DESIGN OF WINGTIP VORTEX TURBINE

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Abstract

During lift the pressure difference across upper and lower sides of the aircraft wing, forces the flow of air to curl around the wing tip resulting in wing tip vortices which in turn creates induced drag.

Induced drag has been a great problem of all the aircraft and at times it reaches up to 70% of the total drag. The idea of wing tip turbine is to use the energy of the vortices to generate extra power thus reducing induced drag at the same time. However total drag would increase due to profile drag of the turbine. To cater it, this design has been done such that the drag created by turbine in a particular phase should not exceed the induced drag reduced by the turbine. In this way maximum energy is extracted with out paying the penalty of drag. The theoretical study is based upon drag type turbine installed on NACA 2418 airfoil whose specifications bear geometric similarity to the wing of T-37 aircraft. The experimental results are based upon the wind tunnel testing of the scale down model of the assumed wing.

1 Introduction

Induced drag has been a great problem of all the aircraft and responsible for this are the wingtip vortices. Efforts have been made to reduce this drag. Use of end plates, drooped tips, tapered tips or winglets is the example of such efforts. However these efforts are not very successful, as these measures have their own limitations but the use of wing tip or vortex turbine gives a new look towards this problem, which is to extract energy of the wingtip vortices, thus reducing induced drag as well as generating shaft power.

Vortex is a phenomenon caused due to pressure difference between the upper and lower surfaces of wing. This imbalance forces the flow to curl around the wingtips, which results in circulation at the wingtip and the trailing edge. The circulation around wingtip reduces effective angle of attack, thus causes reduction in lift and increase in drag. The idea of tip turbine is to convert this wasted energy into useful work. The installation of turbine will be beneficial in two ways. It will reduce the induced drag and reduction in lift due to vortex will also be minimized. Moreover an additional shaft power will be generated which can be utilized for driving any accessory of' the aircraft.

2 Designing Process

The design of turbine involved following steps.

1. Selection of wing and determination of induced drag.
2. Calculating tangential velocity of wingtip vortices.
3. Selecting type of turbine and number of blades.
4. Power and torque calculation.
5. Revised induced drag calculations.
6. Finding drags of turbine.
7. Estimating turbine size.
8. Experimental check

3. Uses of this power

While doing this, few questions arise in every body's mind that what is the use of this power and where we can use this power. First of all it should be clear that on same drag conditions if we are generating extra power in form of shaft horsepower then it is an advantage. In my view, this extra power can be used in following ways:

3.1 Back up power source

Its one possible use is as a back up power source. If we are able to install wing tip turbines there are chances that RAM air turbines could be eliminated, which are mostly used in commercial transports in emergencies.

3.2 Air-conditioning system

If we are able to succeed in extracting more power than a proper air-conditioning system can be installed in aircraft. At the moment, air--conditioning system is linked with compressor operation in most of the aircraft.

3.3 Power sharer

Wingtip turbines may also be used as helpers to the main engines to reduce fuel consumption. This power extracted from the vortex cou1d drive hydraulic pumps, compressors or generators etc. Wing tip turbines could relieve the engines to some extent from generating electricity and they would provide power for electrical controls even if the main engines failed.

3.4 Electronic equipment demand

Main source for electricity is exhaust turbines but in view of more electrical demand in aircraft these turbines can play very important role. Take the example of laser altimeter. Most of the aircraft use conventional altimeter, dependent upon pressure measuring equipment, which at all time have some error whereas laser altimeter, operated by electricity, is very accurate but due to its heavy electrical need, manufacturer of aircraft prefer not to use it

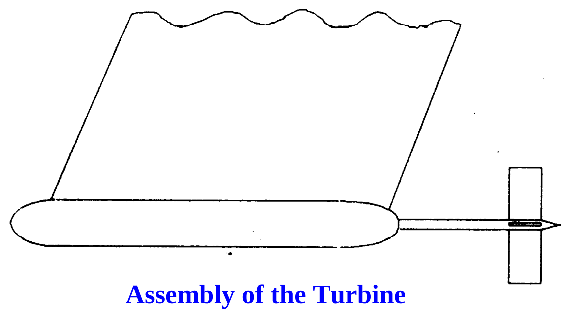
3.5 Drag reducing- laminar flow control system

The turbines can drive air pumps for drag reducing laminar flow control system.

These are some uses and we can use it anywhere. Had this power been obtained at the cost of the drag then we would have not gone for the turbines.

4. Conclusion

The theoretical work is almost supported by the practical results. A nominal size of turbine has been obtained. 17.88% of reduction of induced drag has been obtained at described condition, though which has been covered by drag of turbine. This work suggests that the use of turbine is beneficial as it gives a reasonable amount of power i.e. 0.8582 hp without paying the penalty of drag in this model design.



Assembly of the Turbine
Figure 1

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