REDUCED THRUST TAKEOFF

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Abstract

In this thesis, the contributions of Engine Technical Management in lowering the engine maintenance cost and increasing the profits of airlines are illustrated through the introduction of reduced thrust takeoff.When,why and how to use reduced thrust takeoff are introduced in the thesis.The safety and reliability of reduced thrust takeoff,and especially the benefit in lowering the engine maintenance cost and so on,are also discussed.

1 Introduction

In recent years,with the rapid development of aerobus industry,airlines own many first-class aircrafts. As we all know, the engine as one of the core parts of an aircraft is very expensive.For example,CFM56-3,powered B737-300,costs about 3,000,000 dollars. Therefore, how to use and maintain the engine scientificlly and how to increase the profits effectively become very important for all airlines. However, only by innovating the technology and renewing the equipment are far from enough.The scientific Engine Technical Management with its flexible, efficient, easy to learn and low cost characteristics will increase the profits of airlines.This thesis mainly discusses a very good example in Engine Technical Management--Reduced Thrust Takeoff.

2 Main body

2.1 Purpose and condition of using Reduced Thrust Takeoff

In modern airlines, the aircrafts' aggregate weight is less than the maximum take off weight due to the short airways, the number of boarders and the weight of cargos. Although if the aircraft still takes off with the maximum take off thrust, it will more than meet the minimum safe take off requirement prescribed in the FAR, the longer the engine works with high load, the more side-effects are on the reliability and life-circle of the engine, and the more the engine maintenance cost is.Obviously, it is necessary to choose smaller T/O thrust, namely reduced thrust take off under the circumstance of the aggregate weight less than the maximum take off weight in order to lower the engine maintenance cost.

2.2 Analyse of safety and reliability

First,we analyze some character parameters during takeoff.To meet aircraft performance requirements,the engine is designed to provide a given thrust level to some “flat rate” temperature(FRT).At temperature above FRT,thrust decreases and aircraft performance is adjusted accordingly(See Figure1).

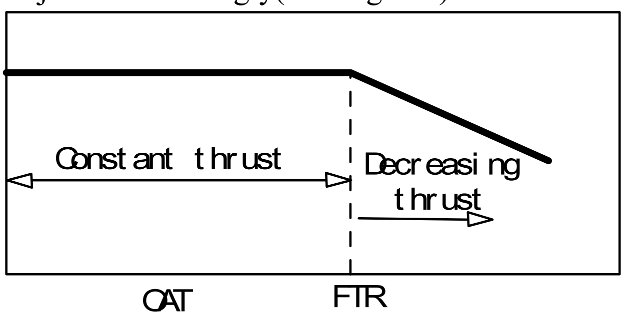


Figure1

N1 for power management schedule increases with TAT(up to FRT)to maintain constant thrust .After FRT,power management N1(and thrust)decreases(See Figure2).

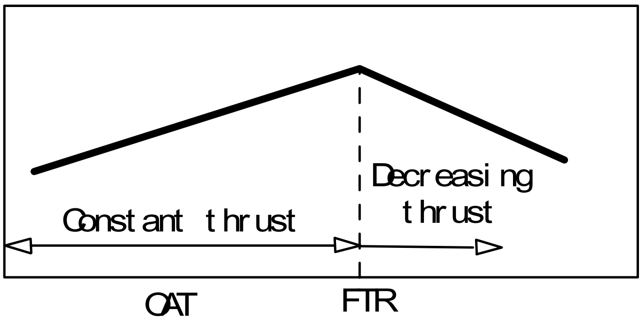


Figure2

EGT increases with TAT to FRT,then remains constant(See Figure3).

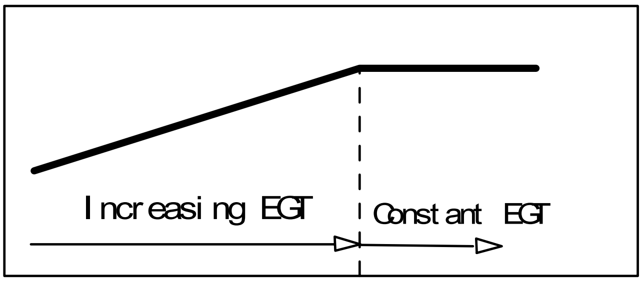


Figure3

After takeoff,if OAT is lower than FRT,with OAT increasing,thrust will keep constant while N1 and EGT will increase. If OAT is higher than FRT, EGT thrust will keep constant while thrust will decrease.We should choose the just thrust according to a temperature higher than OAT when using reduced thrust takeoff.So the thrust and the true takeoff weight are fit to the length of the runway,climbing grads,overcoming barriers,speed of tires and the limitation of minimum speed for brake energy. The higher temperature is supposed temperature or flexible temperature.Then choose the much lower takeoff EPR according to the flexible temperature and the height of the airport.

Is it more dangerous using reduced thrust takeoff if one engine failure provided by FAR-25?Let us compare with the performance of full thrust and reduced thrust and analyze in the method of flexible temperature(See Figure4).

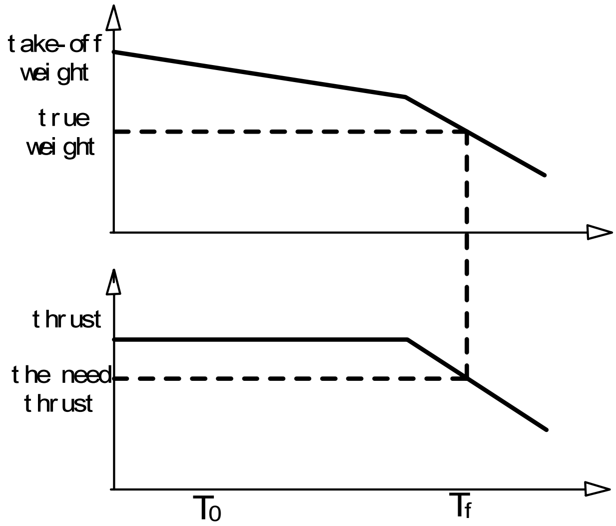


Figure4

Status one:the maximum aerodrome temperature(T_0).It is safe to take off with maximum thrust with the true weight under the temperature.

Status two: the maximum flexible temperature (T_f).Margin thrust is left because T_0 is lower than T_f. It is right safe to take off with reduced thrust with the true weight.

The takeoff limitation provided by FAR-25 and safety level are showed in status one.Now analyze the safety level in status two.

Runway length limitation

If engine failure occurs during takeoff,the TOD and ASD all relate to ground speed.When aerodrome temperature decreases, ground speed will decrease either while indicator speed keep constant.

In status two, ground speed also will decrease.So the TOD and ASD are shorter than in status one. The excrescent runway length can be used to increase takeoff weight and to earn more time to deal with the failure engine.It also increases the safety level.

Climbing grads limitation

It includes both the second climbing grads limitation and overcoming barriers limitation.

It has the same thrust and takeoff weight in status one and status two. It also has the same climbing grads with the same flap angle,lift-drag ratio and thrust-weight ratio.So be the safety level.But thinking about the overcoming barriers limitation,it is safer in status two(See Figure5).

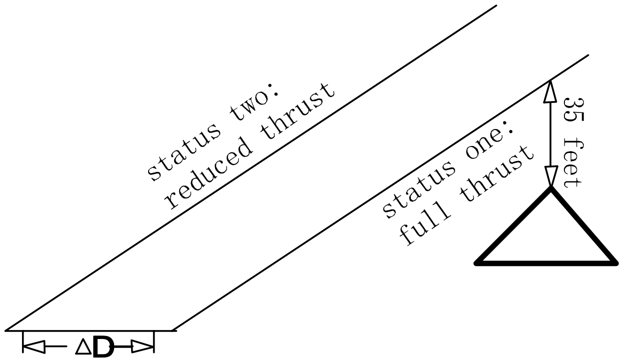


Figure5

Brake energy limitation and tire speed limitation both relate to groud speed.In status two,the groud speed is lower than in status one.So greater takeoff weight are permitTed in status two.

Above all,under the takeoff limitation besides the second climbing grads limitation,it is safer to take off with reduced thrusrt than with full thrust.

2.3 Perform reduced thrust takeoff

The minimun temperature is chosen as the supposed temperature among the temperatures which are decided by the aircraft's aggregate weight, aerodrome atmosphere altitude according to the take off field length, the climbing gradient, brake energy limitation and tire speed limitation , and the minimum operating speed. Then the take off speeds V1,V_R, and V2 are decided by the supposed temperature, aerodrome atmosphere altitude and the aircraft's aggregate weight, and the EPR is decided by the flexible temperature.

Choose the maximum permitted flexible temperature according to the minimum EPR provided by the flight manual.

Choose the flexible temperature according to the runway length limitation and the climbing grads limitation. The flexible temperature also relates to aerodrome atmosphere altitude,the true takeoff weight,flap angle and air-bleed.The flexible temperature with the second step climbing limitation can also be chosen in the same way.

Then find out the takeoff EPR corresponding to the chosen flexible temperature in method 2 in the Takeoff EPR Schedule.Make sure that it is the right temperature.

Decide the maximum takeoff weight according to the right temperature.

Adjust the flexible temperature with the other takeoff limitations such as tire speed and overcoming barrier.

Decide V_R,Vmax and Vmin according to the flexible thrust chosen by the aerodrome atmosphere altitude,the true takeoff weight,flap angle and so on. Make sure that V1 is greater than VMCG.

Find out the right takeoff EPR corresponding to the final chosen flexible temperature and the aerodrome atmosphere altitude.

2.4 The significance of reduced thrust takeoff

(1) Prolong the life-circle of an engine by reduction T_3^*.

As we all know,the longer the engine life is,the higher profit and the lower operation cost is.Turbine,as main part of an engine,is easy to be damaged for its bad working condition with high heat load,great centrifugal force and anomalistic pneumatic force. The great centrifugal force will wiredraw the blade. The anomalistic pneumatic force causes vibration and affixation stress to blade,then blade is easy to fatigue and rupture.

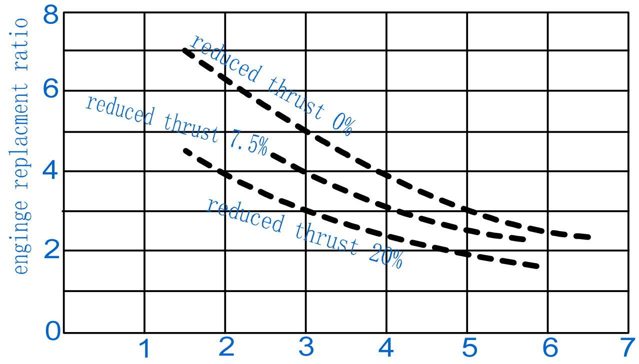
The turbine inlet gas temperature (T_3^*) is an important factor of turbine power.Increasing T_3^* leads to increasing blade load and decreasing metal intensity.It is showed that the metal life has logarithm relation to its temperature.

engine type	JT3D-3B	JT3D-7	JT8D-7	JT9D	CF6	RB211-22
△ T_3^* (℃)	54-56	52	41	46	49	43

Schedule 1

For example,a blade lose 35 percent of its life under the condition with 705 ℃ after operating 3,500 hours but 51 percent under the condition with 870℃ after operating 6.6 hours(see schedule 1).

In schedule 1,the reduced T_3^* about 30 to 50 ℃ when taking off with reduced thrust is showed. It lengthens twice life of the heat section.And the reducing enginge replacment ratio is showed in schedule 2(see schedule 2).



schedule 2

See,using reduced thrust takeoff results in longer engine life,lower maintenance cost and higher reliability caused low operation cost and high profit.

(2) Reduce engine noise by lower N1 and exhaust gas speed.

As we all know,noise does great harm to our heath and operation engine makes a lot of noise for its high rotate speed and energy-full gas flow.Reduced thrust takeoff relating to lower rotate speed and gas flow make noise lower.

(3) Reduce fuel consumption.

Engine efficiency will increase for the lower exhaust gas flow and speed loss and fuel consumption will reduce.

Reduced thrust takeoff is recommended to use in flight manual because of its many advantages.

3 Conclusion

Summarized, reduced thrust takeoff,as a part of engine technical management not only ensures flight safety,but also lengthens engine life,and reduces noise , fuel consumption and maintenance cost.It is obviously that scientific engine technical management could reduce operation cost and increase the profits of airlines effectively. Recommend all airlines practicing engine technical management.

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