brake health are disclosed below, one or more of those embodiments may be characterized by one or more of the following aspects.

In accordance with an aspect, there is provided a method for monitoring health of a brake on a landing gear of an aircraft. The method comprises: (a) generating brake force command data representing brake force commands; (b) applying brake forces to the brake in response to the brake force commands; (c) generating groundspeed data representing measurements of groundspeed of the aircraft during application of brake forces; (d) generating first brake temperature data representing a first brake temperature of the brake at a time before application of brake forces; (e) generating second brake temperature data representing a second brake temperature of the brake at a time after application of brake forces; (f) collecting the brake force command data, groundspeed data, and first and second brake temperature data onboard the aircraft; (g) transmitting the collected data to a ground-based brake health assessment computer system; (h) calculating a brake input energy value by integrating a product of measured groundspeed of the aircraft and commanded brake force during the application of brake forces during a time interval; (i) calculating a brake output energy value by subtracting the first brake temperature from the second brake temperature; (j) calculating a ratio of brake input energy to brake output energy by dividing the brake output energy value by the brake input energy value; (k) determining whether the ratio of brake input energy to brake output energy is within a range of predetermined values or not, wherein steps (a) through (g) are performed onboard the aircraft; and wherein steps (h) through (k) are performed by the ground-based brake health assessment computer system.

In accordance with another aspect, there is provided a method for monitoring health of a brake on a landing gear of an aircraft. The method comprises: (a) applying brake forces to the brake; (b) measuring the brake forces during application of brake forces using a brake force sensor, thereby generating brake force measurement data; (c) generating groundspeed data representing measurements of groundspeed of the aircraft during application of brake forces; (d) generating first brake temperature data representing a first brake temperature of the brake at a time before application of brake forces; (e) generating second brake temperature data representing a second brake temperature of the brake at a time after application of brake forces; (f) collecting the brake force measurement data, the groundspeed data, and the first and second

brake temperature data onboard the aircraft; (g) transmitting the collected data to a ground based brake health assessment computer system; (h) calculating a brake input energy value by integrating a product of the measurements of groundspeed of the aircraft and the brake force measurement data during application of brake forces during a time interval; (i) calculating a brake output energy value by subtracting the first brake temperature from the second brake temperature; (j) calculating a ratio of brake input energy to brake output energy by dividing the brake output energy value by the brake input energy value; (k) determining whether the ratio of brake input energy to brake output energy is within a range of predetermined values or not, wherein steps (a) through (g) are performed onboard the aircraft; and wherein steps (h) through (k) are performed by the ground based brake health assessment computer system.

One embodiment of the subject matter disclosed in detail below is a method for monitoring health of a brake on a vehicle, comprising: (a) generating brake force command data representing brake force commands; (b) applying brake forces to the brake in response to the brake force commands; (c) generating groundspeed data representing measurements of groundspeed of the vehicle during application of brake forces; (d) generating brake data representing measurements of a condition of the brake during application of brake forces; (e) collecting the brake force command data, groundspeed data and brake data onboard the vehicle to form collected data; (f) transmitting the collected data to a computer system that is configured to perform steps (g), (h) and (i); (g) calculating a current value of a brake health indicator that is a ratio of a brake input energy to a brake output energy based on the collected data; (h) determining whether the current value of the brake health indicator is outside a range of expected values or not; and (i) generating a flag in response to a determination in step (h) that the current value of the brake health indicator is outside the range of expected values. The expected values may be are derived from historical brake condition data acquired under similar landing conditions for the same brake or similar brakes. The foregoing method may further comprise the following steps: (j) performing an inspection of the brake following generation of the flag; (k) determining whether the brake should be repaired or replaced or not based on results of the inspection; and (l) repairing or replacing the brake following a determination that the brake should be repaired or replaced.

In accordance with some embodiments, the method further comprises

calculating a brake input energy and measuring a brake output energy, wherein calculating the current value of the brake health indicator comprises calculating a ratio of the calculated brake input energy and the measured brake output energy. In turn, calculating the brake input energy comprises calculating a sum over time of a product of a measured groundspeed of the vehicle and a commanded brake force during application of brake forces. In cases where the brake condition is brake temperature, measuring the brake output energy comprises measuring a first brake temperature at a time before application of brake forces and measuring a second brake temperature at a time after application of brake forces. This method may further comprise removing the

effect of other factors that also affect temperature. In cases where the brake condition is brake force, measuring the brake output energy comprises summing a product of a groundspeed of the vehicle and a brake force over time during application of brake forces.

Another embodiment of the subject matter disclosed in detail below is a method for monitoring health of brakes on a vehicle, comprising: (a) generating brake force command data representing brake force commands; (b) applying brake forces to first and second brakes in response to the brake force commands; (c) generating first thermal energy data representing an amount of thermal energy produced by the first brake during application of brake forces; (d) generating second thermal energy data representing an amount of thermal energy produced by the second brake during application of brake forces; (e) collecting the first and second thermal energy data onboard the vehicle to form collected temperature data; (f) transmitting the collected first and second thermal energy data to a computer system that is configured to perform steps (g), (h) and (i); (g) calculating a current value of a brake health indicator that is a ratio of the amounts of thermal energy respectively produced by the first and second brakes during application of brake forces; (h) determining whether the current value of the brake health indicator is outside a range of expected values or not; and (i) generating a flag in response to a determination in step (h) that the current value of the brake health indicator is outside the range of expected values.

In accordance with some embodiments, the first thermal energy data comprises first brake temperature data representing a temperature change in the first brake during application of brake forces, the second thermal energy data comprises second brake temperature data representing a temperature change in the second brake during application of brake forces, and calculating the current value of the brake health indicator comprises calculating a ratio of the temperature change in the first brake and the temperature change in the second brake. This method may further comprise removing the effect of other factors that also affect temperature. The expected values may be derived from historical brake condition data acquired under similar landing conditions for the same brake or similar brakes.

A further embodiment of the subject matter disclosed in detail below is a system for monitoring health of a brake on a vehicle, comprising a computer system configured to perform the following operations: receiving brake force command data, vehicle

groundspeed data and brake condition measurement data; calculating a current value of a brake health indicator that is a ratio of a calculated brake input energy and a measured brake output energy based on the received data; determining whether the current value of the brake health indicator is outside a range of expected values or not; and generating a flag in response to a determination that the current value of the brake health indicator is outside the range of expected values. In accordance with some embodiments, the computer system is further configured to calculate the brake input energy by calculating a sum over time of a product of measured groundspeed of the vehicle and commanded brake force during application of brake forces. In one proposed example implementation, the brake condition measurement data comprises a first brake temperature measured at a time before application of brake forces and a second brake temperature measured at a time after application of brake forces. In another proposed example implementation, the brake condition measurement data comprises brake force measured during application of brake forces, and measuring the brake output energy comprises summing a product of measured groundspeed of the vehicle and measured brake force over time during application of brake forces.

Yet another embodiment is a system for monitoring health of brakes on a vehicle, comprising a computer system configured to perform the following operations: receiving first thermal energy data representing an amount of thermal energy produced by a first brake during application of brake forces; receiving second thermal energy data representing an amount of thermal energy produced by a second brake during application of brake forces; calculating a current value of a brake health indicator that is a ratio of the amounts of thermal energy respectively produced by the first and second brakes during application of brake forces; determining whether the current value of the brake health indicator is outside a range of expected values or not; and generating a flag in response to a determination that the current value of the brake health indicator is outside the range of expected values. In one proposed example implementation, the first thermal energy data comprises first brake temperature data representing a temperature change in the first brake during application of brake forces, the second thermal energy data comprises second brake temperature data representing a temperature change in the second brake during application of brake forces, and calculating the current value of the brake health indicator comprises calculating a ratio of the temperature change in the first brake and the temperature change in the second

CLAIMS

1. A method for monitoring health of a brake on a landing gear of an aircraft, comprising:

(a) generating brake force command data representing brake force commands;

(b) applying brake forces to the brake in response to the brake force commands;

(c) generating groundspeed data representing measurements of groundspeed of the aircraft during application of brake forces;

(d) generating first brake temperature data representing a first brake temperature of the brake at a time before application of brake forces;

(e) generating second brake temperature data representing a second brake temperature of the brake at a time after application of brake forces;

(f) collecting the brake force command data, groundspeed data, and first and second brake temperature data onboard the aircraft;

(g) transmitting the collected data to a ground-based brake health assessment computer system;

(h) calculating a brake input energy value by integrating a product of measured groundspeed of the aircraft and commanded brake force during the application of brake forces during a time interval;

(i) calculating a brake output energy value by subtracting the first brake temperature from the second brake temperature;

(j) calculating a ratio of brake input energy to brake output energy by dividing the brake output energy value by the brake input energy value;

(k) determining whether the ratio of brake input energy to brake output energy is within a range of predetermined values or not,

wherein steps (a) through (g) are performed onboard the aircraft; and

wherein steps (h) through (k) are performed by the ground-based brake health assessment computer system.

2. The method as recited in claim 1, further comprising generating a flag in response to a determination in step (k) that the ratio of brake input energy to brake

output energy is outside the range of the predetermined values.

3. The method as recited in claim 2, further comprising performing an inspection of the brake following generating the flag.

4. The method as recited in claim 3, further comprising repairing the brake.

5. The method as recited in claim 3, further comprising replacing the brake.

6. The method as recited in claim 1, further comprising comparing the second brake temperature data for the brake with selected brake temperature data collected from the brake during other landings under similar conditions.

7. The method as recited in claim 1, wherein the predetermined values are historical values of the ratio of brake input energy to brake output energy.

8. A method for monitoring health of a brake on a landing gear of an aircraft, comprising:

(a) applying brake forces to the brake;

(b) measuring the brake forces during application of brake forces using a brake force sensor, thereby generating brake force measurement data;

(c) generating groundspeed data representing measurements of groundspeed of the aircraft during application of brake forces;

(d) generating first brake temperature data representing a first brake temperature of the brake at a time before application of brake forces;

(e) generating second brake temperature data representing a second brake temperature of the brake at a time after application of brake forces;

(f) collecting the brake force measurement data, the groundspeed data, and the first and second brake temperature data onboard the aircraft;

(g) transmitting the collected data to a ground based brake health assessment computer system;

(h) calculating a brake input energy value by integrating a product of the measurements of groundspeed of the aircraft and the brake force measurement data during application of brake forces during a time interval;

(i) calculating a brake output energy value by subtracting the first brake temperature from the second brake temperature;

(j) calculating a ratio of brake input energy to brake output energy by dividing the brake output energy value by the brake input energy value;

(k) determining whether the ratio of brake input energy to brake output energy is within a range of predetermined values or not,

wherein steps (a) through (g) are performed onboard the aircraft; and

wherein steps (h) through (k) are performed by the ground based brake health assessment computer system.

9. The method as recited in claim 8, further comprising generating a flag in response to a determination in step (k) that the ratio of brake input energy to brake output energy is outside the range of the predetermined values.

10. The method as recited in claim 9, further comprising performing an inspection of the brake following generating the flag.

11. The method as recited in claim 10, further comprising repairing the brake.

12. The method as recited in claim 10, further comprising replacing the brake.

13. The method as recited in claim 8, further comprising comparing the second brake temperature data for the brake with selected brake temperature data collected from the brake during other landings under similar conditions.

14. The method as recited in claim 8, wherein the predetermined values are historical values of the ratio of brake input energy to the brake output energy.