31st Congress of the International Council of the Aeronautical Sciences
Belo Horizonte, Brazil; September 09-14, 2018

THRUST REVERSER INADVERTENT DEPLOYMENT IMPACT STUDY ON AIRPLANE CONTROLLABILITY

Sui Jiefei
COMAC

Keywords: *Thrust Reverser, Deployment, Controllability*

Abstract

To study the impact of thrust reverser inadvertent deployment to airplane controllability, following a typical thrust reverser inadvertent deployment accident which happened on an regional airplane with two after-fuselage-mounted high bypass engines during flight test, analyze the thrust reverser and engine response and study the airplane controllability in the whole flight envelop.

1 Background

Some catastrophic flight accidents show thrust reverser inadvertent deployment in flight affects airplane safety, especially in airplane takeoff phase and go-around phase. The regulation § 25.933(a)(1)(ii) requires the airplane is capable of continued safe flight and landing under any possible position of the thrust reverser. Because of the difficulty and high risk in demonstrating direct compliance, few intent flight test is designed to study airplane controllability under thrust reverser inadvertent deployment, most airplane thrust reversers are designed to protect against in-flight reverser deployment to a level of safety equivalent to that provided by direct compliance with the regulation[1][2]. Few case of thrust reverser inadvertent deployment can be used to study.

2 Thrust reverser inadvertent deployment

A thrust reverser inadvertent deployment accident happened on a regional airplane with two after-fuselage-mounted high bypass engines during flight test. The airplane was planned to carry out a simulated one-engine in-operative takeoff flight test, when aircraft speeded up to near 140 knots on ground with two engines takeoff thrust, the right throttle lever was slammed from takeoff thrust position to forward idle thrust position to simulate one-engine in-operative, unexpectedly, the throttle lever broke through into reverse thrust region duo to mis-operation. the right thrust reverser started to deploy, the airplane took a hard takeoff.

3 Analysis

When left throttle lever keeps at takeoff thrust position, and right throttle lever is moved into reverse thrust region, although the thrust reverser is designed three lines of defense to protect against thrust reverser inadvertent deployment in-flight, but thrust reverser deployment command generate before airplane liftoff, all landing gears are on ground, the three lines of defense are released as command, the right thrust reverser starts to deploy, thrust reverser actuation system acts normally, the right engine thrust starts to reduce.

As airspeed increasing, the nose landing-gear lift-off, the thrust reverser is designed to deploy only with all landing-gear on ground, so the thrust reverser conducts a stow sequence, but the high airflow due to high airspeed and high engine thrust stops the stow process, the thrust reverser translating-cowl is blocked at about 75% position, the thrust reverser actuators stowed force is balanced with the high airflow.

As left engine produces max thrust and right engine produces reverse thrust, the airplane has insufficient thrust and high drag to takeoff, the airplane conducts a difficulty takeoff, airplane bounded three times before final takeoff. When

main landing-gears lift-off, the hydraulic power to thrust reverser is cut off, the thrust reverser translating-cowl is blew to fully deployed with high airflow. When main landing-gears touchdown, the hydraulic power to thrust reverser is resumed, the thrust reverser tries to re-stow and stops at a specific position, see Figure 1.

As airspeed increases to about 150 knots, the airplane lifts off finally with an about 17 degree angle of pitch, then climb with slow climb rate about 200 ft/min. The airplane is hard to control at the initial climb phase, but at the last climb phase and subsequent level flight, the airplane controllability is acceptable, the right engine thrust is limited to idle in flight even the right throttle lever is push to near takeoff position, then the engine is shut down, the airplane landed safely finally.

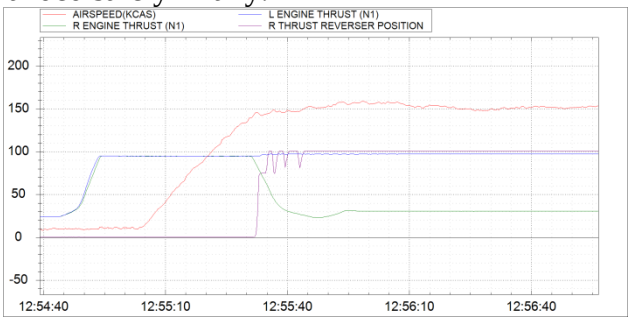

Figure 1:Thrust reverser inadvertent deployment

4 Conclusion

For regional airplane with two after-fuselage-mounted high bypass engine, the airplane controllability with thrust reverser inadvertent deployment is unacceptable for takeoff phase and initial climb phase, the reliability design to protect against in-flight reverser deployment is necessary ,the airplane controllability is acceptable for the subsequent climb phase, level flight with or without shutting down the engine and landing phase.

References

[1] EASA. CS-25 Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes [S]. EASA, 2012.

[2] FAA. Information: Equivalent Level of Safety(EOLS) Finding for Flight Critical Thrust Reverser on the Boeing Model 787-8 Airplane, FAA project NO.TC6918SE-T[S].FAA, 2011.

Copyright Statement

Contact Author Email Address

suijiefei@comac.cc