"Application of larger wings to create more lift force in aeroplane"

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Abstract

Air travel is continuing to experience the fastest growth among all modes of transport. Increasing total fuel consumption and the potential impacts of aircraft engine emissions on the global atmosphere have motivated the industry, scientific community, and international governments to seek various emissions reduction options. the impacts of aviation emissions on the global atmosphere are expected to continue to grow. Despite the efforts to understand and mitigate the impacts of aviation emissions, it still remains uncertain whether proposed emissions reduction options are technologically and financially feasible. The consumption of the fuel in jet plane can be reduced by investing in more fuel-efficient technologies, nurturing the growth of alternative energies.The purpose of this article to reduce fuel consumption in jet plane .At present, jet planes have small wings which indicates they require more velocity tocreate sufficient lift force on the jet plane. Higher velocity in turns requires more reaction force hence greater fuel consumption. This fuel consumption can be reduced by increasing entire surface area of the wings which reduces the requirement of reaction force& this directly decreases fuel consumption.

At Present our counry's defense aircraft consumes large amount of fuel.which in turn increases our defense budget.According to ministry ofdefense,The defense budget is ($37.7 billion) of year 2013 and the budget of our country's major project like "GOLDEN QUADRILATERAL" was ($9.2 billion).which is 1/4th of the our defensebudget.If the fuel Consumption is reduce, which saves our thousands of millions in defense budget .This money can be utilize for major project like "GOLDEN QUADRILATERAL".

Keywords:jet plane, lift force, reaction force

I. INTRODUCTION

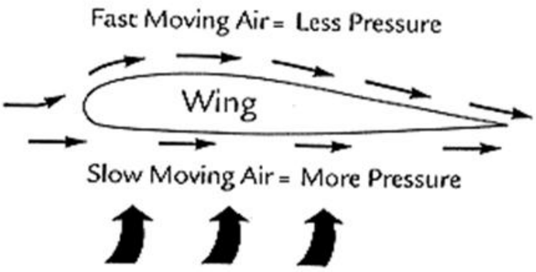
Air travel is continuing to experience the fastest growth among all modes of transport, averaging5 to 6% per year. Increasing total aviation emissions from aircraft engines and their potential impacts on the global atmosphere have drawn the attention of the aviation industry. In a world where we are dependent on the availability of cheap and abundant energy to fuel our cars, heat our homes, and propel our planes, our economic well-being is inexorably tied to the price of oil. And nowhere is the need to respond to this reality urgently. Air transport's contribution to climate change represents 2% of man-made CO2emissions and this could reach 3% by 2050, according to updated figures from the Intergovernmental Panel on Climate Change (IPCC) There is also a direct link between reduced fuel

use and environmental performance – each ton of fuel saved means approximately 3.15tonnes fewer CO2 emissions. This shows that it is necessary to reduce fuel consumption to safe our environment.

The fuel consumed by a jet plane is number of times greater than the fuel consumed by a commercial one. This fuel consumption must be reduced so that it is economically feasible to air travel for everyone. Drag is proportional to the lift required for flight, which is equal to the weight of the aircraft in level flight. As induced drag increases with weight, mass reduction, with improvements in engine efficiency and reductions in aerodynamic drag, has been a principal source of efficiency gains in aircraft, with a rule-of-thumb being that a 1% weight reduction corresponds to around a 0.75% reduction in fuel consumption.

Principle of working of plane

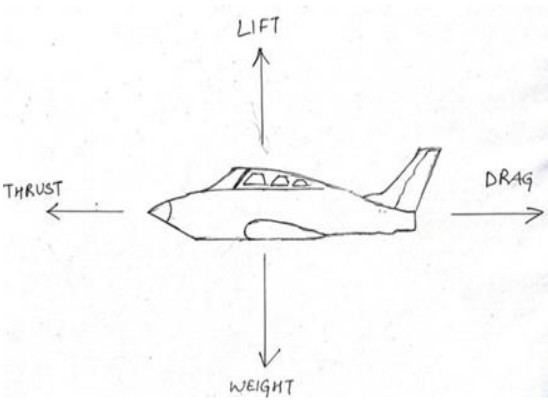
The lift force is generated by a small pressure differential between the upper and lower surfaces of the wing, caused by the aerodynamic reaction to the wing motion through the atmosphere. The magnitude of the pressure differential, and the consequent momentum applied to the airflow, is generally dependent on the speed of the aircraft, the angle of attack and the physical characteristics of the wing. The wing Centre of pressure moves fore and aft in response to changes in the aerodynamic reaction, thereby introducing pitching moments that affect the aircraft's trim. Drag induced by the generation of lift is modified by the plan form, the twist and the aspect ratio of the wing. Ailerons, flaps, and other lift and drag changing devices are fitted to the wing for control and performance purposes.



A jet aircraft (or simply jet) is an aircraft (nearly always a fixed-wing aircraft) propelled by jet engines. Jet aircraft generally fly much faster than propeller-powered aircraft and at higher altitudes – as high as 10,000–15,000 metres (33,000–49,000 ft.). At these altitudes, jet engines achieve maximum efficiency over long distances. The engines in propeller-powered aircraft achieve their maximum efficiency at much lower altitudes. Some jet aircraft can move faster than sound.

FORCES ACTING ON THE AIRPLANE IN FLIGHT

When in flight, there are certain forces acting on the airplane. It is the primary task of a pilot to control these forces so as to direct the airplane's speed and flightpath in a safe and efficient manner. To do this the pilot must understand the among the aerodynamic forces acting on an airplane during flight, four are considered to be basic because they act upon the airplane during all maneuvers.



These basic forces are

: •Lift

•Weight (Gravity)

•Thrust

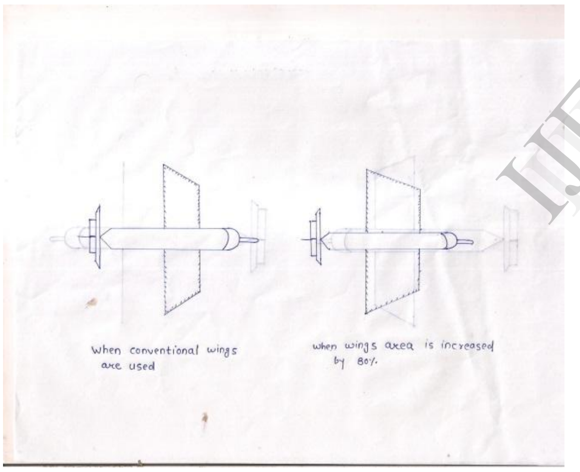
•Drag force and their effects

Lift force

The amount of lift generated by an object depends on the size of the object. Lift is an aerodynamic force and therefore depends on the pressure variation of the air around the body as it moves through the air. The total aerodynamic force is equal to the pressure times the surface area around the body. Lift is the component of this force perpendicular to the flight direction. Like the other aerodynamic force, drag, the lift is directly proportional to the area of the object. Doubling the area doubles the lift.

There are several different areas from which to choose when developing the reference area used in the lift equation. Since most of the lift is generated by the wings, and lift is the force perpendicular to the flight direction, the logical choice is the wing plan form area. The plan form area is the area of the wing as viewed from above the wing, looking along the "lift" direction. It is a flat plane, and is NOT the total surface area (top and bottom) of the entire wing, although it is almost half that number for most wings. We could, in theory, use the total surface area as the reference area. The total surface area is proportional to the wing planform area. Since the lift coefficient is determined experimentally, by measuring the lift and measuring the area and performing the necessary math to produce the coefficient, we are free to use any area which can be easily measured. If we choose the total surface area, the computed coefficient has a different value than if we choose the wing plan form area, but the lift is the same, and the coefficients are related by the ratio of the areas.

This diagram shows the projected surface area for two different aircraft. The airplane on the left is shown in a cruise condition while the airplane on the right is shown in a takeoff or landing condition. Takeoff and landing are times of relatively low velocity, so to keep the lift high (to avoid the ground!) designers try to increase the wing area. This is done by sliding the flaps backwards along metal tracks and shifting the slats forward to increase the wing area. The next time you fly in an airliner, watch the wings during takeoff and landing to see the change in wing area.



Lift is directly related to surface area

Increases the Area- Increases the Lift force

$F_L = \frac{1}{2}\rho V^2 S C_L$

F_L is lift force

ρ is air density

v is true airspeed,

S is Planform area, and

C_L is the lift coefficient at the desired angle of attack, Mach number, and Reynolds number

Now putting the given values

II.ANALYTICAL ANALYSIS

For a conventional aircraft, the drag is divided into two main parts; lift related drag, and non-lift related drag. The first part is called induced drag (D_i), because this drag is induced by lift (pressure). The second part is referred to as zero-lift drag (D_o), since it does not have any influence from lift, and is mainly originates from shear stress.

$D=D_o+D_i$

Induced drag: The induced drag is the drag directly associated with the production of lift.

$D_i=\frac{1}{2}\rho V^2 S C_{Di}$

$C_{Di}=KC_L^2$ here, $C_L=\frac{2mg}{\rho S V^2}$

For calculation ofone has to calculate the value of C_{Di} which can be calculated with the help of above formula.

Zero-lift drag: The zero-lift drag includes all types of drag that do not depend on production of the lift. Everyaerodynamic component of aircraft (i.e. The components that are in direct contact with flow) generates zero-lift drag. Typical components are wing, horizontal tail, vertical tail, fuselage, landing gear, antenna, engine nacelle, and strut. The zero-lift drag is a function of airspeed, air density, reference area, and the external shape of the components.

$D_o=\frac{1}{2}\rho V^2 S C_{Do}$

$C_{Do}=C_{Dof}+C_{Dow}+C_{Doht}+C_{Dovt}+C_{DoLG}\ldots.$

Where C_{Dof}, C_{Dow}, C_{Doht}, C_{Dovt}, C_{DoLG}…………….. are respectively representing fuselage, wing, horizontal tail, vertical tail, landing gear, nacelle, strut, high lift device (such as flap) contributions in aircraft C_{Do}. Dots at the end of equation illustrates that there are other components that are not shown here. They include non-significant components such as antenna, stall horn, wires, interference, and wiper.

By the increase in reference area there is a little change in the value of C_{Dow}, due to increase in wing area only C_{Dow} will change rest all C_{Dof}, C_{Dow}, C_{Doht}, C_{Dovt}, C_{DoLG}… will remain same.

For calculation of do one has to calculate the value of C_{Do} which can be calculated by the calculation by C_{Dow}.Calculation of C_{Dow} is quit tough.

Procedure for calculation of C_{Dow} is explained below:

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Procedure for calculation of C_{Dow} is explained below:

1. Firstly Reynolds no is calculated by using following equation to check whether the flow is laminar or turbulent.

   $$Re=\frac{\rho V}{\mu}\bar{C}$$

2. After calculation of Re machno(M) and skin friction coefficient C_f is calculated. Generally the flow is turbulent so for turbulent flow following equation is used.

   $$M=\frac{V}{a}$$

   $$C_f=\frac{0.455}{[\text{Log}_{10}(\text{Re})]^{2.58}}$$

3. After that F_M, $F_{tc,\ Swet}$all are calculated as per the derived relations.

   $F_M=1\text{-}0.08M^{1.45}$

   $F_{TC}=1+2.7(t|c)_{max}+100\ (t|c)^4{}_{max}$

   $S_{wet}=2[1+0.5(t|c)_{max}]\ bC$

4. Finally the value of $C_{Do(w)}$ is calculated by the use of all above calculated parameters by the relation as follow:

$$C_{Do(w)}=C_{F(w)}F_{TC(w)}F_M\left(\frac{S_{WET(w)}}{S}\right)\left(\frac{C_{Dmin(w)}}{0.004}\right)^{0.4}$$

III. VERIFICATION

Consider a cargo aircraft is cruising at sea level with airspeed of 420 knot (216.40 m/s). With the following features m = 380,000 kg S = 580.32 m^2, MAC = 9.3m,(t/c)max = 18%,Cdmin = 0.0052,S=340m^2,ρ=1.2kg/m^3,K =0.055.calculate the net change in drag force if reference area is increased by 80% with the help of slider gliding plates during accident. Assuming [$C_{Do.}$ = (3*$C_{Do(w)}$)]

Where

m=mass in kg

M=mach no

S=Planform area in m^2

ρ=density in kg/m^3

SOLUTION:

CASE-1WHEN CONVENTIONAL WINGS ARE USED.

For the calculation of net drag force we have to calculate induced and zero drag individually as

$D=D_o+ D_i$

Where

D=Total Drag Force

D_i=Induced drag force

D_o=Zero drag force

$$D_i=\frac{1}{2}\rho V^2SC_{Di}$$

For this we have to calculateC_{Di}

$C_{Di}=KC_L{}^2$ (given k=0.055)

As per given data

$$C_L=\frac{2mg}{\rho SV^2}$$

$$C_L=\frac{2*380000*9.81}{1.255*580.32*(420*.5144)^2}=0.2190$$

$C_{Di}=KC_L{}^2$ (on putting values)

C_{Di}= (0.055)*(0.2190)^2 =0.00263

Now,

$$D_i=\frac{1}{2}\rho V^2SC_{Di}$$

$$D_i=\frac{1}{2}*1.225*(420*0.5144)*580.32*0.00263$$

D_i=448360.60N

Now we have to calculate D_o, as it is assumed that[$C_{Do.}$ = (3*$C_{Do(w)}$)] we will calculate $C_{Do(w)}$) and replaceC_{Do} by $C_{Do.}$ = (3*$C_{Do(w)}$).

Calculation of$C_{Do(w)}$ is as per procedure described in introduction

$$Re=\frac{\rho V}{?}\bar{C}$$

$$Re=\frac{1.225*(420*0.5144)*9.3}{1.785*10^{-5}}=1.37*10^8$$

$$M=\frac{V}{a}$$

$$M=\frac{420*0.5144}{340}=.635$$

Here the flow is turbulent as the Reynolds no is >2*10^6

$$C_f=\frac{0.455}{[\text{Log}_{10}(\text{Re})]^{2.58}}=\frac{0.455}{[\text{Log}_{10}(137889458.8)]^{2.58}}=.002035$$

F_M =1-0.08$M^{1.45}$=1-0.08(.635)$^{1.45}$=0.958

$F_{tc}=1+2.7(t|c)_{max}+100\ (t|c)^4{}_{max}$

F_{tc}=1+2.7(.18)+100 (.18)^4=1.591

S_{wet} =2[1+0.5 $(t|c)$ $_{max}$] bC =2[1+0.5(.18)] 580.32=1265.09 m^2

$$C_{Do(w)}=C_{F(w)}F_{TC(w)}F_M\left(\frac{S_{WET(w)}}{S}\right)\left(\frac{C_{Dmin(w)}}{0.004}\right)^{0.4}$$

$C_{Do(w)}$ =.002035*1.591*0.958*$(\frac{1265.09}{580.32})$*$(\frac{0.0052}{0.004})^{0.4}$

$C_{Do(w)}$=0.00743

Now, $D_o=\frac{1}{2}\rho V^2 S C_{Do}$

$D_o=\frac{1}{2}$*1.225*(420*.5144)^2 *580.32*0.00743*3

D_o=378871.41N

TOTAL DRAG FORCE = D=D_o+D_i

D=378871.41+44836.60

D=423708.01N

CASE-2 ON INCREASES WINGS AREA BY 80%.

New Mac = 9.3+9.3*.8=16.74

New reference area will

be=580.32+580.32*.8=1044.57m^2

(t/c) max = 10%

K =0.090 (approx.)

Again on repeating above procedure we get

$D_i=\frac{1}{2}\rho V^2 S C_{Di}$

For this we have to calculateC_{Di}

$C_{Di}=KC_L^2$ (approx k=0.090)

As per given data

$C_L=\frac{2mg}{\rho S V^2}$

$C_L=\frac{2*380000*9.81}{1.255*1044.57*(420*.5144)^2}$=0.1217

$C_{Di}=KC_L^2$ (on putting values)

C_{Di}= (0.090)*(0.1217)^2 =0.00133

Now,

$D_i=\frac{1}{2}\rho V^2 S C_{Di}$

$D_i=\frac{1}{2}$*1.225*(420*0.5144)*1044.57*0.00133

D_i=40795.22N

Now we have to calculate D_o , as it is assumed that[$C_{Do.}$ = (3*$C_{Do(w)}$)] we will calculate $C_{Do(w)}$ and replaceC_{Do} by $C_{Do.}$ = (3*$C_{Do(w)}$).

Calculation of$C_{Do(w)}$ is as per procedure described in introduction

M =$\frac{420*0.5144}{340}$=.635

F_M =1-0.08M$^{1.45}$=1-0.08(.635)$^{1.45}$=0.958

F_{tc}=1+2.7(.18) +100 (.18)^4=1.591

Re, CF, F_{TC} and s_{wet} will change i.e.

Re =$\frac{\rho V}{?}\bar{C}$

Re =$\frac{1.225*(420*0.5144)*16.74}{1.785*10^{-5}}$=248201025.9

$C_f=\frac{0.455}{[\text{Log}_{10}(\text{Re})]^{2.58}}=\frac{0.455}{[\text{Log}_{10}(248201025.9)]^{2.58}}$=.001879

F_{tc}=1+2.7(.10) +100 (.10)^4=1.28

S_{wet} =2[1+0.5 $(t|c)$ $_{max}$] bC =2[1+0.5(.10)] 1044.57=2193.59 m^2

$C_{Do(w)}=C_{F(w)}F_{TC(w)}F_M(\frac{S_{WET(w)}}{S})(\frac{C_{Dmin(w)}}{0.004})^{0.4}$

$C_{Do(w)}$ =.001879*1.28*0.958$(\frac{2193.59}{1044.57})$ $(\frac{0.0052}{0.004})^{0.4}$

$C_{Do(w)}$ =0.00534

Now, $D_o=\frac{1}{2}\rho V^2 S C_{Do}$

$D_o=\frac{1}{2}$*1.225*(420*.5144)^2 *1044.57*0.00534*3

D_o=490133.37N

TOTAL DRAG FORCE = D=D_o+D_i

D=490133.37+40795.22

D=530928.59N

LIFT FORCE CALCULATION

Lift force is given by

$F_L=\frac{1}{2}\rho V^2 S C_L$

ρ =1.225(kg/m^3)

v =216.40m/s

S =340m^2

C_L=02190

$F_L=\frac{1}{2}$(216.40)^2*1.225*.2190*340

F_L=2135716.6N

Now if we increase area by 80%,

S=340*1.8=612m^2

Theneffective lift force is given by

$F_L=\frac{1}{2}$(216.40)^2*1.225*.2190*612

F_L=3844290.00N

Now % change in lift force is given by

$$\%change= \frac{(New\ Lift\ Force - Old\ Lift\ Force)}{Old\ Lift\ Force} * 100\%$$

$$\%\ change = \frac{(3844290 - 2135716)}{2135716.6} * 100\%$$

% change=80%

IV.CONCLUSIVE REMARKS

The Purpose of this article is to increase the lifting capacity of the plane for the same fuel consumption for to reduce the fuel consumption for lifting capacity. Although it can be interpreted from the analysis that with with increasing area by 80%,the rise in drag force is 30%.which inturn with increase fuel consumption but we can condone this rise in drag force because we have aggrandized the lift force by 80%.This will definitely increases the mileage per passenger.

This paper can become advantageous for the further research in the same direction.

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