C-49-10

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE RECOMMENDED PRACTICE

ARP 1217

Issued May 1979
Revised

INSTRUMENTATION REQUIREMENTS FOR TURBOSHAFT ENGINE PERFORMANCE MEASUREMENTS

1. This Aerospace Recommended Practice (ARP) defines the measurement parameters that may be used by a pilot or operator to monitor the thermodynamic health of a turboshaft engine in a helicopter and the measurement system accuracies desired.

2. DEFINITIONS

2.1 Condition Monitoring: Engine condition monitoring involves the observation of various measured parameters to detect changes with operating time for a given operating condition.

2.2 Diagnostics: Proper interpretation of the monitored parameters allows the observer to determine the health of the engine. If changes in the parameters have not taken place, operation can be continued. However, if a change is noted, the cause can be diagnosed and appropriate action taken.

3. DISCUSSION

During the past few years, interest has grown in the concept of "on-condition" maintenance, which permits the removal of an engine when a monitoring device such as a chip detector or vibration sensor indicates that the engine requires maintenance action. Similarly, if the performance of an engine and its components can be monitored, the engine need not be removed from the helicopter for overhaul at a pre-determined time between overhaul (TBO), but only if engine performance deterioration exceeds specified limits. Simultaneously, with proper location of the measuring sensors, it is possible to diagnose where the performance deterioration has occurred so that appropriate maintenance action can be taken. While the concept of "on-condition" maintenance may not be universally applicable, it may offer reduced operating costs.

The determination of the thermodynamic health of an engine traditionally has involved the measurement of a certain set of cycle parameters. Newer techniques involve measuring changes in component characteristics with time. In the case of the latter technique measurement, repeatability is more important than absolute accuracy.

The recommendations in paragraph 4. are intended for either technique.

Whether the more traditional analysis or newer technique is used, studies have shown that the measurement of the following parameters are the most useful for determining changes in efficiencies and flow capacities of turboshaft engines with time.

T_1	-	Temperature at Inlet/Engine Interface
P_1	-	Pressure at Inlet/Engine Interface
N_1	-	Gas Generator Rotor Speed
N_2	-	Power Turbine Rotor Speed
T_3	-	Temperature at Compressor Discharge

(Continued)

3. (Continued)

P_{S3}	-	Static Pressure at Compressor Discharge
$T_{4.5}$	-	Temperature at Power Turbine Inlet
$P_{S4.5}$	-	Static Pressure at Power Turbine Inlet
τ	-	Power Turbine Output Torque
W_f	-	Engine Mass Fuel Flow

It should be understood that the above parameters can be used to monitor the condition of the full compressor and gas generator turbine consisting of either a single or dual rotor. In the majority of cases, isolating the fault to the compressor section or to the gas generator turbine section is sufficient to prescribe maintenance action.

4. RECOMMENDATIONS

Depending on the maintenance philosophy of a particular installation, some or all of the parameters listed in paragraph 3. might be utilized. The final choice of the parameters and the condition monitoring and diagnostic procedures to be employed should be performed in accordance with methods described in the installation manual or in accordance with methods agreed by the user with the helicopter manufacturer. As a minimum, provisions should be made for the pilot or operator to monitor T_1, P_1, N_1, N_2, $T_{4.5}$, and torque. With this in mind, the following are recommended accuracies and repeatabilities of the measurement systems:

4.1 Engine Inlet Temperature (T_1): The temperature just ahead of the engine/airframe interface is normally used, since compressor inlet temperature is not directly measured. The present accuracy of measurement is ± 2°C. An accuracy of ± 1°C is desired. The present repeatability is ± 0.1°C and is acceptable. Accuracy and repeatability is required over full scale.

4.2 Engine Inlet Pressure (P_1): The inlet pressure is a direct function of altitude, flight speed, and ram pressure recovery. The variation of inlet pressure has a directly corresponding effect on power output. If barometric pressure is used as an alternate to a direct measurement of P_1, the accuracy of the altimeter at sea level should be within ±50 ft (±152 cm), the equivalent of ±0.2% in inlet pressure. The present repeatability is ±50 ft (±152 cm), and is acceptable. Accuracy and repeatability are required over full scale.

4.3 Gas Generator Speed (N_1): The accuracy of speed measurement can have an important bearing on performance determination. Using speed as a prime parameter requires better instrumentation than is currently available. The present accuracy is ±.25% and repeatability is ±.1% and are acceptable and required above 50%.

4.4 Power Turbine Speed (N_2): Where power turbine speed and output torque are used to determine power, the accuracy of power determination will vary directly with the accuracy of power turbine speed measurement. The present accuracy is ±.25% and repeatability is ±.1% and are acceptable and required above 80% scale.

4.5 Compressor Discharge Temperature (T_3): In conjunction with other parameters for a given operating condition, T_3 is used to assess changes in overall compressor efficiency and flow capacity. The present accuracy is ±5°C. An accuracy of ±3°C is desired. The present repeatability is ± 3°C, but ±1°C is desired. Accuracy and repeatability are required over the full scale.