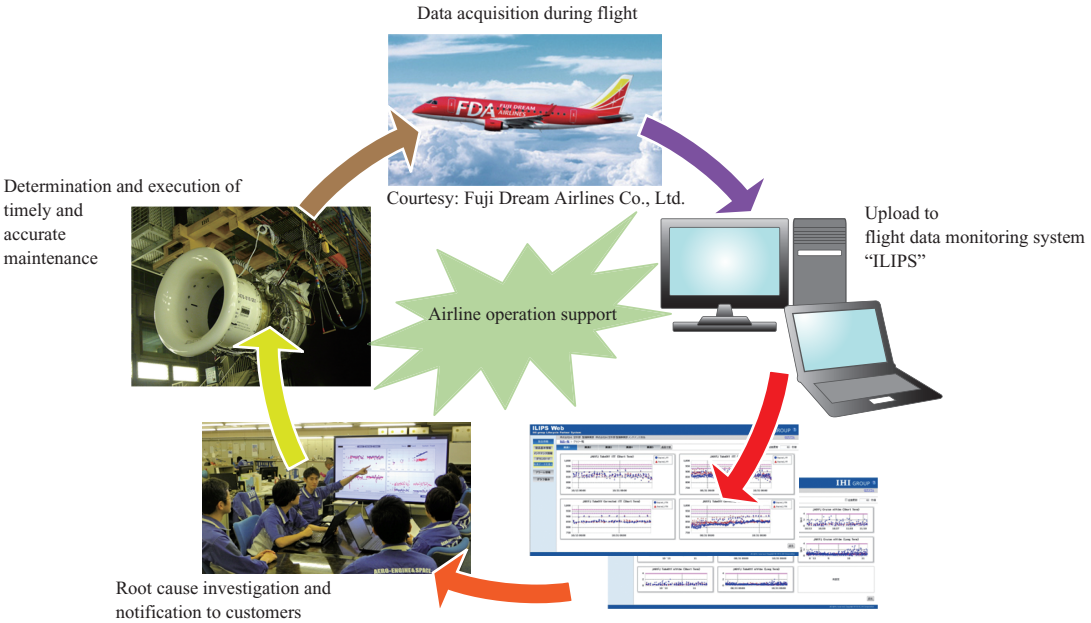
Engine Monitoring Facilitates On-Time Arrival and Departure

IHI offers an engine performance monitoring service for civil aircrafts

Japanese airlines now priding themselves on the world's best on-time arrival and departure rate.
They take all possible measures to absolutely prevent mechanical problems resulting in flight delay or flight cancellation.
IHI utilizes their unique platform "ILIPS" to monitor a trend in engine performance during flight, and performs anomaly detection, data acquisition, failure prognostic to support the operation of an aircraft.



Flow of engine performance monitoring service

Lifecycle business

IHI overhauls and repairs civil aircraft engines on the basis of customers' maintenance specifications. For the overhauls and repair, we make the most of internal systems and databases to promote varieties of business improvement, quality improvement, and cost reduction, and provide customers with a manufacturing service called "engine maintenance" in the most suitable form.

On the other hand, in the world, it has been demanded to provide lifecycle support, i.e., to support the lifecycle of a product from the delivery to operation, maintenance, and selling of it. As a result, it has been required not only to stay in the service called engine maintenance, but also to expand our services to a value-added service called "kotozukuri (value creation)" such as the optimization of customers' operations.

For this reason, IHI is aiming to utilize a remote

maintenance common platform (IHI group Lifecycle Partner System: ILIPS), an internally developed system, to provide proposals and services such as a reduction in operation cost, engine removal schedule or timing, and optimization of maintenance specifications, and thereby totally support customers from operations to maintenance. The core of the total support is monitoring, i.e., condition monitoring and data acquisition.

On-condition maintenance and proactive maintenance

Civil aircraft engines usually adopt a maintenance method based on the condition, called an on-condition maintenance. This is a maintenance method or way in which maintenance is performed basically in compliance with customer's maintenance specifications such as "after xx hours operation, overhaul xx module or part," and in the process of the maintenance, only a deteriorated module or part is repaired based on their conditions. Since only a problematic part is repaired in terms of safety, the maintenance can be performed at a minimum cost.

The deterioration condition of the engine can be examined by two different methods. One of them is a method adapted to proceed with the examination while directly observing engine parts in a condition where the engine is mounted in an airframe as is conventionally done or in a condition where the engine is removed from the airframe and sent to a maintenance company. In either case, only damaged parts can be found by checking the actual parts, and repaired.

The other one is a method adapted to observe monitoring data. Although it is less accurate than checking the actual parts, a condition inside the engine can be grasped before proceeding with maintenance work, and therefore the need for engine removal or disassembly can be checked in advance to minimize an effect on a flight. When further advancing this method, proactive maintenance, i.e., active maintenance taking account of future maintenance becomes possible.

In the future, it will be important to check the internal condition of an engine by monitoring an engine trend, in addition to checking the condition of actual parts.

Monitoring of engine

There are two types of monitoring methods for aircraft engines, of which one is real-time monitoring and the other one is trend monitoring.

The real-time monitoring is such that a pilot monitors an engine condition in a cockpit from moment to moment. This is done on an airline's responsibility in terms of a safety flight. When an airframe system detects an abnormal value, the system raises an alarm and the pilot him/herself makes an action, or aircraft line maintenance technicians of the airline make a necessary action after landing.

On the other hand, the trend monitoring is such that an airline, engine manufacturer, and/or maintenance company monitor a trend in an engine condition on a flight basis. Maintenance is performed as necessary on the basis of the resulting trend data. In this case, IHI acts as a maintenance company, and therefore performs the trend monitoring to provide technical services and advice meeting customer's requirements with the trend data.

Engine performance data acquisition system

Data on engine performance acquired on an aircraft during flight is transmitted to the ground using an air-ground data link system called ACARS (Automatic Communications Addressing and Reporting System). The data acquired during flight is transmitted using ACARS to a server of a provider specialized in handling such data via a ground-based antenna of the provider. An airline can obtain the data acquired on the aircraft from the server. In addition, a manufacturer of an engine mounted has an agreement with airline to obtain the monitored engine performance data. Therefore, the performance data transmitted to the provider from the aircraft is transferred to the engine manufacturer as well.

An airline entrusting IHI with engine maintenance automatically transfers performance data, that is the same data as that received by an engine manufacturer such as GE Aviation (USA) or Pratt & Whitney (USA), to IHI in almost real time when data is acquired on an aircraft, and such data is accumulated in the ILIPS server.

Data acquisition is performed under the specific condition, and immediately transmitted to the ground. Specifically, data acquisition is performed once when an aircraft takes off and once when the aircraft reaches a stable cruise condition. Data to be acquired includes approximately 40 parameters such as engine exhaust gas temperature, fuel flow rate, oil temperature and pressure, vibration value, rotor speed, and bleed condition. All of the items are uploaded to ILIPS. Note that at this stage, the data is raw data.

Engine trend monitoring and failure prognostic

IHI provides customers (airlines) with proactive maintenance proposals and technical services by monitoring and analyzing engine performance data.

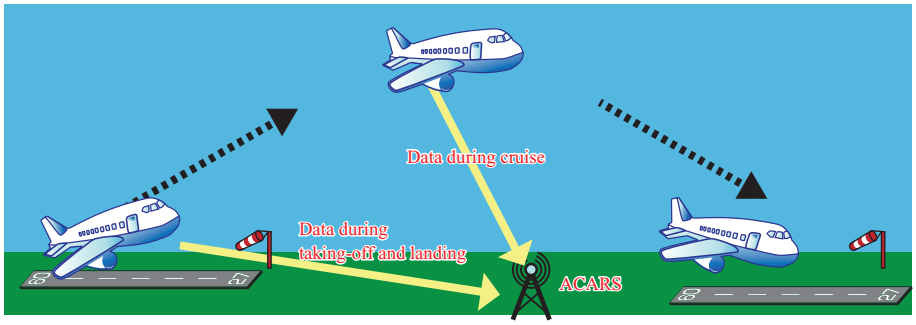
(1) Data acquisition

Engine performance data during flight is acquired in real time and automatically uploaded to ILIPS in a manner as described above. ILIPS is accessible via Internet connection, and the data can be monitored anytime 24 hours a day.

(2) Data analysis

Using acquired data, the following analyses are performed. Not only raw data but analysis results can also be monitored on ILIPS.

(a) To perform various performance correction calculations for a basic gas turbine, which under a certain condition, converts performance data acquired



Engine performance data acquisition system

from an engine used in various flight and environmental conditions and facilitates monitoring of a change in engine performance.

(b) To identify performance deterioration level and part/location by comparing bland-new engine performance and actually monitored deteriorated engine performance using an "engine performance analysis model" used when an engine was initially designed.

(c) To represent the probability of near-future engine failure by using a statistical method to predict near-future performance data from trend data on past engine performance.

(3) Trend monitoring

(a) Short-term trend review: To detect potential problems, and provide effective advice to a line maintenance section of an airline before engine performance data exceeds an operating limit.

(b) Long-term trend review: To detect performance deterioration on each module to advise on the optimum borescope inspection timing and engine removal timing by comparing an engine performance analysis model used for designing with monitoring data, and in addition, propose highly accurate, low-cost, and optimum performance recovery maintenance specifications using IHI's databases.

(4) Automatic anomaly detection

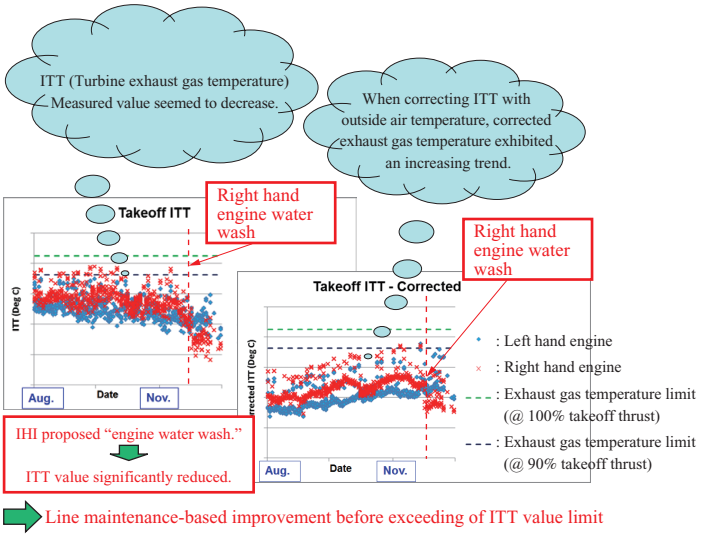
The system automatically detects the exceeding of a limit and a sudden change in parameter, and automatically gives notice of an alarm.

Let us here introduce a specific example. In a trend graph of the exhaust gas temperatures of CF34-8E engines over approximately half a year, the exhaust gas temperatures seemed not to change much with time, but to be stable. However, in fact, the effect of outside air temperature on the engine exhaust gas temperature was included in trends from summer to fall.

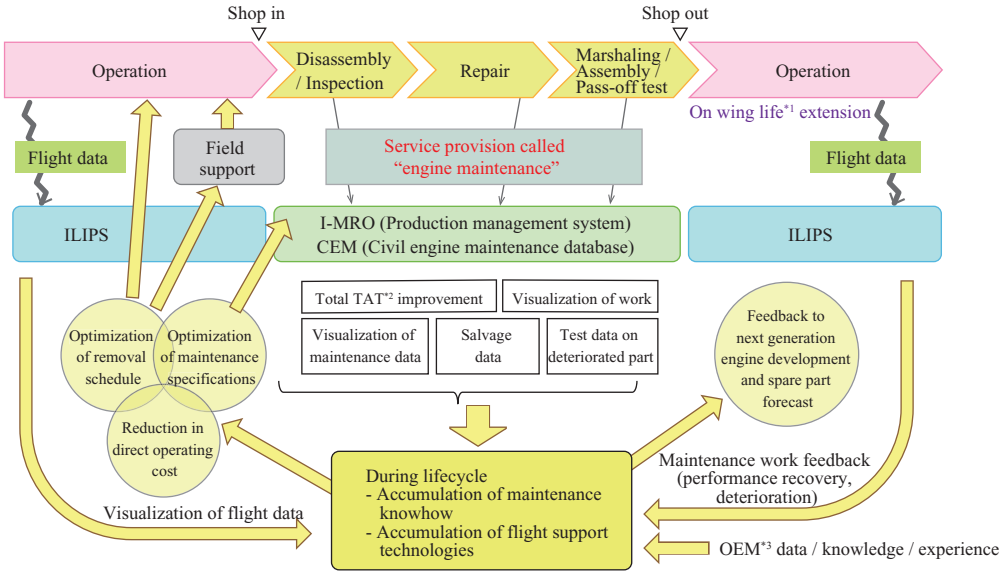
Therefore, when switching to a trend graph obtained by correction calculation based on the outside air temperature, it turned out that the exhaust gas temperatures of the engines both gradually increased. In particular, the exhaust gas temperature of the right hand engine was high in absolute value as compared with the left hand engine. When the exhaust gas temperatures exhibit such trends, it can be expected from past accumulated data that dirt is accumulated in the engines depending on a flight route and the number of flights, thus causing performance deterioration. If the engines are left as they are, the exhaust gas temperatures will reach an operating limit value, and in the worst case, there will be fears of flight delay and cancellation.

Therefore, we proposed washing the inside of the right hand engine with water or hot water to a customer, and consequently the exhaust gas temperature of the engine was able to be significantly reduced after the water washing. That is, the performance was restored.

On the other hand, IHI's unique failure diagnosis can provide predicted exhaust gas temperatures after one to two weeks, and also provide the possibility of exceeding the exhaust gas temperature operating limit value resulting in flight restriction. This is like the probability of precipitation in a weather forecast, and when the possibility of exceeding the limit value after one to two weeks is low, an engine is still secure, whereas the possibility is determined to be high, an airline can plan maintenance such as washing the inside of the engine with water within the next one to two weeks.



"Short-term" trend monitoring (exhaust gas temperature)
: CF34-8E engine case



Note *1 : On wing life: Engine on wing life
*2 : TAT: Turn Around Time
*3 : OEM: Original Equipment Manufacturer

Lifecycle support

Providing advice based on IHI's past maintenance experience using monitoring data, and performing proactive maintenance in an airline using the unique failure diagnostic technology as described above enable on-time arrival and departure.

In addition, when an engine suffering from higher exhaust gas temperature is brought to IHI for maintenance, we will propose the optimum maintenance specifications that describes repairing only key parts of a high pressure turbine to reduce only the exhaust gas temperature on the basis of the past engine maintenance experience, and achieve the optimum maintenance at low cost.

We are providing product lifecycle support by providing not only in-plant engine maintenance but also flight support as described above.

Future development

A new model engine will acquire much more data during flight. We will analyze such collected data in accordance with a method suitable for purposes, and thereby propose superior flight support plans to customers as an aircraft engine maintenance company, and in addition, expand the scope of business as a maintenance company.

Also, as the leader of domestic jet engine manufacturers, we will utilize such data for new engine developing so as to make the optimum condition sustainable throughout product lifecycle.

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