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Borescope Inspection Management for Engine

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Abstract. In this paper, we try to explain the problems need to be improved from the two perspectives of maintenance program management and maintenance human risk control. On the basis of optimization analysis of borescope inspection maintenance scheme, the defect characteristics and expansion rules of engine heat terminal components are summarized, and some optimization measures are introduced. This paper analyses human risk problem of engine hole from the aspects of qualification management, training requirements and perfection of system, and puts forward some suggestions on management.

1. Introduction

Borescope inspection is a main means to carry out maintenance of engine ontology condition, which is a very important preventive maintenance measure in engine management. According to the relevant statistics, 90% of the non-scheduled engine replacement is discovered through borescope inspection. In addition to routine inspection of hole, borescope inspection is also an important method for the problems of engine ontology such as surge, vibration and performance drift. Therefore, it is of great significance to strengthen the management of borescope inspection to ensure operation safety [1].

Similar to other maintenance safety management projects, engine borescope inspection management mainly includes maintenance programme management and maintenance of human risk control.

2. Engine Borescope Inspection Maintenance Scheme Management

2.1. The necessity of optimization of borescope inspection maintenance scheme

The contents and interval of current aircraft maintenance scheme are mainly based on MPD. As a normative document provided by aircraft manufacturers, MPD's process of development has been rigorously evaluated and approved. Therefore, it has a high guiding significance. But maintenance programmes must also be targeted. In addition to adhering to the provisions of continuous airworthiness document, borescope inspection maintenance scheme needs to be optimized according to the operating environment and characteristics of the airline's own fleet [2].

Main factors influencing the functional performance of engine body parts with blade leading edge abrasion caused by sand and dust environment, erosion caused by internal cooling gas path blockage, chemical corrosion caused by special composition in the air or dust and oceanic environment; engine thrust level, reduction rate and the ratio of passage ratio also have some influence on recession rate of the hot end parts. The influence of operating environment is sometimes decisive, such as the HPTB, HPTN, LPT1N ablation phenomenon of CFM56-7B engines in the dust environment of India and China.

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In general, manufacturers will also introduce some targeted modification programs or monitoring measures, but the reaction speed is often slow, and may not have the desired effect. Timeliness is sometimes a factor to be considered in the decision-making of the borescope inspection maintenance scheme associated with preventing engine failure during flight.

With the deepening of industrialization and urbanization in China, engine operating environment has gradually deteriorated. In addition, the expansion of airlines on route networks and operational bases could lead to new operational environmental problems. Therefore, the borescope inspection maintenance program needs to be adjusted according to reliability data of fleet and internal and external operational experience, so it is possible to make borescope inspection work to have the effect of preventive maintenance [3].

Another reason for the adjustment of borescope inspection maintenance scheme is the difference between civil aviation industry at home and abroad, they have different concept in the management of preventing engine failure during flight. The MPD provided by the manufacturer is based on the statistics and operation requirements of the world fleet, with more emphasis on cost factors. The CFM56-7B model allows engine failure rate 0.003 during a 1000-hours flight. As an integral part of the plan preventing engine failure during flight, domestic airlines should not stick to MPD, but should aim at the engine failure rate of less than 0.001 during a 1000-hours flight.

2.2. Optimization of engine borescope inspection maintenance scheme

The optimization of engine borescope inspection maintenance scheme mainly includes the content of borescope inspection and the adjustment of interval. The optimization of borescope inspection maintenance scheme should be based on reliability data statistics and engineering analysis, so as to avoid unnecessary overmaintenance.

2.2.1. Trace analysis on run event. In order to properly adjust the maintenance plan of borescope inspection, it is necessary to keep track of the operation event data of both domestic and foreign models and our own fleet, and analyze the causes and probability. On CFM56-7B models, since January 2008 to December 2011, nearly four years of engine failure events among world fleet to statistics, in the engine failure cases having determined the causes, there are 13 opportunities to prevent through borescope inspection, including 4 times of HPT blade fault, 4 times of HPC blade fault, 4 times of wear for no.3 bearing seat, 1 times of LPT blade fault. Further information tracking of engine failure cases during flight find that some of the borescope inspection items specified in the current 737NG model MPD are not targeted, for example, there are no inspection requirements for the front edge of HPTB. The loss of HPC casing coating of RB211-535 engine is an important fault, but the condition of the casing coating is not required to be inspected regularly on MPD [4].

2.2.2. Analysis of defect expansion law. In addition to track and analyze engine running events related to borescope inspection, also need to further research extension rule of all kinds defects, according to the probability and extension features of engine body defect, arrange the interval of borescope inspection. In general, the hot end of engine components such as combustion chamber and high pressure turbine blade, high and low pressure turbine guide vane defects will expand over time, the original damage of cold end components such as HPC basically not expanded. The characteristics of expansion characteristics about the two engines of CFM56-7B and RB211 are calculated, the results are as follows:

The LPT1N crack is a common defect of the domestic CFM56-7B fleet, and the average time of the domestic fleet is 24000FH / 14600 FC (exceed AMM standard). CFM issued SB 72-0637 for this purpose, and requested the implementation of LPT1N borescope inspection project on the engine running in China from CSN=6400 cycle. According to the monitoring experience, some new engines find cracks after using 6000 cycles. If the old blades were used during the overhaul, there could be a serious crack in the thousands of cycles after the installation, and the earliest detection of a single engine in LPT1N was the CSO=767 cycle. LPT1N cracks is related to internal corrosion, defect extension usually occurs in the form of new crack, it is difficult to predict the law, and the failure of performing SB73-0132 modification for fuel nozzle can also lead to LPT1N local defect. In view of the defect on AMM standards were relaxed and the case of LPT1N defects is rare, there are two engines discovered crack for the first time in 6333 cycles, is used on wing monitoring to 14407 cycle. As shown in figure 1.

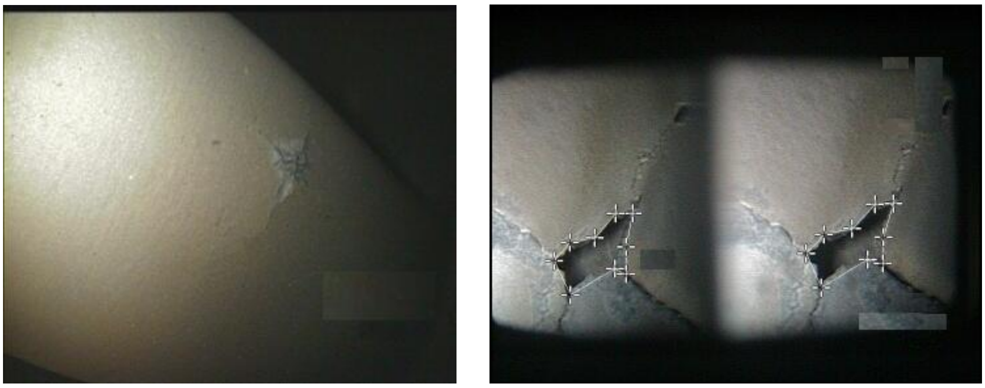

Figure 1. ESN874274 Engine LPT1N Defect.

According to the information, the users of CFM56-5B /7B in China have had 17 non-planned cases from January 2010 to September 2011 because of the HPTN issue, and the average ECSN=13,000 cycle in the next issue. SB 72-0637 calls for the implementation of HPTNGV borescope inspection project for the engine running in China from CSN= 9600. Monitoring experience is new engine will have a mild oxidation after 12000 cycles, damage on individual engine is relatively serious, but defect extension is slow, most of the engines have a bigger chance to use more than 17000 cycles on wings. After overhaul, the HPTN defect may be even exceeded after the 4000 cycles [5].

According to the latest operation experience of CFM56-7B engine in China, some airlines have conducted inspection of the front edge for CFM56-7B engine HPTB recently, and have completed the comprehensive reconnaissance for the feet's HPTB status. Monitor found the main damage form of HPTB front is ablation or damage caused by foreign object, general after CSN = 12000 cycle time, but there is one engine in the CSN = 4612 cycle is a foreign object damage, the other engine found ablation caused by gas path blockage in internal CSN = 9000 cycle. There is a lack of monitoring experience in HPTB damage extension. As shown in figure 2.

Figure 2. CFM56-7B Engine HPT Defect.

Moving and static blade friction on the HPC non-executing of SB72-0581 and SB72-0665, is one of the main reasons for CFM56-7B engine non-scheduled replacement. To prevent risks, airlines improve the borescope inspection threshold related SB 72-0515 from 24000 hours to 20000 hours for the first time, monitoring found that most engine borescope inspection for the first time in passes TSN= 20000 hours, and show signs of wear, often before it passes TSN= 26000 hours to manual regulation issued standards, defect expand more quickly. During this period, borescope inspection interval needs to be adjusted dynamically according to defect condition.

For the engine with defect, mainly through the establishment of power engineers review the borescope inspection report system, perfect the borescope inspection report assessment process, dynamic adjustment according to the defect situation borescope inspection perform follow-up interval. In addition, it is necessary to strengthen the control of the troubleshooting process for major engine failures, organize thematic meetings to discuss the problem of troubleshooting, and to specify the timing of borescope inspection.

3. Engine Hole Detective Maintenance Risk Management

Experience has shown that the most easiest to occur in borescope inspection include equipment aging leads to leak detection, improper instrument operation results in measurement errors, failure to inspect the site thoroughly due to lack of skill or skill, understanding error to manual standard. In order to improve the management of maintenance in engine borescope inspection, we can consider the improvement of personnel quality, strengthening training and improving management system.

3.1. The quality requirements of borescope inspection agents

The quality requirements of borescope inspection staff are high, and the requirements of the airlines for the qualification of the agents usually include educational background, maintenance experience and training. Considering the professional characteristics of borescope inspection work, the agents need to master the basic structure knowledge of engine and have certain English level.

3.2. Training requirements for borescope inspection agents

The scope and depth of knowledge required for different job and level agents can be different.The knowledge and skills of an excellent engine inspector should include the following aspects:

3.2.1. Familiar with the safety knowledge of engine borescope inspection. Include safety precautions related to borescope inspection, such as hanging warning signs before work, installing C letter lock and isolating reverse push. Master the rotor rotating maximum torque limit and various borescope plug disassembling the torque requirements, pay attention to prevent accidental rotational rotor artificial or natural causes, knows how to prevent being hit by the rotor equipment, how to handle the borescope pipe binding, has the general concept of engine cooling time.

Use and understand the work card or manual properly, be able to access and understand the work card and AMM manual. Master the management procedures related to engine borescope inspection including the specification of borescope inspection card.

3.2.2. Mastering basic specialized knowledge. timely understanding of the new type engine defect information, internal configuration change, change of AMM standard information, understand the main defects of ontology of the engine and the potential consequences.

3.3. Management system of engine borescope inspection

Developing management regulations for engine borescope inspection needs to consider feasibility of the problem, in addition to conform to the characteristics of borescope inspection, sometimes also need to combined with the size of airlines, project management and maintenance personnel and other factors.

3.3.1. Add reminders or warnings. Add some warnings or prompts on job card or borescope inspection equipment, such as the prompt of defect feature, temperature limit of engine internal, limitation of equipment operation, etc.

3.3.2. Review system. The reinspection system is a practical and effective error prevention measure for all maintenance work. The reinspection method of borescope inspection can include on-site inspection and post-mortem examination. The factors that should be taken into consideration include the importance of specific work items, temperature limitation of instrument operation and human resources, which are both feasible and effective, but also increase the workload.

3.3.3. Qualification control. Experienced personnel should be assigned to perform important or difficult hole inspection items, such as engine reception and withdrawal, internal leak detection, fault diagnosis and engine inspection.

3.4. Human factor risk prevention

For the risk control from maintenance point of view, in addition to the factors such as intensity of work, work environment, quality of engine borescope inspection also depends on the executive level of technology, experience, skills and sense of responsibility.

Engine borescope inspection personnel need to master some basic visual inspection skills, such as finding the right viewing angle and field of vision, avoid the light too dark, strong light reflection and vision brought about by the factors such as inappropriate miscalculation. Workers can choose active and passive inspection according to his mental state, and allocate his energy properly. For some areas that are prone to problems, it is important to observe, such as the middle of HPC and the upper part of hot end components. When defects such as gaps and cracks are found, the other surface of the blades should be inspected. In addition, if work time is longer, should arrange workers rest in the middle, lest visual fatigue. Managers should also give full consideration to the adverse psychological effects of inclement weather and noise conditions [6].

In the engine borescope inspection work, we also need to emphasize the human initiative. In fact, the engine internal flaws or suspected of ontology is relatively rare, it's not possible for borescope inspection reports to describe accurately, AMM manual can't explaine them comprehensively, especially for blade gap, crack, wear and tear, the judgment of these problems need to base on a certain working experience, sometimes borescope inspection personnel may need site compared to the other one even more of the same parts of the engine, can take the initiative to carry out this kind of work depends largely on the borescope inspection personnel sense of responsibility and motivation.

It is necessary to strengthen the experience communication and maintain contact with the factory. There is no doubt that the workers should consult others in time. Airlines can regularly arrange the personnel to communicate with each other, learn from experience, and prevent systematic errors.

4. Conclusion

Engine borescope inspection management mainly includes maintenance program management and maintenance of human risk control. Borescope inspection maintenance scheme should be optimized according to operation characteristics and safety management of airlines, and based on reliability data statistics. The optimization mode of borescope inspection maintenance scheme mainly includes the content of borescope inspection and the adjustment of maintenance interval. The risk management can be considered from improving the quality of personnel, strengthening training, improving management system of borescope inspection, etc., and paying attention to the human factor risk control in the daily work.

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