

Review of Thrust Reverser Mechanism used in Turbofan Jet Engine Aircraft

Mohd Anees Siddiqui^{1*} and Md Shakibul Haq²

¹*Department of Mechanical Engineering, University Polytechnic, Integral University, Lucknow, INDIA.*

²*Department of Mechanical Engineering, University Polytechnic, Integral University Campus, Shahjahanpur, INDIA.*

Abstract

Through this paper an initiative is taken to put focus on a special technique of thrust reverser mechanism which is common to the aviation industries but an uncommon in general. In this technique, forward thrust produced by jet engine of aircraft is diverged to reverse direction so as to provide an additional braking effect during landing and power back effect. This additional braking effect is responsible for reducing the landing run and other considerations related to safety of aircrafts. Different ways for thrust reverser i.e. Cascade type reverser system (cold stream), Clamshell door system (hot stream) and Bucket target system (hot stream) discussed. As Bucket target system has advantages over other systems of thrust reversal thus different mechanism of this type of thrust reversal are also discussed further.

Keywords: Jet Engine, Thrust reverser, Bucket target.

1. Introduction

Thrust reversal, also called reverse thrust, is the temporary diversion of an aircraft engine's exhaust so that the thrust produced is directed forward this acts against the forward travel of the aircraft, providing deceleration. Thrust reversers are used by many jet aircraft to help slow down just after touch-down, reducing wear on the brakes and enabling shorter landing distances. Reverse thrust is typically applied immediately after touchdown, often along with spoilers, to improve deceleration early in the landing roll when residual aerodynamic lift and high speed limit the effectiveness of the

friction brakes located on the gear. When thrust is reversed, passengers will hear a sudden increase in engine noise, particularly seated just forward of the engines [1].



Fig. 1: A KLM with reverse thrust buckets (left) [6] and Northwest DC9's used to pushback with reverse thrust "Power Back"(right). [7]

One common misconception about thrust reversing is that the engine itself actually runs in reverse, but this is not the case. In other words, air does not come in through the nozzle of the engine and be exhausted through the inlet to "reverse" the thrust. The engine itself still operates in the same manner, but the thrust it generates is redirected to produce drag.



Fig. 2: Different decelerating devices installed on current commercial aircrafts such as wheel brakes, spoilers and thrust reversers.

1.1 Requirement of thrust reverser mechanism

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, 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.

1.2 Advantages of Thrust Reverser Mechanism

As far as use of Thrust Reverser Mechanism is concerned, it has several advantages related to safety and other factors.

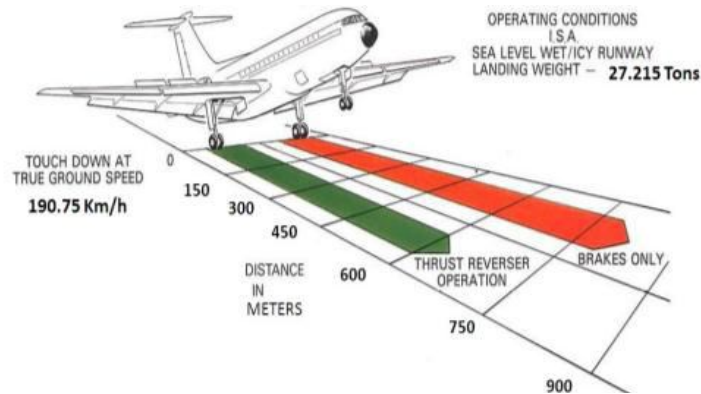


Fig. 3: Comparative landing runs with and without thrust reversal and it is seen that by using thrust reversers, landing is reduced up to an extent and this effect is more in slippery and icy runways. [1]

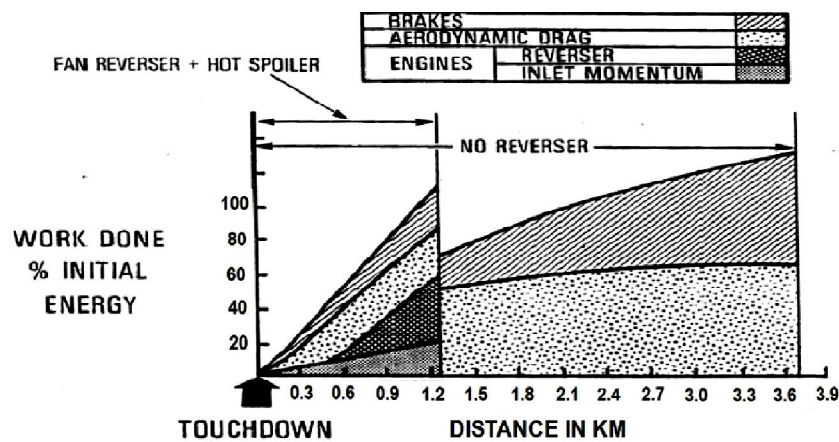


Fig. 4: Graph shows relation b/w work done and landing run with respect to use of thrust reversers in icy/wet runways, and it is seen that landing run is reduced about 2.5 Kms. [3].

The airlines accept that thrust reversers are necessary for safe operations. In general, the airlines feel that thrust reversers provide an added margin of safety for transport aircraft operations [2].

2. Engine Power Reverse Thrust Characteristics [3]

Engine power reverse thrust characteristics can be drawn as per the rated rpm and % of rated Thrust, it is observed that Reverse thrust is max at higher speeds of Engine. So, Thrust reversers are more efficient at higher engine rpm.

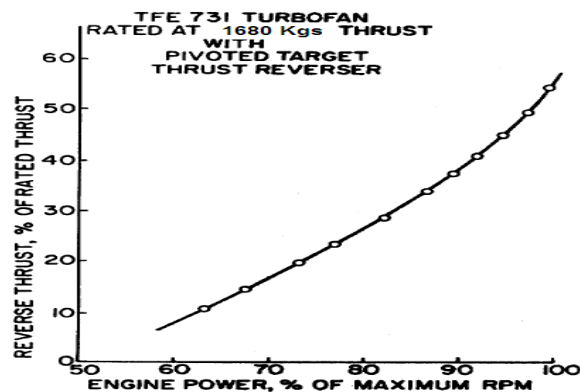


Fig. 5: Graph for a turbofan engine of reverse thrust data versus engine power level for the reverser geometry of an embodiment of the bucket target type thrust reverser in the deployed position.

3. Different Thrust Reverser Types

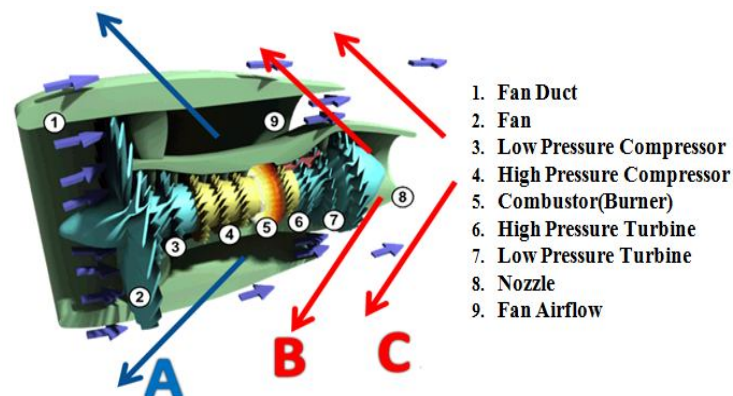


Fig. 6: Animated cross-section of jet engine showing different parts and arrows show ways of reversing thrust.[8]

3.1 Cascade type reverser system (cold stream)

The cold stream reverser system can be actuated by an air motor, the output of which is converted to mechanical movement by a series of flexible drives, gearboxes and screw-

jacks, or by a system using hydraulic rams. When the engine is operating in forward thrust, the cold stream final nozzle is 'open' because the cascade vanes are internally covered by the blocker doors (flaps) and externally by the movable (translating) cowl; the latter item also serves to reduce drag. On selection of reverse thrust, the actuation system moves the translating cowl rearwards and at the same time folds the blocker doors to blank off the cold stream final nozzle, thus diverting the airflow through the cascade vanes.

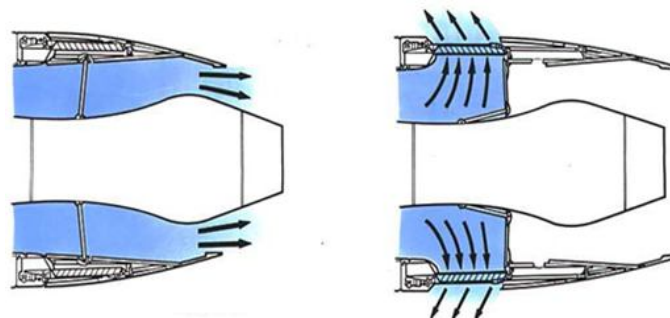


Fig. 7: Cascade type thrust reverser system using cold fan stream for reverser of thrust of a jet engine.

3.2 Clamshell door system (hot stream)

The clamshell door system is a pneumatically operated system. On the selection of reverse thrust, the doors rotate to uncover the ducts and close the normal gas stream exit. Cascade vanes then direct the gas stream in a forward direction so that the jet thrust opposes the aircraft motion. The clamshell doors are operated by pneumatic rams through levers that give the maximum load to the doors in the forward thrust position; this ensures effective sealing at the door edges, so preventing gas leakage. The door bearing and operating linkage operate without lubrication at temperatures of up to 600 °c.

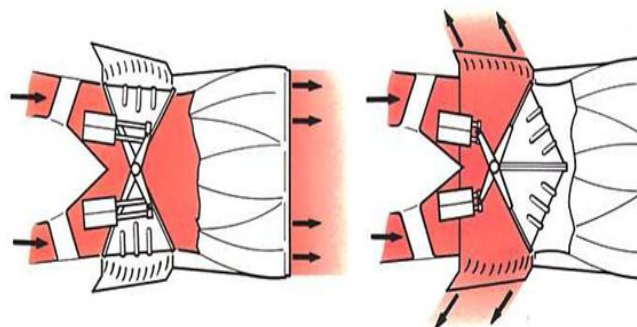


Fig. 8: Thrust reverser system using clamshell doors which are installed after turbine but before nozzle of a jet engine.

3.3 Bucket target system (hot stream)

The bucket target system is hydraulically actuated and uses bucket-type doors to reverse the hot gas stream. The thrust reverser doors are actuated by means of a conventional pushrod system. A single hydraulic powered actuator is connected to a drive idler, actuating the doors through a pair of pushrods (one for each door). The reverser doors are kept in synchronization through the drive idler. The hydraulic actuator incorporates a mechanical lock in the stowed (actuator extended) position. In the forward thrust mode (stowed) the thrust reverser doors form the convergent-divergent final nozzle for the engine.

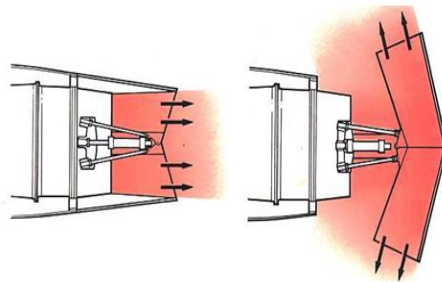


Fig. 9: Bucket target type thrust reverser system using deflector doors which are installed after nozzle of a jet engine.

As per the geometry of jet engine, maximum thrust is available only at the exit of nozzle. It is seen in bucket target type of thrust reverser mechanism is more efficient than other types because maximum amount of thrust which is coming out from jet engine is made to be reversed by using deflector doors at the back of jet engine.

4. Types of Mechanisms for Bucket Target Type Thrust Reverser

As bucket target system is more efficient than other thrust reversal mechanism so further different patents, reports and other available literature related to bucket target type thrust reverser mechanism is reviewed further.

4.1 Pivot fairing thrust reverser

A thrust reverser includes a pair of doors covering corresponding portals in an exhaust duct between an inlet and outlet nozzle at opposite ends thereof. The duct also includes a pair of side beams having actuators mounted thereon, and operatively joined to the doors for selective rotation thereof about corresponding pivots. In pre-exit type thrust reversers, the reverser doors are located upstream from the discharge end of the nozzle resulting in a typically more complex configuration for integrating the doors in the stowed and deployed positions. In particular, the stowed doors must minimize aerodynamic losses of the exhaust channeled there through during normal operation, as well as providing a streamlined outer surface for reducing drag. And, the doors should

be suitably sealed to the exhaust nozzle when stowed for reducing or minimizing exhaust gas leakage through the convoluted perimeter of the doors. [3]

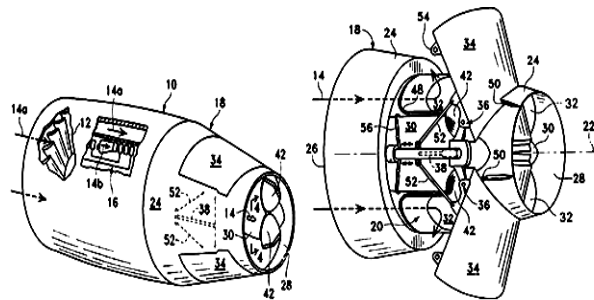


Fig. 10: Isometric view of an exemplary turbofan gas turbine aircraft engine having a thrust reverser mounted at the end in stowed (left) and deployed (right) [3]

4.2 Screw Jack Mechanism

This mechanism consist a pair of nested screw jacks commonly driven by a drive motor. The inner screw jack translates the blocker doors aft and the outer screw jack deploys the blocker doors into the engine jet stream. The first screw jack is operatively coupled to a translating support which translates either aft or forward, depending on the rotational direction of the first screw- jack to either deploy or stow the reverser doors. The translating support carries the reverser or blocker doors therewith. A second screw jack is mechanically connected to the first screw jack and rotates therewith. The second screw jack is connected through a translatable carriage and drive links to each reverser or blocker door. The slid able connection between the first and second screw jacks allows the second screw jack to translate relative to the first screw jack when rotated. The second screw jack has threads of a different pitch than those of the first screw jack. The thread pitch difference causes the reverser or blocker doors to translate aft at a speed at greater than the speed which they are rotated into or out of the engine gas steam thereby ensuring that the engine is not back pressured or overheated as the thrust reverser is deployed [4].

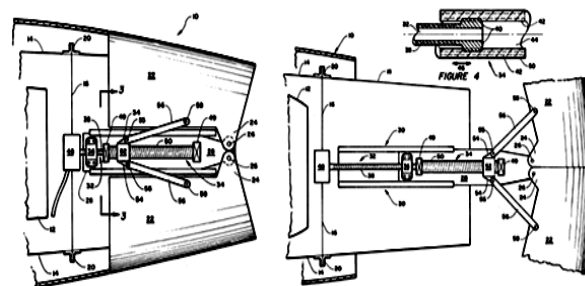


Fig. 11: Diagrammatic side elevated section of the rear portion of an aircraft engine depicting the reversing mechanism in stowed (left) and deployed (right). [4]

4.3 Fishmouth Thrust Reverser Nozzle

A thrust reverser nozzle for coaxial-flow turbofan engines comprising target-type deflector doors which are hinged for deployment about a fixed axis by means of actuation about single fixed pivots mounted on support structure on either side of the engine nacelle rearward portion. The deflector door's outer surfaces are shaped to match existing aerodynamic contours of the aircraft engine nacelle so as to provide a lower boattail angle for improved drag characteristics in the stowed or normal flight position. Geometry of the upstream portion of the inside surface of the doors is sized and shaped with end plates so that when the deflector doors move to the deployed position, the exhaust streams are diverted outward and forward to produce a desired level of reverse thrust [5].

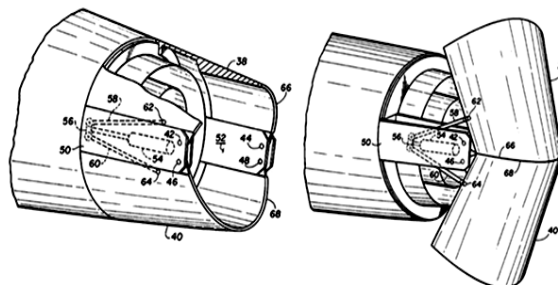


Fig. 12: Section view of the embodiment of thrust reverser with the actuator mechanism and the deflector doors in stowed position (left) the deployed position (right) [5].

5. Conclusion

In the present scenario with the proper implementation of this technique of additional braking system more and more accidents can be avoided in adverse climatic conditions. This technique also shows how the energy that would go in vain would be utilized in such a positive manner. As per the geometry of jet engine, maximum thrust is available only at the exit of nozzle. It will be better to install reversers at the position where maximum forward thrust is available. It is seen in bucket target type of thrust reverser mechanism is more efficient than other types because maximum amount of thrust which is coming out from jet engine is made to be reversed by using deflector doors at the back of jet engine.

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