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CFD ANALYSISOF UNMANNED COMBAT AERIAL VEHICLE (UCAV) BY VARYING ANGLE OF ATTACK

Sunil Kumar V[1*],Harshit C R[1], Shivaramu H T[2], Nagaraj[2],Umashankar K S[3]

[1]UG Students, Department of Mechanical engineering, KVGCE, Sullia, DK, Karnataka.
[2]Assistant Professor, Department of Mechanical engineering, KVGCE, Sullia, DK, Karnataka.
[3]Professor, Department of Mechanical engineering, KVGCE, Sullia, DK, Karnataka.

Abstract: ***Using CATIA V5 design software a model was designed on the platform of Unmanned Combat Aerial Vehicle (UCAV).Computational Fluid Dynamics (CFD) Analysis was performed on the ANSYS Workbench 14.0(Fluent) of the UCAV. The Design was particularly done for low speed and high Angle of Attack (AOA) criteria. Important results were interpreted such as lift, drag and lift to drag ratio for various AOA which eventually leads to determining stall angle of the UCAV. Primitively stall angle of the UCAV is found to be 30 degrees and the lift to drag ratio as 7.63, thus making UCAV to have high stall angle at lower speeds. 100-120m/s are taken for lower speed phenomena, density of air being constant at 1.22 kg/m^3.***

Key words: ***UCAV, Computational Fluid Dynamics, Angle of attack, stall angle.***

I. INTRODUCTION

Air superiority remains an essential military mission. Even though control of the air does not itself destroy or defeat the majority of enemy forces, it provides the freedom of action and strategic flexibility that allow other military forces to do so. Air superiority is a central control to a full range of military defensive force, including superiority over sea and land forces, close air support, interception and freedom of manoeuvre for ground forces. In the recent years learning from post second world war, rise of communism over the pan Asian countries has lead to dramatic change in the concept of armed forces. There is significant political pressure to develop combat capabilities in UAV's. The National Defence Authorization Act for FY 2001 states, "It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology, such that by 2010, one-third of the aircraft in the operational deep-strike force are unmanned". UAV's will play a major role in the increasingly dynamic battle that will typify 21st century warfare. The political and economic impetus for less risky and less costly platforms for national defence is leading to a vast expansion in the search for unmanned missions. The ready time for a combat UAV is quite impressive and essential. Such as the fighter pilot black out in heavier G's Absence of cockpit also makes it easy to maintain in times of hardship. In 1996 the United States Air Force (USAF) Scientific Advisory Board (SAB) determined that there were nine potential mission areas for Unmanned Combat Aerial Vehicles (UCAV). One of these roles was the suppression of enemy air defences (SEAD). It has been projected that the USAF along with the allied forces could enter development on UCAV as soon as 2003, with an initial capability possibly as early as 2005, as but not later than 2008. If a UCAV could effectively accomplish the air superiority mission, then the USAF and the allied forces could forego the costly simultaneous development of vehicles with overlapping qualities to replace the F-22 and other modern 4-5th generation modern jets. The potential for technology and economics to influence political decision making formulates the basis for the research question of this study[1, 2].

II. UCAV DESCRIPTION

The UCAV specially uses DELTA WING structure. The general characteristics of delta wing have. The long root chord and short span of the delta wing make it structurally efficient. It can be built stronger, stiffer and at the same time lighter than a swept wing of equivalent lifting capability. Its long root chord also allows a deeper structure for a given aerofoil section, providing more internal volume for fuel and other storage.

2.1 CATIA 3D MODEL OF UCAV

The modelling of the UCAV is designed with reference of delta shape fighter jet is TEJAS mk1A is shown in Fig. 1.The Dimensions(Fig.2) of UCAV are as follows
Length = 14.48 m
Wing span =9.6 m
Height = 3.4m

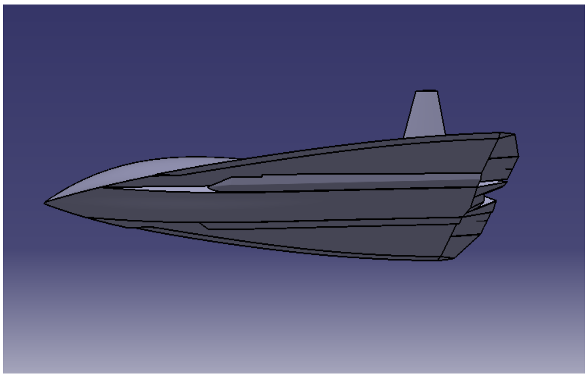

Fig.1:3D models of UCAV

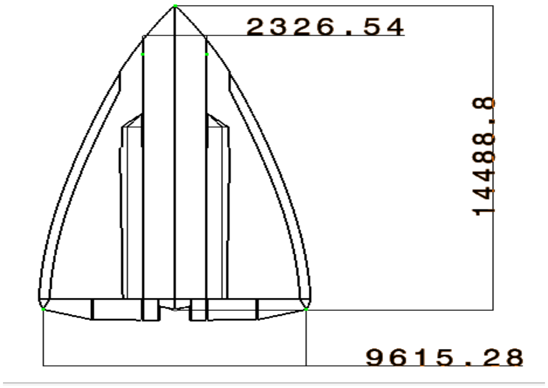

Fig. 2: Dimension of the UCAV(mm)

Body and wing section is extended by 1 m in comparison to TEJAS mk1Abecause of engine position where the LCA mk1A uses GE-404 IN 20 and UCAV design is on GE -414 power plant which vary in length, diameter, weight and power the engine produces. The weapons are mounted inside fuselage so larger wing span will helps for stability and reasonable change in AOA [3].

III. METHODOLOGY

Ansys offers engineering simulation solution sets in engineering simulation that a design process requires. Companies in a wide variety of industries use ANSYS software. It uses CFD and FEM and various other programming algorithms for simulating and optimising various design problems. ANSYS has many sub parts out of which we have used FLUENT. ANSYS Fluent uses CFD for analysis and is mainly used for simulation of fluid mechanics and thermodynamics problems. Data of various fluid and solid materials are already fed into the ANSYS database which we use.

3.1 MESHING OF THE CONTINUUM

The meshing of the aircraft is done using ANSYS (Fluent) CFD 14 is shown in Fig. 3. In this the continuum from ANSYS Workbench is imported, then the continuum is divided into different parts like inlet, outlet, symmetry, wall and the UCAV and the required meshing conditions are applied and the continuum is meshed.

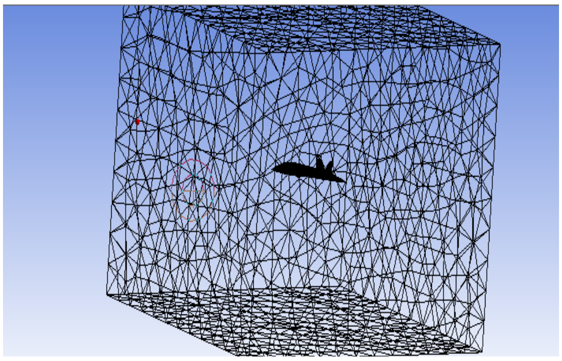

Fig. 3: Meshing of the Continuum in ANSYS (Fluent) CFD 14

3.2. MATERIALS

Only density is considered as the material property of the air and it is constant 1.22kg/m^3.

3.3. BOUNDARY CONDITIONS

The important boundary conditions in an External Flow Analysis are velocity at inlet of the continuum and pressure at the outlet of the continuum. According to the specifications of the UCAV Aircraft, the speed of the aircraft is 100-120m/s.The outlet boundary condition is given as pressure and its value is given as 0 Pa.

The rest of the faces of the continuum are mentioned as wall or symmetry, which means that these faces are under no-slip condition i.e. there is zero velocity on these faces. This no-slip condition means that the flow conditions will not apply outside these walls and adjacent to these walls.

IV.ANALYSIS OF UCAV

Once the boundary conditions are set, the solution methods and controls are set for this simulation.

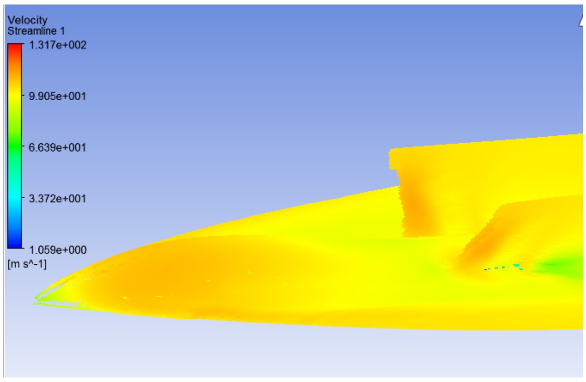

Fig.4: Velocity vector of the UCAV at AOA 5 degree

The inlet velocity applied at the boundary condition is 100m/s and 131m/s is encountered after passing over the UCAV body at the end of the continuum is shown in Fig.4.

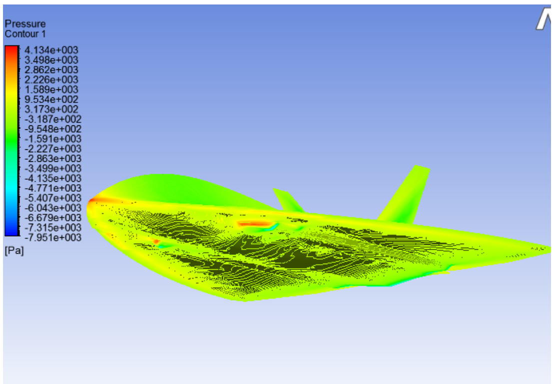

Fig.5: Pressure vector of the UCAV at AOA 5degree

Low pressure layer is streamed on the top layer of the body and high pressure being underneath of the body. This creates suitably high pressure difference which creates the required lift. The Pressure vector in Fig.5 observed is low pressure being -7.951e^3 Pa and high pressure being 4.134e^3 Pa. Table 1 and 2 shows coefficient of lift, drag and its ratio.

TABLE 1: VARIATION OF LIFT AND DRAG COEFFICIENT WITH ANGLE OF ATTACK

ANGLE OF ATTACK	COEFFICIENT OF LIFT	COEFFICIENT OF DRAG
2	0.3455	0.0672
4	0.7747	0.1030
5	1.0715	0.1395
6	1.2780	0.1758
8	1.8833	0.2927
10	2.5614	0.4666
12	3.2511	0.6899
14	4.1563	1.0145
16	4.8570	1.4450
18	5.6250	1.8352
20	6.2200	2.1790
22	6.8665	2.6641
24	7.5845	3.2354
26	7.7614	3.6387
28	8.4415	4.325
30	8.8049	4.8955
32	8.4562	5.0768
34	7.2469	5.1254

TABLE 2:VARIATION OF CL V/S CL/CD MAX WITH DIFFERENT ANGLE OF ATTACK

A.O.A	COEFFICIENT OF LIFT	L/D MAX
2	0.3455	5.14
4	0.7747	7.52
5	1.0715	7.68
6	1.2780	7.26
8	1.8833	6.43
10	2.5614	5.48
12	3.2511	4.71
14	4.1563	4.01
16	4.8570	3.133
18	5.6250	3.06
20	6.2200	2.85
22	6.8665	2.57
24	7.5845	2.33
26	7.7614	2.13
28	8.4415	1.95
30	8.8049	1.79
32	8.4562	1.66
34	7.2469	1.54

4.1 GRAPHICAL REPRESENTATION OF RESULTS

The lift coefficient decreases after passing through the stall angle of 30 Degree and making it to lose altitude at a faster rate is observed in Fig.6.

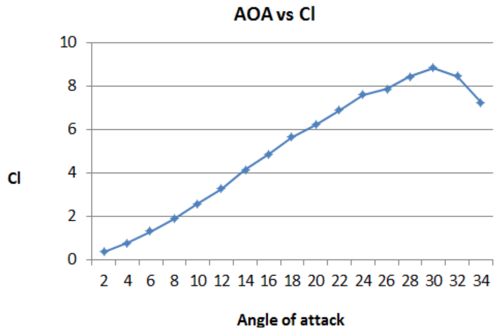

Fig. 6: Angle of attack with lift coefficient

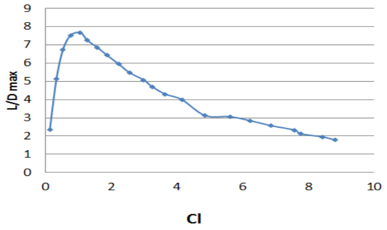

Fig. 7: lift by drag ratio with different Coefficient of lift

For AOA 5 degrees Cl being 1.0715 (Table 2) and maximum L/D ratio is 7.68 is noticed in Fig. 7.

V.CONCLUSION

The CFD analysis of UCAV is compared with Tejasmk1A

- *The UCAV wing span area is bit more than the LCA Tejas due to its configuration, the stall angle obtained is 30 degrees when compared to LCA Tejas 24 degrees.*
- *The UCAV's L/D max was 7.68 and Tejas being that of 8.8*

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