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Redesign Of The ABT-18 Speed Brake To Suit Its Conversion To Unmanned Aerial Vehicle

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***Abstract:** The serviceability of the ABT-18 aircraft has declined due to high cylinder temperature, low power and excessive vibration. The Nigerian Airforce (NAF) resolved to convert the trainer aircraft into an unmanned aerial vehicle for surveillance purposes in order to enhance its service efficiency. The speed brake was among the major components selected for the conversion through redesign. Three speed brake design options were considered. The 2D speed brake plate design was made and analyzed for rectangular, triangular and circular brake plates at angle 45^0 and 90^0. The plates were simulated using ANSYS software package to check the suitability of the speed brake for the conversion of ABT-18 aircraft to an Unmanned Aerial Vehicle. Results obtained from the analysis showed that at approach velocity of 39m/s, the rectangular, triangular and circular speed brakes brought the aircraft to rest in 4sec, 4min 17 sec and 29 sec respectively. The rectangular plate speed brake design placed at 90^0 has the best tendency of returning the aircraft approach velocity to zero within a shorter period (4 sec). The rectangular plate speed brake design is therefore recommended as the most suitable to use on the ABT-18UAV.*

***Keywords:** speed brake plates, approach velocity, unmanned aerial vehicle (uav), reynolds number, stall velocity.*

I. INTRODUCTION

The Air Beetle (ABT-18) is a two seater, single engine propeller aircraft. It was locally assembled in Nigeria by Dornier Aviation Company in 1996 in conjunction with NAF engineers. It is used for primary student pilot training by the NAF. The ABT-18 aircraft is conventional all–metal, monocoque aluminum design [1]. It has a fire wall made of aluminum steel with dynafocal engine mount in order to withstand drag friction, heat resistivity and corrosion. The fuselage length is 6.15m and wing span of 7.0m. Over the years, the ABT-18 aircraft has encountered challenges of landing gear buckling, low power generation as well as high cylinder temperature as a result the NAF has put up a research in conjunction with Air Force Institute of Technology (AFIT) to see the possibility of modifying the aircraft into an unmanned air vehicle. The research entails modification of engine, fuel tanks, as well as the speed brake among others. This research focuses on the design of the speed braker. Currently the speed brake is manually operated but modifying it entails complete design of entire new speed brake to suit the present UAV design requirement. Although the modification is on going there are substantial efforts, put together by different people [1], although his research has not been able to carry out Finite Element Analysis on the speed brake to ascertain areas susceptible to stresses. However the present design has identified the different shapes which have different drag profile or values. The design equally addressed shear force and bending moment on the speed brake thereafter estimated the material suitable for the design, in addition estimated weight the of the material used in the design and based on the these parameters a suitable actuator will be selected to control the movement of the speed brake before and after landing. [2]. The ABT-18 is used for primary pilot training by the Nigerian Air Force (NAF). The Aircraft is known as the Van’s RV-6A in the USA. The trims are electrically operated. The wings house the integral fuel tanks. The one-piece sliding canopy allows entry to the cockpit from both side and it is jettison-able in emergency. The Aircraft is powered by a Textron Lycoming two bladed engine with 180 hp at 2700 rpm which drives the constant speed propellers. [2]

II. METHOD AND MATERIALS

The drag values for different brake plates shapes as intended to used to determine best fitted for the speed brake of ABT-18 UAV aircraft were obtain by mathematical calculation using the characteristics stall speed

Thus the stall speed is defined by

$Vstall = \sqrt{\frac{2W}{\rho_{\infty} S C L_{MAX}}}$, with density of the aircraft with reference to its altitude Eqn1.0 And

Reynolds number (Re) has the deciding role in determining the skin-friction coefficient, of a component. The Re-per-unit length speed and altitude is computed also. Then characteristic lengths of each component, according to. Reynolds number (Re) is given by

$Renold's\ Number = \frac{\varrho v L}{\mu}$, Eqn 2.0 [3]

Thereafter, evaluation by iteration of the brake plates finite element analysis of various plate materials were simulated using CATIA software V5R19 , in display gave the shear forces, bending moments and principal stresses of the speed brake plates positioned at right angle. In order to determine the air flow characteristics of the plates, the geometry of the plate's creation, meshing and computational fluid dynamics analysis was done using ANSYS software package. After initializing the iterative simulation calculation of the designed various shapes speed brake plates positioned at angle 90 and 45 degrees by the ANSYS fluent solver, results in respect to ANSYS were obtained showing the velocity magnitude of the aircraft and respective time it takes the velocity to come to rest on landing.

III. RESULTS

s/n	Shapes	Drag(N)	Remark
1.	Rectangle shape	274.20	
2.	Circular shape	21.20	
3.	Triangle shape	12.20	
4.	Cube	8.8	

Table 1: Result of Calculated Drag Values for Different Shapes

Serial	Material	Mass(kg)
1.	Zinc	1.718
2.	Aluminium	0.656
3.	Steel	1.902
4.	Copper	2.154
5.	Chromium	1.74

Table 2: showing Distribution by mass of Different Types of Material

SHAPES	ANGLE	TIME(SEC)
RECTANGLE	90^0	4
RECTANGLE	45^0	26
CIRLE	90^0	29
TRIANGLE	90^0	04:17

Table 3: Showing Different shapes of speed brake with Respect to Time

Figure 1: Side view of Speed Brake showing principal stress

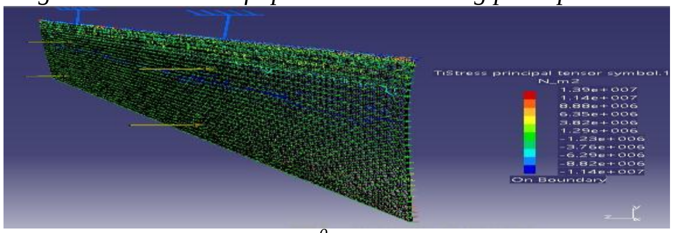

Figure 2: Speed brake at 90^0 showing stresses using CATIA V5R15

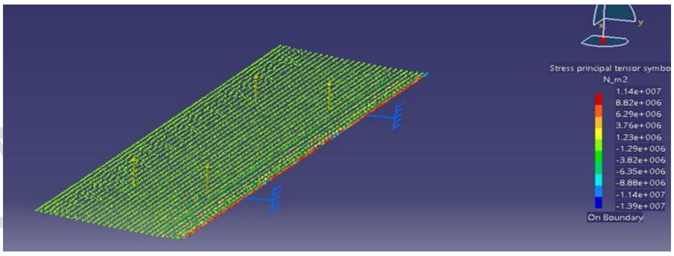

Figure 3: Speed Brake showing stresses using CATIA V5R19

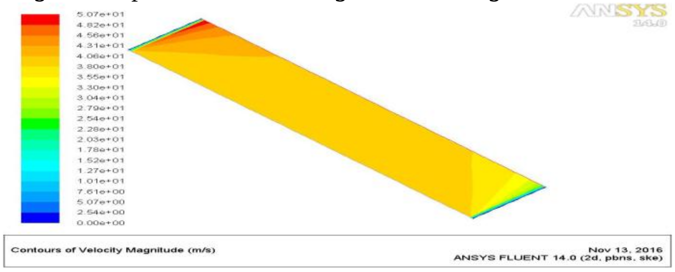

Figure 4: Contours of velocity magnitude on the speed brake at 45^0 Using ANSYS V14.0

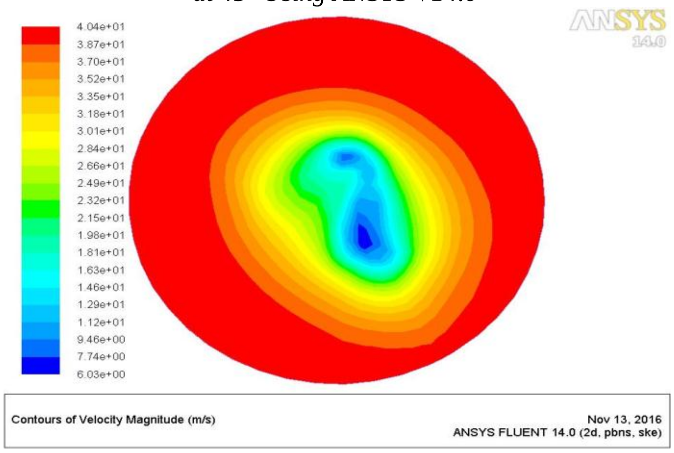

Figure 5: Contours of Velocity Magnitude using ANSYS Soft Ware Version 14.0

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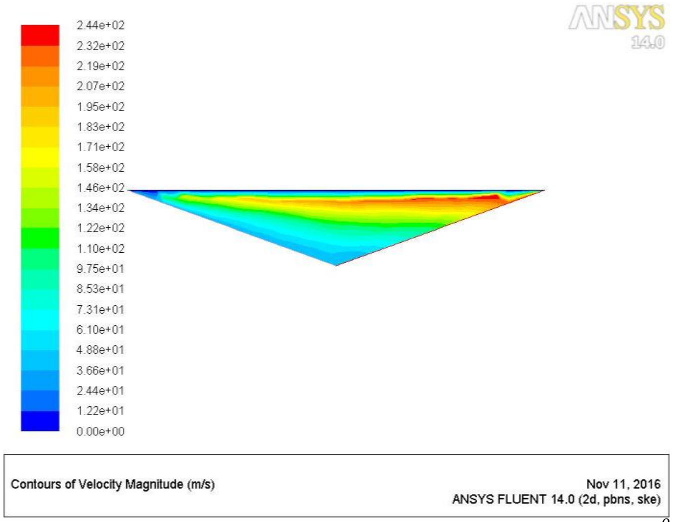

Figure 6: Contours of Velocity Magnitude of a Triangle at 90^0 Using ANSY

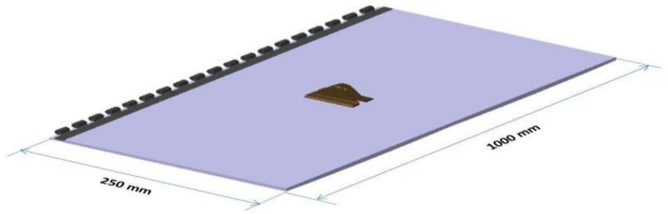

Figure 7: Modified speed brake

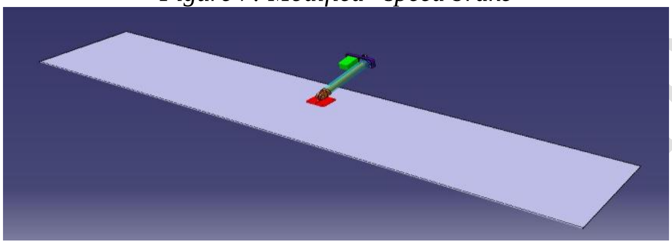

Figure 8: Image of Speed Brake with an Actuator Using CATIA V5R19

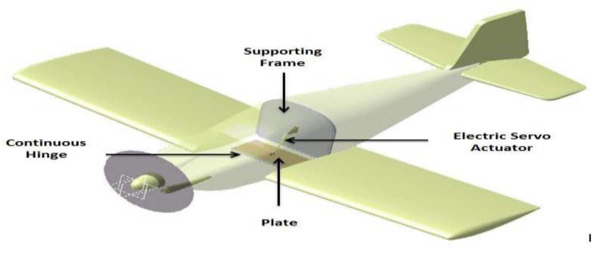

Figure 9: UAV Surface Model of the Integrated Speed Brake Using CATIA Software

IV. DISCUSSION AND CONCLUSION

The major requirement in the design of speed brake is to produce the required drag as far as possible. The drag depends on shape and speed which are design- dependent as well as properties of air which are nature dependent. Drag estimates start with the isolated shape component. Table 1 shows the result of calculated values for different shapes. The rectangular shape has the highest drag profile of 274.0N while the cube has the least value of 8.8N; it is therefore recommended that rectangular shape is the best shape for the design. From the graph it can be inferred that stall speed increases with increase in altitude as density decreases. The least value of the stall speed was chosen to calculate the approach speed of the aircraft because the approach speed has a significant role in determining whether the air flow that strikes the speed brake is turbulent or laminar and this influences the selection of material for the speed brake. The value obtained for the Reynolds Number was 29, 5000 which is greater than 2,100. This signifies that the airflow that strikes the speed brake is turbulent in nature. Based on the approach speed a landing distance was calculated using different runway conditions, at various flap settings. The aircraft will therefore need a landing distance of 330.m to come to complete stop. These were properly illustrated in the main work.

The drag is dependent on the approach speed of the aircraft as well as the shape, triangle shape was found to be the shape that produces the highest drag profile. The nature of the air that strikes the speed brake is turbulent in nature. The parameter obtained is an indicator of the type of material that is been selected. CATIA software was used to simulate the region that will likely wear out due to stresses on the speed brake while ANSYS simulates the nature of velocity, static pressure as well as the turbulent nature of the flow across the inlet, interior and outlet. Therefore there was velocity variation, from maximum velocity to zero as depicted by the velocity contour graphs shown and from the results of this work, read that the rectangular brake plate reduced the aircraft landing velocity to zero in a time of 4 seconds lesser than other considered shaped brake plates. Therefore the rectangular shaped speed brake plate is the most suitable for the UAV ABT-18 aircraft and thereby recommended.

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