Aeroplane Fuselage Design Modification to Overcome Pressure Drag Resistance

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Abstract – The design of aeroplane fuselage body is done by principle of aerofoil shape. The aeroplane main body is not in perfectly aerofoil shape rather the wings are in perfectly aerofoil shape. This increases projecting area for striking of fluid on aeroplane, which results into large drag force acting on it. This paper is related with design of external body of aeroplane, describing the use of pipes with decreasing diameter with length. When the pipe bunches are fitted on aeroplane outer body then the drag force will be reduced by greater amount and due to decreasing air diameter going through pipes from other end, acceleration of aeroplane will be created .The drag force acting on the aeroplane is equally distributed to all pipes and its effect to decelerate aeroplane is nullified to greatest amount. The total power consumption of aeroplane will be greatly reduced by implementing this arrangement.

Keywords: Pipes, Aeroplane, Fuselage, Design, Drag, Aerofoil, Aerodynamic.

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INTRODUCTION

Powers saving techniques are very important in this modern era because the use of fuel may create a shortage in future, so such techniques should be implemented where efforts should be taken to use the renewable energy source. In aeroplane the use of drag energy is very important for conversion purpose. Reduction in drag force is very important in design of an aeroplane. Basically the automobiles have aerodynamic shape to overcome drag force. The speed of an aeroplane is nearly equal to speed of sound so this greatly affects power consumption. In case of aeroplane two types of friction are considered as drag friction and skin friction. Skin friction is neglected because it never applies much force on aeroplane but drag friction is considered because it applies force on aeroplane. If we design an aeroplane with the pipe arrangement then drag force is reduced by 75%. This airplane has a body centreline engine. Fuel is carried in tank located in the wing. Major issue in aircraft is static stability. The modern research should be carried out in design of aircraft to reduce the power consumption. The wings must serve as fuel tanks and also support the engine. Vehicles' 50% of fuel consumption is due to aerodynamic drag on highways. Comparatively considered for aeroplane it is huge part of fuel consumption i.e. about 75% [5]. This research is focused on flow of fluid and aerofoil shape of aeroplane. The design of rear part has great impact onto the aeroplanes aerodynamic behaviour. Drag and lift are greatly influenced by topology of flow in this area. Minimum pitching moment and minimum drag must be produced by wing while lifting. Also there are various requirements for aircraft structure designs like high strength, low weight, high stiffness, large fatigue life and all. Aircraft designs are done to use each and every component to its full capacity. Major aircraft components like wings, fuselage tails is designed to take specific type of load [1].

AEROPLANES DESIGN ACCORDING TO AEROFOIL SHAPE:

Aeroplane is generally built up from the basic components like wings, fuselages, tail and control surfaces; the fuselage has great importance in order to design aeroplanes among them. The aerodynamic drag and rear surface pressure were measured and analysed to quantify the effect of synthetic jet. From the result, the effect of synthetic jet actuation on aerodynamic drag differs according to the slant angle of the body. The aerodynamic drag was reduced for 25° slanted body, but increased for 35° model. In addition, jet angle, momentum coefficient, and driving frequency affect the quantity of change in aerodynamic drag. Aerodynamic drag is an important factor in aeroplane's fuel consumption. Pressure drag which is the main component of total drag is a result of boundary layer separation from aeroplane surface [4].

NEED OF RESEARCH:

A large contribution to the aerodynamic drag of an aeroplane arises from the failure to fully recover pressure in the wake region, especially on square back configurations. The design of aeroplane with aerofoil shaped wings and fuselage is desirable to economy of fuel.

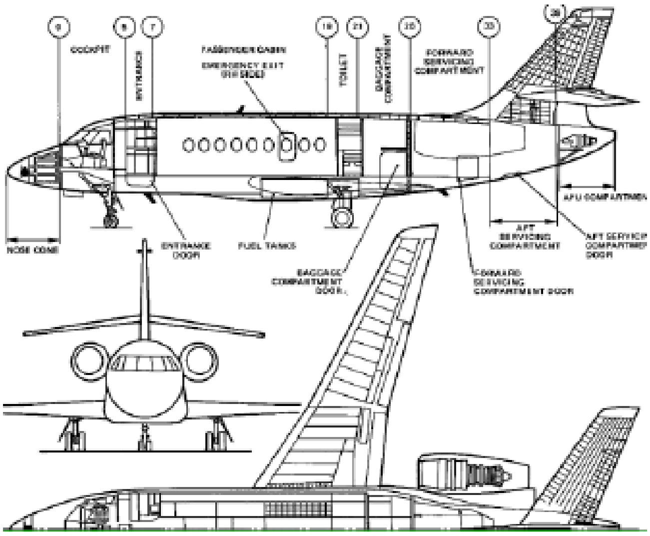

Fig.1: General design structure of aeroplane [2]

Above figure shows general design of aeroplane with outline of it. The front portion is designed with space leaving to cockpit, so as per the design considerations the frontal area of aeroplane has less accurate aerofoil shape. Thus the flowing fluid projecting area increases which will be reason to increase in drag force acting of aeroplane. The non-aerofoil shape of fuselage causes separation of flow of fluid. Thus the design should not change as cockpit design changes as to require larger space for the same [2].

Fig.2: Modern Aeroplanes [3]

In modern aeroplanes primarily design is outlined to aerofoil shape for wings and also for fuselage of aeroplane. For perfect timing lift of aeroplane the shape of wings must be in aerofoil shape, but fuselage external design changes as per requirement but on the other hand it increases drag to aeroplane, which increases consumption of fuel. And thus requires more energy to drive the aeroplane. Because of this it is necessary to modify the design of fuselage of aeroplane. And in order to modify the design of fuselage this research is very important.

DETAILS OF PROVISION OF PIPES TO FUSELAGE:

The pressure drag and the friction drag are the two main types of drag resistance to bodies in the flow of fluid. In the case of aeroplane the friction drag is theoretically neglected due to Mach number is equal to 1, because the jet aeroplane's speed is nearly equal to the speed of sound 340 m/s.

Thus considering these factors the fuselage is designed with proper cover of pipes from nose to tail of aeroplane (Refer Fig.3 and Fig.4).In that figures we give only the fuselage of aeroplane for simplification .But in actual practice the regular accessories like wings, turbojet, etc. Are present as per previously designed aeroplane .The diameter of the pipes used to cover the fuselage is proportionate to maximum diameter of fuselage i.e. the diameter at the middle of aeroplane. The diameter of these pipes for the specific aeroplane can be designed with CFD analysis of prototype and wind tunnel experiments. Thus, for varying dimensions of fuselage the diameter of pipes changes proportionate to it. The data about the dimensions of pipes cannot be predicted viewing cursorily. So the actual dimensions of pipes are not mentioned in this research.

IMPLEMENTATION OF NOZZLE AT THE END OF PIPES

Fig.3: Fluid jet convergent nozzle [6]

At the end of the pipes the nozzle is attached for the purpose of increasing the kinetic energy of the flowing medium at the expenditure of its pressure and internal energy. At the end of the pipes the fluid jet convergent nozzle should be used. The nozzles used at the end of pipes help to increase the kinetic energy of air, this outlet air flow ejects with high velocity which increases the speed of aeroplane and this energy directly helps to accelerate the aeroplane [7].

DESIGN DETAILS OF FUSELAGE OF AEROPLANE IN ORDER TO OVERCOME THE PRESSURE DRAG

For the proper working of this arrangement there is a need of proper designing. For that the pipes used to cover the fuselage having diameter at the nose are greater than its tail side diameter. Due to this drag on the nose is reduced and it is converted into kinetic energy which helps the turbo engine to accelerate the aeroplane. Overall result of the modification in the design is the pressure drag is reduced and kinetic energy is generated which helps to accelerate the aeroplane. Finally this arrangement saves the fuel required to the aeroplane. The weight of pipes increases the total weight of aeroplane and thus more power is required to drive the aeroplane. This power consumption can be minimised by selecting material for pipe having light weight and high tensile and shear strength (materials like Aluminium and alloys of Aluminium and Lithium and other metals). The friction drags produced inside and outside of the pipes are very small and can be neglected.

The design of fuselage of aeroplane can be as shown in fig.4 and the front view of aeroplane is as shown in fig. 5. This design is created in the CATIA software.

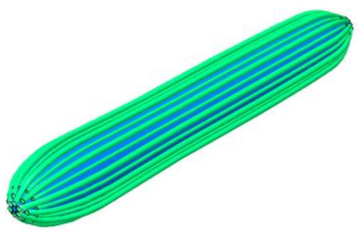

Fig. 4 The Fuselage of aeroplane with cover of pipes to fuselage ISO view

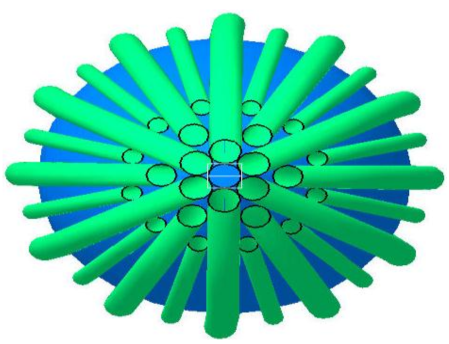

Fig. 5 The fuselage of aeroplane with cover of pipes to fuselage front view

The multiple layers of pipes on fuselage is aimed that to separation of flow of air, which will cause reduction in projection area of aeroplane. The first layer of pipe is bundled at the nose and its frontal surface firstly faces the flow of fluid. The second layers of pipes are on over the first layer of pipe. The second layer is bundled at small distance behind the first layer. The layers are increased up to the increasing projection area of aeroplane (Refer fig.5). All the layers of pipe are covering the surface of fuselage, especially at the mid-portion of fuselage where the diameter of fuselage is more. The pipes used in the layers have decreasing diameter as its length increases towards tail of the aeroplane. The diameters of the pipes are decreased for the purpose of increasing velocity and decreasing the pressure of the air passing through the pipe. The pressure force of air ejecting through pipe is converted into kinetic energy which helps to accelerate the aeroplane.

EXPERIMENTAL ANALYSIS:

For checking the validity we have done one experiment on the shape similar in the experimental analysis for the purpose of checking validity of the design the one experiment is performed by us, by using torque measuring instrument. The sensor used in the torque measuring instrument is strain gauges. The torque measuring instrument have lever of length 0.5 m. The torque acting on this lever can be measured by this instrument and displayed on the display provided with the instrument. Firstly the two plastic bottles are taken and aerofoil shape is given to them. Then bottle one of them had covered with pipes with multiple layers as described in earlier. The bottle with covering of pipes is as shown in fig.6.

Fig.6 Experimental Model

As the bottles are projected to the flow of water then with the help of torque measuring instrument the torque acting on these two bottles is measured. The flow of water is turbulent because of the velocity of water is 0.5651 m/s. The multiple readings are taken of torque acting on lever and then the forces acting on two bottles were calculated. These final readings are shown in table no. 1.

OBSERVATION TABLE:

Table No.1: Experimental Readings

Sr. No.	Type of design	Torque acting on prototype (Nm)	Force acting on prototype (N)	Velocity of flowing water (m/s)	Reynolds Number
1	Design without	1.96	0.49	0.56	69,734
2	Design with pipes	0.49	0.98	0.56	77,364

CONCLUSION:

- Because of implementation of nozzles at the end of pipes huge amount of pressure energy is converted into kinetic energy. This kinetic energy of flowing air is used to accelerate the aeroplane. Thus, it causes saving in fuel consumption of aeroplane.
- Finally, it is concluded that the flow separation of flow of air striking to the aeroplane is approximately ideal. Due to this modified design of fuselage these forces are diverted and also used for the accelerating work.
- By using nozzles we can control direction of the aeroplane because of which the fuel consumed to control the direction is also saved.
- When we mount such type of pipe arrangement on the aeroplane, then the friction drag on the aeroplane also increases. To overcome this problem it is necessary to fill the gaps between two successive pipes by using proper and light weight filler material.
- The modification in design is limited by a variety of additional factors such styling, aesthetic view and weight. But these factors are eliminated by using proper designing as well as proper selection of material. Due to all these reasons the modified design of fuselage of aeroplane there is considerable saving fuel..

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