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Paper on Hybrid Operated Cascade Thrust Reversal

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ABSTRACT

Through this paper an attempt is made to focus on a special technology based on application of cascade thrust reverser in turbofan engine which is common to the aviation industries but an uncommon in general. The airlines accept that cascade thrust reverser is necessary for safe operations because it provides an added margin of safety for transport aircraft operations. In this technology, forward thrust produced by turbofan engine of aircraft is diverged to reverse direction so as to provide an additional deceleration effect during landing and power back effect. Technical aspects such as engine power reverse thrust characteristics, modes of operation and speed limits of thrust reverser mechanism along with technical problems are discussed. As this mechanism is crucial for safety of aircraft therefore thrust reverser & engine maintenance-schedule is also discussed further. Basically here we introduce modified version prototype for cascade shell type thrust reversal incorporated with guide vane to deflect air in forward direction. Here we are implementing hybrid functioning of thrust reversal in addition with Automatic plus manual application by using micro-controller. Micro-controller basically programmed to sense speed of air or speed of aircraft during landing (applicable to operate thrust reversal) and this passes signal to linear actuator connected to thrust reversal and allow thrust reversal duct to open the vane and deflect the air flow in forward direction.

Keywords : Landing Run, Turbofan Engine, Thrust Reverser, Microcontroller

I. INTRODUCTION

Now a day cascade thrust reversal having important role during landing of aircraft. It acts as one of deceleration device. Cascade thrust reversal, also called cold stream thrust reversal. It is the temporary diversion of an aircraft engine's exhaust so that it is directed forward, rather than backwards. Reverse thrust acts against the forward travel of the aircraft, providing deceleration. Cascade thrust reverser systems are featured on many jet aircraft to help slow down just after touch-down, reducing wear on the brakes and enabling shorter landing distances. Such devices affect the aircraft significantly and are considered important for safe operations by airlines. There have been accidents involving cascade thrust reversal systems. Cascade thrust reverser use in high bypass turbofan engine. During normal operation, the reverse thrust vanes are blocked. On selection, the system folds the doors to block off the cold stream final nozzle and redirect this airflow to the cascade vanes. This technique is employed for improving aircraft runway performance and it is observed that by using cascade thrust reverser especially in wet runway there is considerable reduction in landing run which is responsible for safety of passenger aircraft.

Here we introduce modified version for cascade shell type thrust reversal incorporated with guide vane to deflect air in forward direction. Here we are implementing hybrid functioning of thrust reversal in addition with Automatic plus manual application by using micro-controller. Micro-controller basically programmed to sense speed of air or speed of aircraft during landing (applicable to operate thrust reversal) and this passes signal to linear actuator connected to thrust reversal and allow thrust reversal duct to open the vane and deflect the air flow in forward direction.

Figure 1. Boeing 777 with cascade thrust reverser deployed

Cascade thrust reversal is one of the types of thrust reversal. There are various types of mechanism use in cascade thrust reversal as given below.

1. Fan duct.
2. Fan.
3. Low pressure compressor.
4. High pressure compressor
5. Combustor
6. High pressure turbines
7. Low pressure turbine
8. Nozzle
9. Fan airflow
10. Cascade vane

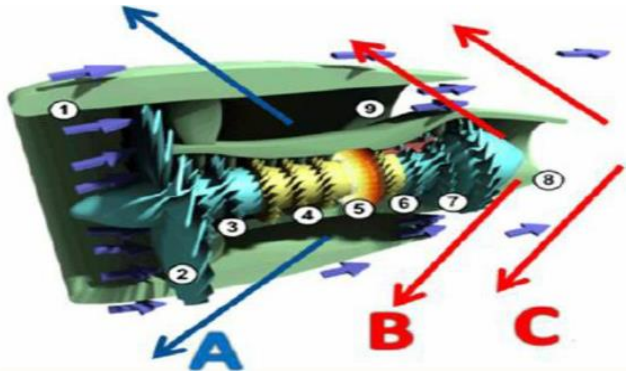


Figure2.Component of Boeing 777 with cascade thrust reverser ge **4** of **10**

II. NECESSARY OF CASCADE THRUST REVERSER

1. A cascade reverser is a reverse thrust system most typically installed on high bypass ratio turbofan engines. Cascade Thrust reverser mechanism are requires by an airplane to reverse maximum amount of Thrust available, to reduce brake wear, to reduce taxi distance, to reduce certified Landing field lengths,

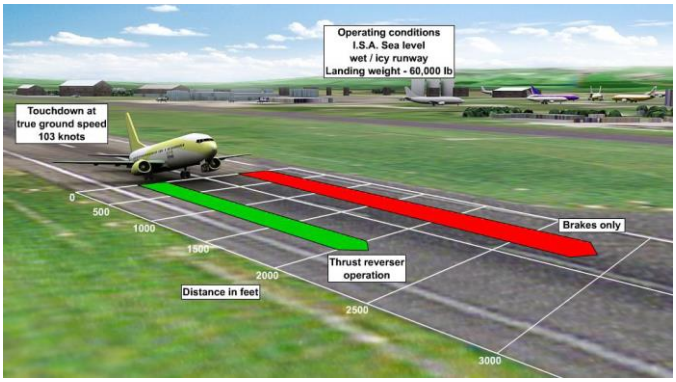
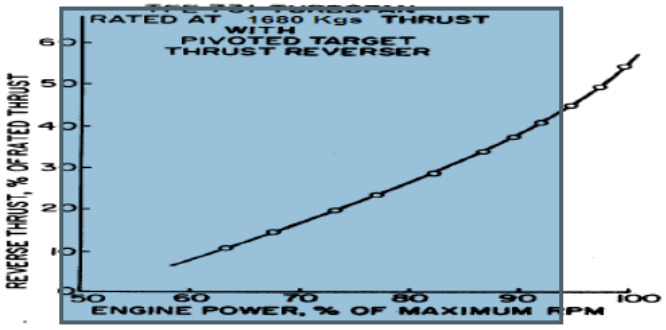


Figure 3. Necessary of cascade thrust reverser

2. To provide additional stopping force on wet, slushy and icy Runways, for refused takeoffs (RTO), to reverse maximum thrust for power back and in Addition to brakes and spoilers, an airplane's engines can also be used to help bring the Vehicle to a stop by reversing its thrust.



III. HYBRID OPERATED CASCADE THRUST REVERSER

In this type of thrust reversal prototype, we are using microcontroller which sense the speed of duct fan and send the signal to microcontroller which allows linear actuator to actuate the translating cowl (Cascade duct). In this type we are actuating thrust reverser manually as well as automatically.

A. COMPONENT OF HYBRID OPERATED CASCADE THRUST REVERSER

1. Duct fan (Blower Fan)

The fan is a device which is use to pass the air. The air will be pass from duct fan. Fan we are using is blower fan as to provide the air flow to initiate thrust.

2. Electric motor

Electric motor is a device which is use to convert electric energy to mechanical energy. Electric motor is use to drive the Blower fan.

3. Microcontroller with Speed sensor

Microcontroller is programmed with speed sensor is order to actuate Actuator rod during landing speed when aircraft touches ground.
This actuation of rod with progress ducts to move back.

4. Cascade vane/Duct

Translating cowl with linear actuator. It is in conical duct shape opened from both side to bypass air. Vane use to cover the pocket at forward thrust and uncover the same when duct moves back due to spring force at hinged point. it also guide the air in reverse direction.

6. Nozzle

Nozzle is incorporated with engine end to get effective thrust for aircraft for flight motion. Nozzle function is to amplify velocity to get sufficient amount of air velocity.

7**.** Linear Actuator

Actuator plays the significant role in this prototype. Linear actuator which is linked with Microcontroller. The rod of linear actuator is signalized by microcontroller after accessing Fan speed/Landing Speed.

B. DESIGN OF HYBRID OPERATED THRUST REVERSER

Figure 4. Fabricated Hybrid Cascade thrust Reversal Prototype

C. WORKING OF HYBRID OPERATED CASCADE THRUST REVERSER

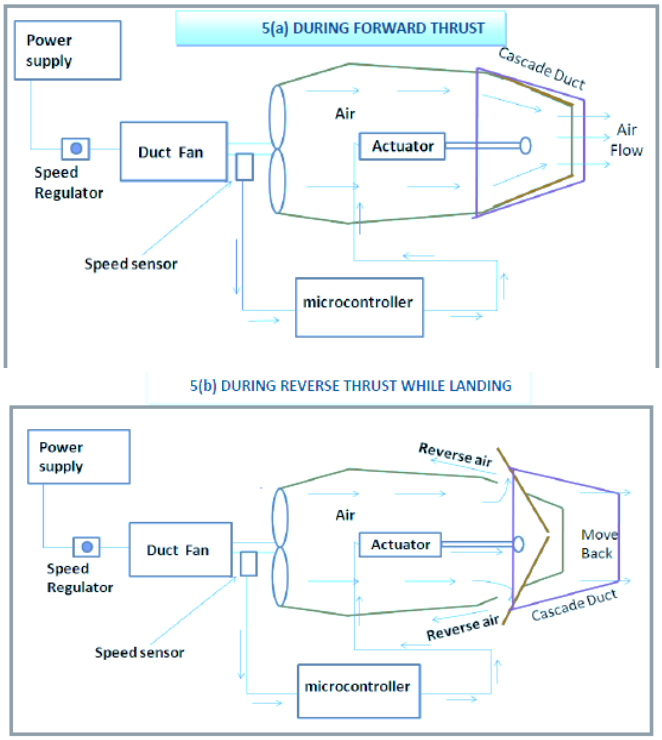


Figure 5. Working Principle Hybrid Cascade thrust Reversal Prototype

As shown in fig 5(a) & 5(b), external electric motor connected to blower fan. The electric motor rotates the blower fan. The air will passed through casing due to forced action of blower. Air will pass through the nozzle to provide the high velocity and create the thrust as shown in Fig 5(a).The speed sensor installed in front of blower fan. Blower fan is set to provide max thrust at 1500 rpm which can be recorded through speed sensor connected directing fan shaft.

As shown in fig 5(a) & 5(b), the speed sensor senses the speed and gives the signal to microcontroller. When speed less 200 RPM recorded by sensor provide signal to microcontroller. Microcontroller judge the signal that it comes below landing speed and pass on signal to actuator to progress the rod connected with Cascade duct. Linear actuators slide the translating cowl and the cascade duct which allows Cascade vane to retract and uncover the pocket to bypass the air in reverse direction as shown in Fig 5(a). The compressed air from the engine will bypass through pocket in guidance with cascade vane and reverse thrust generated. When the speed goes at taxi speed then speed sensor sends the

signal to microcontroller. The microcontroller actuate the linear actuator which slide the translating cowl and cover the cascade vane then air will pass straight backward through Nozzle.

Microcontroller has a provision to set this operation in manual mode with the help of lever which directly provide signal in actuator to actuate the rod at our need during landing run. This make this thrust reversal to work in **Hybrid mode** (Automatic +Manual).

D. OBSERVATION AND CALCULATION

Formulae required for the calculation of mass flow rate and thrust is mentioned below:

$$Mass\ flow\ rate(m) = \rho \times A \times v$$

$$Thrust(F) = m \times v$$

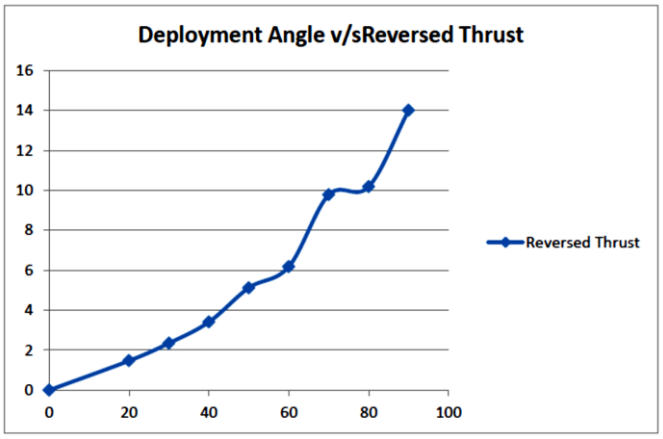
Here we get the variation of reversed thrust at different bucket angle.

Table: 1 Readings at different deployment angle at the outlet of upper and lower buckets

Angle of Deployment (In Degree)	Velocity at different points before and after deployment (In m/s)		
	Central Outlet point	Upper outlet point	Lower outlet point
At Nozzle Outlet	23.9	-	-
0	21.8	-	-
20	19.1	0.6	1.9
30	18.2	2.0	2.0
40	17.8	3.0	2.8
50	16.1	4.3	4.4
60	14.2	4.7	5.8
70	11.2	8.4	8.2
80	8.0	9.8	7.5
90	2.5	12.5	12.4

Table: 2 Calculated Reversed thrust at different deployment Angles

Deployment Angles(degree)	Total Thrust reversed(Newton)
0	0
20	1.47
30	2.35
40	3.41
50	5.12
60	6.18
70	9.77
80	10.18
90	14



E. ADVANTAGE OF CASCADE THRUST REVERSE

1. The efficiency of thrust reversal will increase.
2. With the use this technique we can reduce the attention of pilot during landing
3. We can apply thrust reversal automatically & manually.
4. It has better maneuvering effect especially in case of military aircraft.

IV. CONCLUSION

1. With the proper implementation of this technique of additional braking system provided.
2. More accident can be avoided in adverse climatic condition and other technical issue in landing gear brake.
3. This technique also shows how the energy that would go in vain would be utilized in such positive manner.
4. By making use of hybrid technique, pilot need not to worry in applying additional braking manually via lever in cockpit.
5. Microcontroller is well programmed to access speed of fan via speed sensor and actuate rod at required time during landing.

V. FUTURE SCOPE

1. By using microcontroller we can operate thrust reverser automatically.
2. We can simultaneously use both automatically & manually operate.
3. In co-operation of better avionics system to link this hybrid system to actual aircraft engine.

4. Microcontroller in actual aircraft required to control with landing gear retraction system and speed of air during landing

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