynamic parameters of 60-90 years jet fighters. The relative changes of the mass characteristics are adduced in table 2.

Table 2

Weight parameter	Parameter ratio
1.Takeoff weight	1.10
2. Airframe weight	1.13
3. Relative fuel weight	1.07

The increase of takeoff weight is due to large aircraft volume and heavier airframe because of internal bay.

The subsonic maximum lift-to-drag ratio at transition from initial arrangement without external store to RLS arrangement was not changed, since there were constant determining geometric parameters: wing span, wetted surface area.

$$(L/D)_{\max\ M<0.9} = \frac{1}{2\sqrt{C_{D0}A_2}} \approx \frac{l}{2}\sqrt{\frac{\pi}{C_{f_{eqv}}A_{wet}}}$$

$$\tilde{N}_{f_{eqv}} = \frac{\tilde{N}_{D0}S}{A_{wet}}$$

Maximum lift to drag ratio of RLS arrangement is increased due to elimination of the external stores in comparison with initial arrangement with external stores (table 3).

1.2 RCS.

The calculation of RCS is performed under the program "SIGMA-8 FAAD" developed in TsAGI. The calculation method includes external reflection, arbitrary shaped cavities, surface discontinuities solution.

The method doesn't take into account the reflection from any internal structure within radar-transparent skins. The median RCS values on sectors 15° are used at angle of elevation $\alpha = 0$ at wavelength of 10 sm.

1.3 Flight-performance

The relative changes of the basic flight-performance are adduced in table 3. The calculation of RLS arrangement is performed for the case of nonadjustable "S" - shaped air intakes determining decreasing of an installed thrust at supersonic speeds M > 1.5 by comparison with initial arrangement (adjustable air intakes).

Table. 3

Flight-performance	Relative change
1. Maximum trimmed lift to drag ratio • =11km, M = 0.8 M = 1.5	 1.11 1.08
2. Takeoff thrust-to-weight ratio	0.92
3. Takeoff wing load	0.81
4. Sustained g-load • = 5 km, • = 0.9	0.98
5. Specific excess power • = 5 km, • = 0.9	1.00
6. Maximum Mach number	1.03
7. Maximum altitude	1.00
8. Subsonic range	1.3
9. Supersonic range, M=1.5	1.5
10.RCS, θ = 0 90°	0.05 0.12

2 Transition to arrangement with internal armament bay at proportional change of the sizes.

Vital importance at RCS reduction is internal arrangement of armament. “ … there is no sense to be engaged in reduction of RCS, if the aircraft will be equipped with external armament ” [4].

Given section shows the analysis of transition from an arrangement with external stores to an internal armament bay (IAB) arrangement both designed under given subsonic range and sustained g-load. The geometric proportions determining external shape of an aircraft – form coefficient F, relative wetted surface area A_{wet}/S are constant.

Such analysis is performed with use of the program “FAKS-Eng”, realizing a Technique of Jet Aircraft Parameters Calculation under Design Requirements [5].

Fig. 1 shows the ratio of required takeoff weight of IAB arrangement to that one of initial arrangement depending on subsonic range and maximum sustained g-load.

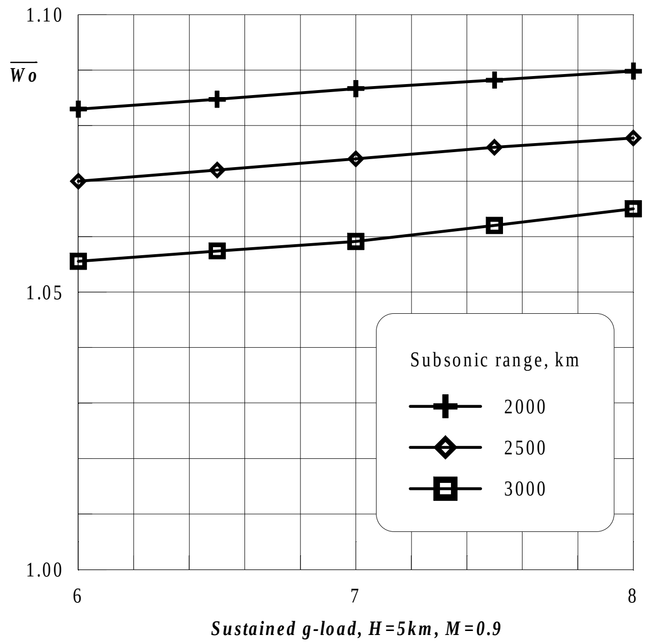

Fig.1. Relative change of takeoff weight.

Fig. 2 and 3 show the relative change of required maximum lift-to-drag ratio at subsonic cruise conditions and required wing aspect ratio.

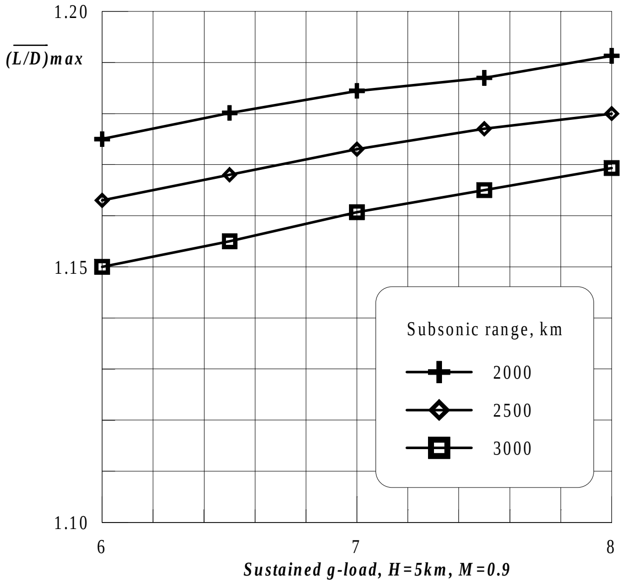

Fig.2. Relative change of required maximum lift-to-drag ratio

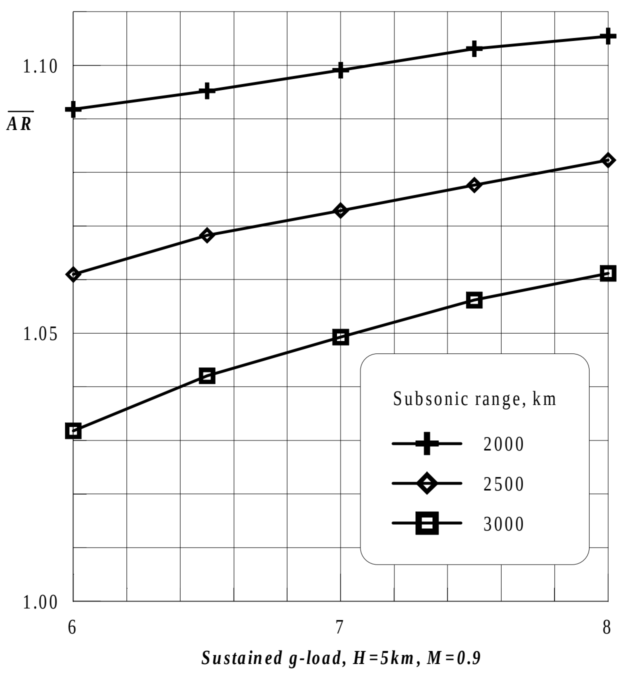

Fig.3. Relative change of required wing aspect ratio.

The outcomes of calculation show, that the IAB arrangement has increased takeoff weight (on 6 - 9 %) and requires increased wing aspect ratio (on 5-10 %) in comparison with initial arrangement.

Conclusions

The going from a 4-th generation fighter to version with a reduced level of signature under the given engine is possible at constant values of overall dimensions and at necessary transformation of an external shape. At this the subsonic manoeuvrability is insignificantly worsened, the subsonic and supersonic range is increased.

The transition from external stores arrangement to arrangement with internal armament bay at given engine under specified subsonic range and sustained g-load results in increase of takeoff weight (6 - 9 %) and requires the increase of wing aspect ratio of 5 - 10%.

References

[1] Ray Whitford, *Designing for Stealth in Fighter Aircraft (Stealth from the Aircraft Designer's Viewpoint)*, Paper No 965540, 1996, World Aviation Congress, October 21-24 .

[2] John Paterson, *Measuring Low Observation Technology's Effects on Combat Aircraft Survivability*, Paper No 975544, 1997, World Aviation Congress, October 13-16 1997 Anaheim, CA

[3] David C.Aronstein, Albert C.Piccirillo, *Have Blue and F-117A: Evolution of the "Stealth fighter"*, AIAA, 1997.

[4] Aviation Week and Space Technology, 1988, v. 129, 26/IX, N 11, p. 233.

[5] I.G.Bashkirov and R.D.Irodov, *Calculation of Jet Aircraft Parameters Under Design Requirements*, Paper No 975598, 1997, World Aviation Congress, October 13-16, Anaheim,CA.