

THE GENERAL CHARACTERISTICS AND PROPERTIES OF A FIGHTER JET AIRCRAFT F-16

Samer AL-RABEEI*, **Michal HOVANEK**, **Peter KORBA**

Department of Aviation Engineering, Faculty of Aeronautics, Technical University of Kosice,
Rampová 7, 041 21 Kosice, Slovakia

**Corresponding author*. E-mail: samer.abdo@tuke.sk

Abstract. The fighting in the air-to-air combat and air-to-surface combat represents a relatively new type of combat, happening for a period of only around seventy years. In these years a quick technological advancement took place and caused the development of very primitive weapons to the present beyond the visual range or point-to-shoot capabilities of nowadays aircraft. Though aerial combat fundamentals remained very similar to those in the past, seasoned only by actual combat and exercises for training purposes. Although these standards remained almost untouched, the technological advancement in aircraft design and weapon systems is immense. This applies also to the fighter jet aircraft called F-16. The F-16 is one of the most widespread fighter jets ever produced, if not the most. It is important to improve the aircraft design and its systems for navigation, orientation, and maybe most importantly, its 'weaponry and surrounding accessories.

Keywords: aircraft F-16; aviation industry; F-16 fighter

1. INTRODUCTION

F-16, also known as Fighting Falcon is a single-engine, single-seat fighter jet constructed by the Dynamics Corporation, which is a part of Lockheed Martin Corporation. The aircraft is built not only for the use by the United States, but is also exported into more than twelve other countries. The origin of the plane is in an order from 1972, where a proposal for lightweight cost-effective air-to-air fighter was made. This aircraft is capable of all-weather use and are usable in air-to-surface attacks too. The first F-16 was delivered to the US-Air Force in 1978. The plane itself is fifteen meters long and has a wingspan of 9.45 meters. Its power is generated by a single Pratt & Whitney (or General Electric) turbofan engine, which can produce with afterburning 102 to 130 kilonewtons of thrust. The top speed of this particular plane can reach up to more than twice the speed of sound. Generally, it is equipped with a 20 mm rotary cannon and can also be armed with various bombs and missiles attached under the fuselage of the plane or its wings. Carrying a typical combat load, the weight of the aircraft is approximately 10 000 kilograms, while this number can be alternating depending on the type and amount of loadout it carries. This weight still represents only around half the weight of the previous generation aircraft F-4 Phantom II.

The fuselage of the aircraft flares out at its juncture with wings, which are made using aluminum alloy, providing the aircraft greater lift and stability at steep angles of attack. The F-16 uses a so called „fly-by-wire“ system, which issues commands to the control surfaces on in the wings and tail. The cockpit is also equipped with „heads-up-display “instrumentation system. This system projects important data, such as flying and combat data, onto a transparent screen in front of the pilot. Next there is a complex bomb-aiming system, which uses either laser-range finder and high-speed data processing. Even though there is this complex bomb-aiming system, F-16 can still drop ordinary bombs with a great precision from low altitudes. Thanks to these advanced systems that are installed onto or into the F-16, this aircraft is considered a highly capable and versatile aircraft. The plane has been constructed under a license in Belgium, Netherlands and Turkey. It has also been used as the basis for Japan's FS-X fighter jet. The aircraft has proved its effectiveness after being sold to U.S. allies

in the Middle East, where it was used in Israeli-Syrian conflict in 1982 and in the Persian Gulf War in 1990-1991. [2]

2. RESEARCH AND ANALYSIS

2.1. History and origin

The genesis of the successful F-16 fighter / attack aircraft lies in the response to serious shortcomings in the American fighter design revealed by the Vietnam War.[3]

Probably the biggest problems of the F-16 during development was the unpopularity with the USAF. Knowing that their aircraft was constantly threatened with cancellation, General Dynamics' designers were basically forced to do everything possible, and then some to maintain performance and prevent cost increases. For example, while F-15 body accounted for about 25% titanium, titanium in F-16 was limited to 2%. As another example, a fixed motor input was used to keep costs down, although a variable inlet would provide better performance above Mach 1.5. [3]

The F-16 was a success by every standard. The USAF used it intensively and successfully for air-to-ground flights in the 1991 Gulf War and in all subsequent conflicts. The Israeli air force also had a great success with it. [3]

Looking back, with the current point of view we can find out how the original concept has been preserved. [3]

2.2. Variants of the F-16 Fighting Falcon

An incredible amount of variants of the F-16 were produced by the General Dynamics, Lockheed Martin, and also by other licenses manufacturers like the ones in Belgium and Netherlands. There are multiple groups in which the individual types of F-16 can be placed into. Spanning from the prototype variants of the aircraft to proposed types that were not in production yet. In this section there are described the individual variants of the F-16 fighter jet.

YF-16

Two prototypes were built in 1973, and the first flight took place on 21st of January 1974. The second prototype flew on 9th of March 1974. The F-16 also flew in the Air Combat Fighter Competition, where it came first. [5]

F-16 FSD

The first type of this aircraft flew on 8th of December 1976 and later was used as test demonstrators for various tests and further research. [5]

F-16E/F – “E” in this case stands for a single seat aircraft, while “F” represents the two-seater. This variant, or name, is now special to United Arab Emirates Air Force. There is also a not official nickname for this variant – Desert Falcon. [5]

F-16E/F Block 60 - The Block 60 designation was planned to be used originally in 1989. It was supposed to be the F/A-16 which sported a 30 mm cannon and a stronger structure of wing for anti-tank weapons such as 7.62 mm pods. This jet was also in consideration to

replace the A-10 warthog. The "original" Block 60 did not go into production, and its designation basically ends the series of adding another block. The main differentiation from earlier blocks are conformal fuselage mounted fuel tanks, similar to those ones used in Block 50/52 Plus. Block 60 represents huge technological advancement and is being delivered to Slovak Republic in 2022-2023. [5]

F-16V Block 70/72 - the Block 70/72 features advanced avionics, a proven Active Electronically Scanned Array (AESA) radar, a modernized cockpit with new safety features, advanced weapons, conformal fuel tanks, an improved performance engine, and an industry-leading extended structural service life of 12,000 hours. Operational capabilities are enhanced through an advanced datalink, targeting pod and weapons, Infrared Search and Track (IRST); precision GPS navigation and advanced Common Digital Flight Control Computer with an enhanced Autopilot/Auto Throttle with life-saving Automatic Ground Collision Avoidance System (Auto GCAS). [6]

3. AERODYNAMICAL PROPERTIES OF THE WING

In order to describe the aero-dynamical properties of the wing on F-16 fighter jet, there is necessary to have a so called NACA profile number. The NACA profile for F-16 is 64A204. To be able to generate the profile graphical representation it is necessary to get a .dat file with the information about the profile itself. This file is obtainable for free on the following website: https://m-selig.ae.illinois.edu/ads/coord_database.html. Since there is not the exact profile file, 64-206 profile was selected, which is the most resembling profile to the original one. After getting the .dat file it is possible to import it into a program called **xflr5**. This particular program allows the user to generate the profile of the wing, and also to calculate all the necessary data (Fig 1). It is possible to change Reynold's number, as well as alpha (angle of attack), mach number and others.

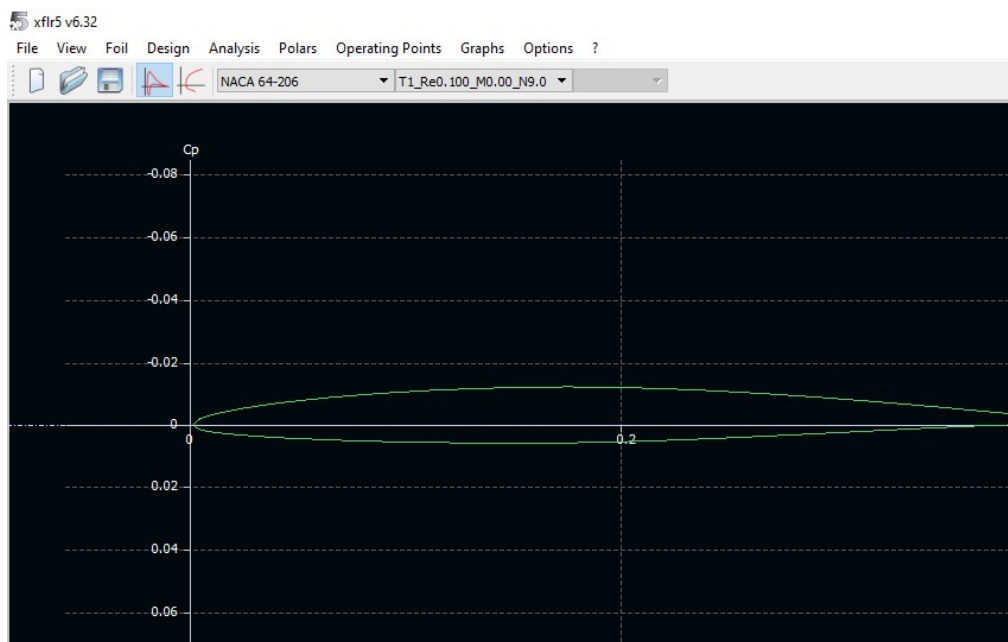


Figure 1 NACA 64-206 profile in xflr5

Switching to the „Polar view “it is possible to see multiple graphs with multiple polars. Individual polars stand for different Re numbers. Xflr5 can calculate with many Re numbers. Xflr5 also provides the simulation of different angles of attacks at the same time, which can be used to collect data of coefficient of drag (CD), coefficient of lift (CL) and pitching moment (CM) in different angles of attacks. It is also possible to set the number of iterations before the program will stop calculating, to prevent from endless calculation execution. After these calculations are done, the polars can be exported into text document files. Any of these documents can be selected and imported into Microsoft Excel. Later graphs or plots can be created from the calculated data. These graphs provide the general information for about the wing profile.

1 1 Reynolds number fixed				Mach number fixed			
xtrf =	1.000 (top)		1.000 (bottom)				
Mach =	0.000	Re =	0.030 e 6	Ncrit =	9.000		
alpha	CL	CD	CDp	Cm	Top Xtr	Bot Xtr	Cpmin
0.000	0.0002	0.01893	0.00549	-0.0095	1.0000	1.0000	-0.6272
0.500	0.0331	0.01929	0.00567	-0.0073	1.0000	1.0000	-0.4382
1.000	0.0654	0.01977	0.00608	-0.0052	1.0000	1.0000	-0.2642
1.500	0.0968	0.02039	0.00668	-0.0033	1.0000	1.0000	-0.3829
2.000	0.1272	0.02116	0.00748	-0.0014	1.0000	1.0000	-0.5658
2.500	0.1567	0.02207	0.00851	0.0004	1.0000	1.0000	-0.7581
3.000	0.1853	0.02314	0.00976	0.0020	1.0000	1.0000	-0.9576
3.500	0.2129	0.02440	0.01128	0.0034	1.0000	1.0000	-1.1614
4.000	0.2394	0.02587	0.01312	0.0046	1.0000	1.0000	-1.3649
4.500	0.2645	0.02761	0.01533	0.0055	1.0000	1.0000	-1.5605
5.000	0.2877	0.02968	0.01800	0.0061	1.0000	1.0000	-1.7310

Figure 2 Part of the exported calculations from Xflr5

From all the data provided by Xflr5 (Fig. 2) it is possible to create graphs, first of the following is comparison of the drag coefficient to lift coefficient (Fig. 3), while the second graph represents changing lift coefficient and pitching moment using different angles of attack (Fig. 4).

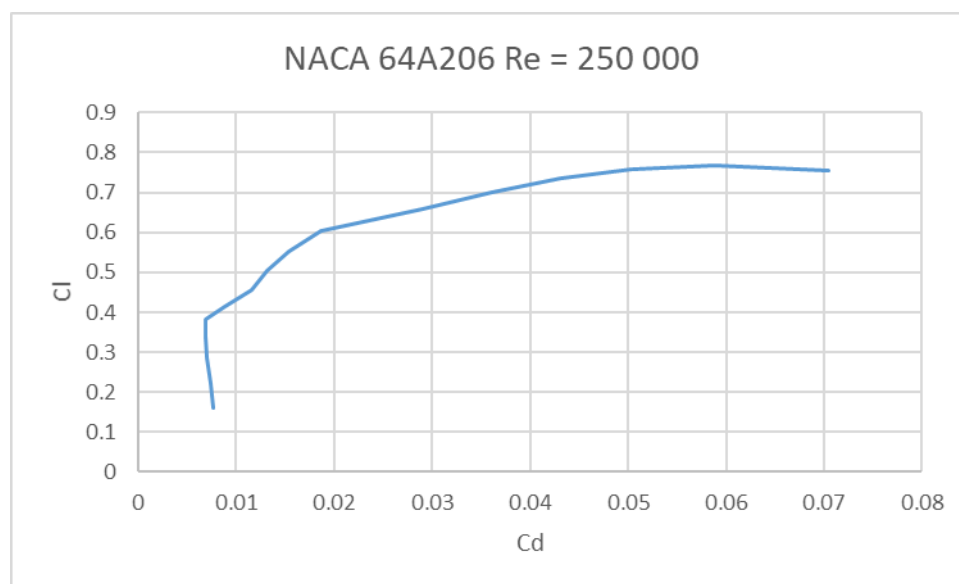


Figure 3 Comparison of drag coefficient to lift coefficient

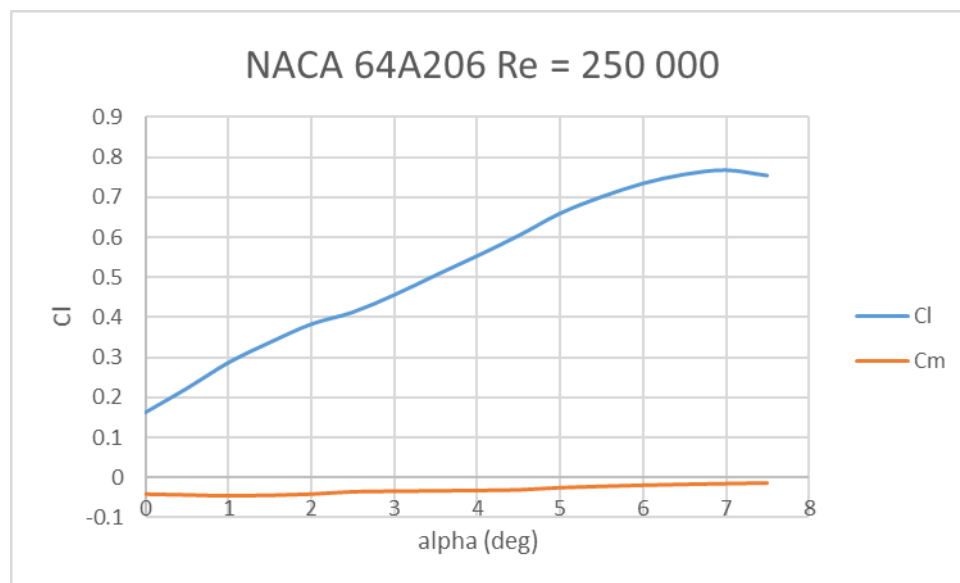


Figure 4 Lift coefficient and pitching moment in different angles of attack

4. CONCLUSION

It is possible to conclude that F-16 Fighter Falcon represents a great piece of aircraft. It has been deployed in multiple conflicts and exported to many countries. It is a versatile aircraft, which can be adapted to the needs of the particular place of use. This is also supported by the fact some aircraft are used in desert conditions, while others are used in much colder regions. The long life cycle of the aircraft and subsequent upgrades made along the way prove that it is a viable option. Newest Blocks of the aircraft (or newest variants) are on the top of the technological advancement, and are comparable to much more expensive aircraft such as F-35, while being much cheaper to operate. Of course each aircraft has its own use, but the fact F-16 is an excellent piece of technology remains true, and most likely will remain true for the entire time this jet will be supported and upgraded in the future.

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