CLAIMS

1. A method for detecting performance of an APU, comprising:

obtaining exhaust gas temperature EGT, compressor inlet temperature LCIT, starting time STA, service time TSR and bleed pressure PT;

comparing respectively a difference between EGT and LCIT (i.e., EGT-LCIT), STA, TSR and PT with their respective threshold values;

assigning respectively weights to comparison results between EGT-LCIT, STA, TSR and PT and their respective threshold values; and

determining the performance of the APU based on the weighted comparison results between EGT-LCIT, STA, TSR and PT and their respective threshold values.

2. A method according to claim 1, wherein, the threshold value of EGT-LCIT is an EGT redline value $EGT_{Redline}$ of the APU.

3. A method according to claim 1, wherein, the threshold value of STA is a performance decline value $STA_{WarningLine}$ of STA.

4. A method according to claim 1, wherein, the threshold value of TSR is a corresponding time TSR_{rt} where the reliability of time-on-wing of the APU is 70%.

5. A method according to claim 1, wherein, TSR_{rt} is calculated based on actual data through Poisson distribution.

6. A method according to claim 1, wherein, the threshold value of the PT is a minimum bleed air pressure PT_{Min} of the APU or is a lowest inherent bleed air amount $PT_{BaseLine}$ of the APU during normal operation.

7. A method according to claim 1, wherein, the step of comparing comprising:

calculating ratios or differences between EGT-LCIT, STA, TSR, PT and their respective threshold values.

8. A method according to claim 1, wherein, the weight of the TSR is greatest and the weight of the PT is lowest.

9. A method according to claim 8, wherein, given R1, R2, R3 and R4 are respective weights of the EGT-LCIT, STA, TSR, PT, R1=0.2, R2=0.3, R3=0.35 and R4=0.15 where the APU is an APS3200 APU.

10. A method according to claim 9, wherein, given R1, R2, R3 and R4 are respective weights of the EGT-LCIT, STA, TSR, PT, R1=0.3, R2=0.2, R3=0.35 and R4=0.15 where the APU is an GTCP131-9A APU.

11. A method according to claim 1, wherein, the step of determining comprising:

determining the performance of the APU based on the following formula:

$$PDI = R1\frac{EGT - LCIT}{EGT_{RedLine}} + R2\frac{STA}{STA_{WarningLine}} + R3\frac{TSR}{TSR_{rt}} + R4\frac{PT_{Min}}{PT}$$

wherein, PDI is a performance detection index reflecting the performance of the APU, R1, R2, R3 and R4 are respective weights of EGT-LCIT, STA, TSR and PT, and PT_{Min} may be replaced by $PT_{BaseLine}$.

12. A method according to claim 11, further comprising:

determining the performance of the APU is well when the PDI is less than a first predetermined value;

determining the performance of the APU is normal when the PDI is greater than the first predetermined value but less than a second predetermined value;

determining the performance of the APU is in a decline period when the PDI is greater than the second predetermined value; and

determining the performance of the APU is in a failure period when the PDI is greater than a third predetermined value.

13. A method according to claim 12, wherein, the first predetermined value is 0.7, the second predetermined value is 0.85 and the third predetermined value is 0.95.

14. A method according to claim 1, wherein, the step of determining comprising:

determining the performance of the APU based on following formula:

$$PDI = R1\frac{EGT_{cor}}{EGT_{RedLine}} + R2\frac{STA}{STA_{WarningLine}} + R3\frac{TSR}{TSR_{rt}} + R4\frac{PT_{Min}}{PT_{cor}}$$

wherein, PDI is a performance detection index reflecting the performance of the APU, R1,

R2, R3 and R4 are respective weights of the EGT-LCIT, STA, TSR and PT, EGT_{cor} is the EGT under standard condition, PT_{cor} is the bleed air pressure under standard condition, and PT_{Min} can be replaced by $PT_{BaseLine}$.

15. A method according to claim 14, further comprising:

determining the performance of the APU is well when the PDI is less than a first predetermined value;

determining the performance of the APU is normal when the PDI is greater than the first predetermined value but less than a second predetermined value;

determining the performance of the APU is in a decline period when the PDI is greater than the second predetermined value; and

determining the performance of the APU is in a failure period when the PDI is greater than a third predetermined value.

16. A method according to claim 15, wherein, the first predetermined value is 0.7, the second predetermined value is 0.8 and the third predetermined value is 0.85.

17. A method according to claim 14, wherein, the PT_{cor} is calculated according to a following formula:

$$PT_{cor} = \frac{PT}{\delta} + \Delta PT$$

wherein, ΔPT is a function related to a temperature, δ is an altitude pressure correction factor and is calculated according to a following formula:

$$\delta = e^{\frac{\frac{ALT \times 0.3048}{1000}}{\frac{R(TAT+273.15)}{mg}}}$$

wherein, ALT is an altitude or standard altitude, TAT is an ambient temperature or total temperature, m is an air quality and is 29, $g=10m/s^2$, and R is an adjustment parameter.

18. A method according to claim 17, wherein, the EGT_{cor} is calculated according to a following formula:

$$EGT_{cor} = EGT + \Delta EGT + p1\frac{PT}{\delta} + p2(PT_{cor} - PT_{Req})$$

wherein, ΔEGT is a function related to a temperature, PT_{Req} is a lowest bleed air pressure required when an engine starts, and p1 and p2 are correction coefficients.

19. A method according to claim 1, wherein, the step of obtaining comprising:

obtaining the EGT, LCIT ,STA ,TSR and PT from an APU message.

20. A method according to claim 19, wherein, the APU message includes an A13 message of Airbus or an APU message of Boeing.

21. A method according to claim 19, further comprising:

generating the APU message including the EGT, LCIT ,STA ,TSR and PT of operation information of the APU.

22. A method according to claim 19, further comprising:

transmitting the APU message to a server utilizing ACARS or ATN.

23. A method for detecting performance of an APU, comprising:

obtaining an operation parameter of APU selected from a group consisting of exhaust gas temperature EGT, starting time STA, bleed air pressure PT and an angle of IGV of APU;

determining whether the parameter changes significantly; and

determining the performance of the APU based on whether the parameter changes significantly.

24. A method according to claim 23, wherein, the operation parameters includes the EGT, STA, PT and the angle of the IGV.

25. A method according to claim 23, further comprising:

obtaining a plurality of values of the parameter in a period;

fitting the plurality of values of the parameter to obtain a slope; and

comparing the slope with a reference slope to determine whether the slope changes significantly.

26. A method according to claim 23, further comprising:

obtaining initial value of the parameter after installation of the APU as respective reference value;

obtaining a plurality of values of the parameter in a period;

calculating a plurality of variations between the plurality of values of the parameter and the respective reference value;

fitting the plurality of variations of the parameter to obtain a slope; and

comparing the slope with a reference slope to determine whether the slope changes significantly.

27. A method according to claim 23, further comprising:

obtaining a plurality of values of the parameter in a period as a sample;

obtaining a plurality of values of the parameter in a pervious period of equal length as another sample; and

comparing the two samples as independent samples to determine whether significant change occurs.

28. A method according to claim 23, further comprising:

obtaining a plurality of values of the parameter in a period; and

performing multipoint smooth processing on the plurality of values of the parameter.

29. A method according to claim 23, further comprising:

obtaining a plurality of values of the parameter in a period; and

performing smooth processing on the plurality of values of the parameter according to the following formula:

$$X_{new} = C1X_{smooth} + C2X_{old}$$

Wherein, X_{old} is a value before the smooth processing, i.e., a measured value, X_{new} is a value after the smooth processing, X_{smooth} is a value of an adjacent value after being smooth-processed, or is an average value of several adjacent value, and C1 and C2 are weights.

30. A method according to claim 29, wherein, the C1 is 0.8 and the C2 is 0.2.

31. A method according to claim 23, further comprising:

converting respectively the obtained EGT and PT into EGT_{cor} and PT_{cor} under a standard condition.

32. A method according to claim 31, wherein, the PT_{cor} is calculated according to a following formula:

$$PT_{cor} = \frac{PT}{\delta} + \Delta PT$$

wherein, ΔPT is a function related to a temperature, δ is an altitude pressure correction factor and is calculated according to a following formula:

$$\delta = e^{\frac{\frac{ALT \times 0.3048}{1000}}{\frac{R(TAT+273.15)}{mg}}}$$

wherein, ALT is an altitude or standard altitude, TAT is an ambient temperature or total temperature, m is an air quality and equal to 29, g=10m/s^2, and R is an adjustment parameter.

33. A method according to claim 32, wherein, the EGT_{cor} is calculated according to a following formula:

$$EGT_{cor} = EGT + \Delta EGT + p1\frac{PT}{\delta} + p2(PT_{cor} - PT_{Req})$$

wherein, ΔEGT is a function related to a temperature, PT_{Req} is a lowest bleed air pressure required when an engine starts, and p1 and p2 are correction coefficients.

34. A method according to claim 23, wherein, the step of obtaining comprising:

obtaining the parameters from an APU message.

35. A method according to claim 23, wherein, it is determined that the performance of APU is in the decline period if any one of EGT, STA, PT and IGV changes significantly.

36. A method according to claim 23, wherein, it is determined that the performance of APU is in the decline period if any two of EGT, STA, PT and IGV change significantly.

37. A method for detecting performance of an APU, comprising:

obtaining an operation parameter of APU selected from a group consisting of exhaust gas temperature EGT and bleed air pressure PT of APU;

determining whether the parameter is close to its extreme value; and

determining the performance of the APU based on whether the parameter is close to its respective extreme value.

38. A method according to claim 37, wherein, the extreme value of the EGT is EGT's redline value $EGT_{Redline}$ of the APU.

39. A method according to claim 37, wherein, the extreme value of the PT is the lowest bleed air pressure PT_{Req} required when an engine starts.

40. A method according to claim 37, wherein, as to the PT, the following formula is adopted:

$$PT_{Tolerance} = PT_{cor} - PT_{Req}$$

wherein, $PT_{Tolerance}$ is a margin of the PT, i.e., a difference between the PT and the lowest bleed air pressure required when an engine starts; when $PT_{Tolerance}$ is close to 0, the performance of the APU is in a decline period;

wherein, the PT_{cor} is calculated according to the following formula:

$$PT_{cor} = \frac{PT}{\delta} + \Delta PT$$

wherein, ΔPT is a function related to a temperature, δ is an altitude pressure correction coefficient and is calculated according to a following formula:

$$\delta = e^{\frac{\frac{ALT \times 0.3048}{1000}}{\frac{R(TAT+273.15)}{mg}}}$$

wherein, ALT is an altitude or standard altitude, TAT is an ambient temperature or total temperature, m is an air quality and equal to 29, g=10m/s^2, and R is an adjust parameter.

41. A method according to claim 40, wherein, as to the EGT, the following formula is adopted:

$$EGT_{Tolerance} = EGT_{RedLine} - EGT_{cor}$$

wherein, $EGT_{Tolerance}$ is a margin of the EGT, i.e., a difference between the EGT and the $EGT_{RedLine}$; when the $EGT_{Tolerance}$ is close to 0, the performance of the APU is in a decline period;

wherein, the EGT_{cor} is calculated according to the following formula:

$$EGT_{cor} = EGT + \Delta EGT + p1\frac{PT}{\delta} + p2(PT_{cor} - PT_{Req})$$

wherein, ΔEGT is a function related to a temperature, PT_{Req} is the lowest bleed air required when an engine starts, p1 and p2 are correction coefficient.

42. A method according to claim 40, wherein, the step of obtaining comprising:

obtaining the parameters from an APU message.

CLAIMS

1. A method for detecting performance of an APU (100), comprising:

obtaining exhaust gas temperature EGT, compressor inlet temperature LCIT, starting time STA, service time TSR and bleed pressure PT;

comparing respectively STA, TSR, PT and a difference between EGT and LCIT (i.e., EGT-LCIT) with their respective threshold values;

assigning respectively weights to comparison results between STA, TSR, PT and EGT-LCIT and their respective threshold values; and

determining the performance of the APU (100) based on the weighted comparison results between STA, TSR, PT and EGT-LCIT and their respective threshold values, wherein the step of determining comprises determining the performance of the APU (100) based on the following formula:

$$PDI = R1\frac{EGT_{cor}}{EGT_{RedLine}} + R2\frac{STA}{STA_{WarningLine}} + R3\frac{TSR}{TSR_{n}} + R4\frac{PT_{Min}}{PT_{cor}},$$

wherein PDI is a performance detection index reflecting the performance of the APU (100), R1, R2, R3 and R4 are respective weights of the EGT-LCIT, STA, TSR and PT, EGT_{cor} is the EGT under standard condition, PT_{cor} is the bleed air pressure under standard condition, and PT_{Min} can be replaced by $PT_{BaseLine}$.

2. A method according to claim 1, wherein the threshold value of EGT-LCIT is an EGT redline value $EGT_{Redline}$ of the APU (100).

3. A method according to claim 1, wherein the threshold value of STA is a performance decline value $STA_{WarningLine}$ of STA.

4. A method according to claim 1, wherein the threshold value of TSR is a corresponding time TSR_n where the reliability of time-on-wing of the APU (100) is 70%.

5. A method according to claim 1, wherein TSR_{ri} is calculated based on actual data through Poisson distribution.

6. A method according to claim 1, wherein the threshold value of the PT is a minimum bleed air pressure PT_{Min} of the APU (100) or is a lowest inherent bleed air amount $PT_{BaseLine}$ of the APU (100) during normal operation.

7. A method according to claim 1, wherein the step of comparing comprises:

calculating ratios between EGT-LCIT, STA, TSR, PT and their respective threshold values.

8. A method according to claim 1, wherein the weight of the TSR is greatest and the weight of the PT is lowest.

9. A method according to claim 1, further comprising:

determining the performance of the APU (100) is well when the PDI is less than a first predetermined value;

determining the performance of the APU (100) is normal when the PDI is greater than the first predetermined value but less than a second predetermined value;

determining the performance of the APU (100) is in a decline period when the PDI is greater than the second predetermined value; and

determining the performance of the APU (100) is in a failure period when the PDI is greater than a third predetermined value.

10. A method according to claim 9, wherein the first predetermined value is 0.7, the second predetermined value is 0.8 and the third predetermined value is 0.85.

11. A method according to claim 1, wherein the PT_{cor} is calculated according to the following formula:

$$PT_{cor} = \frac{PT}{\delta} + \Delta PT,$$

wherein ΔPT is a function related to a temperature, δ is an altitude pressure correction factor and is calculated according to the following formula:

$$\delta = e^{\frac{\frac{ALT \times 0.3048}{1000}}{\frac{R(TAT+273.15)}{mg}}},$$

wherein ALT is an altitude or standard altitude, TAT is an ambient temperature or total temperature, m is an air quality and is 29, g=10m/s^2, and R is an adjustment parameter.

12. A method according to claim 11, wherein the EGT_{cor} is calculated according to the following formula:

$$EGT_{cor} = EGT + \Delta EGT + p1\frac{PT}{\delta} + p2(PT_{cor} - PT_{Req}),$$

wherein ΔEGT is a function related to a temperature, PT_{Req} is a lowest bleed air pressure required when an engine starts, and p1 and p2 are correction coefficients.

13. A method according to claim 1, wherein the step of obtaining comprises:

obtaining the EGT, LCIT, STA, TSR and PT from an APU message.

14. A method according to claim 13, wherein the APU message includes an A13 message of Airbus or an APU message of Boeing.

15. A method according to claim 13, further comprising:

generating the APU message including the EGT, LCIT, STA, TSR and PT of operation information of the APU (100).

16. A method according to claim 13, further comprising:

transmitting the APU message to a server utilizing ACARS or ATN.