CLAIMS

1. A method of detecting a rotor bar fault of an electrical machine, said method comprising,

acquiring a set of online signals from the electrical machine over a period, said set of online signals comprising at least one vibration signal, and a summed signal of magnetic flux signals, each magnetic flux signal obtained from a respective flux sensor positioned on an external surface of the electrical machine,

wherein the summed signal of magnetic flux signals is obtained by acquiring and summing a set of *p* flux signals to obtain a total flux signal, wherein the set of *p* flux signals is acquired from *p* flux sensors positioned along a circumference of a cylindrical frame of the electrical machine, such that any two adjacent flux sensors along the circumference of the cylindrical frame have an angular separation of 360/*p* degrees with respect to the longitudinal axis of the cylindrical frame, wherein *p* represents the total number of poles of the electrical machine;

extracting an online anomaly indicator value from the set of online signals;

comparing the online anomaly indicator value with a baseline anomaly indicator value of a corresponding loading condition; and

determining presence of a broken or cracked rotor when the online anomaly indicator value deviates from the baseline anomaly indicator value by a threshold.

2. The method of claim 1, wherein the electrical machine is a motor or generator comprising,

a stator having a cylindrical frame, the cylindrical frame comprising a plurality of electrically conductive windings arranged therein;

a rotor having a cylindrical body concentrically mounted and rotatable within the cylindrical frame of the stator, said rotor having a drive end and a non-drive end; and

an elongated shaft member coaxially mounted to the rotor, said shaft member protruding from the rotor at the drive end.

3. The method of claim 2, wherein acquiring the set of online signals from the electrical machine comprises,

acquiring and summing a set of *p* flux signals to obtain a total flux signal, wherein the set of *p* flux signals is acquired from *p* flux sensors positioned proximate the stator along the circumference of its cylindrical frame, such that any two adjacent flux sensors along the circumference of the cylindrical frame have an angular separation of 360/*p* degrees with respect to the longitudinal axis of the cylindrical frame, wherein *p* represents the total number of poles of the motor or generator;

acquiring one or more vibration signals from an accelerometer; and optionally

acquiring either a phase current or a line current of the electrical machine.

4. The method of claim 3, further comprising,

computing a set of online load values from the set of online signals, said set of online load values is one or more selected from the group consisting of shaft speed value, slip value and RMS value of a phase current or line current of the electrical machine.

5. The method of claim 3 or 4, wherein extracting the online anomaly indicator value from the set of online signals comprises computing an RMS value of magnitudes of one or more frequency components of the total flux signal, said frequency components associated with the rotor bar fault;

optionally wherein computing the RMS value comprises

performing a Fourier transform on the total flux signal; and

extracting magnitudes of frequency components from the frequency spectrum of the total flux signal.

6. The method of any one of claims 2 to 5, further comprising performing an initial calibration of the electrical machine when the electrical machine is in a healthy condition, prior to the acquiring of the set of online signals, the initial calibration comprising,

acquiring and storing a set of baseline load values under a range of loading conditions from no-load condition to full-load condition,

wherein the set of baseline load values is one or more selected from the group consisting of shaft speed value, slip value, and RMS value of a phase current or line current of the electrical machine;

optionally wherein the initial calibration further comprises extracting a set of baseline anomaly indicator values corresponding to a set of loading conditions ranging from no-load condition to full-load condition, when the electrical machine is in the healthy condition;

wherein extracting a baseline anomaly indicator value for a corresponding loading condition comprises,

acquiring and summing a set of p flux signals to obtain a total flux signal for the corresponding loading condition;

performing a Fourier transform on the total flux signal to obtain a magnitude of the total flux signal; and

extracting a magnitude of frequency components from a frequency spectrum of the total flux signal.

7. The method of claim 6, further comprising identifying the corresponding loading condition, prior to comparing the online anomaly indicator value with the baseline anomaly indicator value of the corresponding loading condition,

wherein the step of identifying the corresponding loading condition comprises,

comparing the set of online load values from the electrical machine with the set of baseline load values to identify the corresponding loading condition; and

selecting the baseline anomaly indicator value for the identified corresponding loading condition.

8. The method of any one of claims 2 to 7, further comprising providing input of parameter values of the electrical machine, said parameter values comprising number of poles, full-load current and full-load slip of the electrical machine.

9. A non-transitory computer readable storage medium having stored thereon instructions for instructing a processing unit of a system to execute a method of detecting a broken or cracked rotor bar during online operation of an electrical machine, said method comprising,

acquiring a set of online signals from the electrical machine over a period, said set of online signals comprising at least one vibration signal, a summed signal of magnetic flux signals, each magnetic flux signal obtained from a respective flux sensor positioned on an external surface of the electrical machine,

wherein the summed signal of magnetic flux signals is obtained by acquiring and summing a set of *p* flux signals to obtain a total flux signal, wherein the set of *p* flux signals is acquired from *p* flux sensors positioned along a circumference of a cylindrical frame of the electrical machine, such that any two adjacent flux sensors along the circumference of the cylindrical frame have an angular separation of 360/*p* degrees with respect to the longitudinal axis of the cylindrical frame, wherein *p* represents the total number of poles of the electrical machine;

extracting an online anomaly indicator value from the set of online signals;

comparing the online anomaly indicator value with a baseline anomaly indicator value of a corresponding loading condition; and

determining presence of a broken or cracked rotor when the online anomaly indicator value deviates from the baseline anomaly indicator value by a threshold.

10. A method of estimating an additional operating expenditure due to one or more mechanical anomalies in an electrical machine, the method comprising,

acquiring a set of online signals from the electrical machine over a period, said set of signals comprising at least one vibration signal, at least one magnetic flux signal and at least one current signal;

extracting an online anomaly indicator value from the set of online signals;

comparing the online anomaly indicator value with a baseline anomaly indicator value of a corresponding loading condition;

determining presence of mechanical anomaly when the online anomaly indicator value deviates from the baseline anomaly indicator value by a threshold; and

computing the additional operating expenditure over a time frame, said time frame starting from an instance when the mechanical anomaly is determined until an instance when an overall vibration velocity of the electrical machine is projected to reach a defined unacceptable range.

11. The method of claim 10, wherein the electrical machine is a motor or generator comprising,

a stator having a cylindrical frame, the cylindrical frame comprising a plurality of electrically conductive windings arranged therein;

a rotor having a cylindrical body concentrically mounted and rotatable within the cylindrical frame of the stator, said rotor having a drive end and a non-drive end; and

an elongated shaft member coaxially mounted to the rotor, said shaft member protruding from the rotor at the drive end.

12. The method of claim 11, wherein acquiring the set of online signals from the electrical machine comprises,

acquiring at least one vibration signal from an accelerometer;

acquiring and summing a set of *p* flux signals to obtain a total flux signal, wherein the set of *p* flux signals is acquired from *p* flux sensors positioned proximate the stator along the circumference of its cylindrical frame, such that any two adjacent flux sensors along the circumference of the cylindrical frame have an angular separation of 360/*p* degrees with respect to the longitudinal axis of the cylindrical frame, wherein *p* represents the total number of poles of the motor or generator; and

acquiring either a phase current or a line current of the electrical machine.

13. The method of claim 12, further comprising,

computing a set of online load values from the set of online signals, said set of online load values is one or more selected from the group consisting of shaft speed value, slip value and RMS value of a phase current or line current of the electrical machine.

14. The method of claim 12 or 13, wherein extracting the online anomaly indicator value from the set of signals comprises,

computing an RMS value of magnitudes of one or more frequency components of the total flux signal, or an RMS value of magnitudes of one or more frequency components of the phase or line current, said frequency components associated with the mechanical anomaly;

optionally wherein computing the RMS value comprises

performing a Fourier transform on the total flux signal or the phase or line current; and

extracting magnitudes of frequency components from the frequency spectrum of the total flux signal or the phase or line current.

15. The method of any one of claims 11 to 14, further comprising performing an initial calibration of the electrical machine when the electrical machine is in a healthy condition, prior to the acquiring of the set of online signals, the initial calibration comprising,

acquiring and storing a set of baseline load values under a range of loading conditions from no-load condition to full-load condition,

wherein the set of baseline load values is one or more selected from the group consisting of shaft speed value, slip value, and RMS value of a phase current or line current of the electrical machine;

optionally wherein the initial calibration further comprises extracting a set of baseline anomaly indicator values corresponding to a set of loading conditions ranging from no-load condition to full-load condition, when the electrical machine is in the healthy condition.

16. The method of claim 15, further comprising identifying the corresponding loading condition, prior to comparing the online anomaly indicator value with the baseline anomaly indicator value of the corresponding loading condition,

wherein the step of identifying the corresponding loading condition comprises,

comparing the set of online load values from the electrical machine with the set of baseline load values to identify the corresponding loading condition; and

selecting the baseline anomaly indicator value for the corresponding loading condition.

17. The method of any one of claims 10 to 16, wherein computing the additional operating expenditure over the time frame comprises,

computing power loss, additional current due to the one or more mechanical anomalies, and overall vibration velocity at regular time intervals; and

storing the computed power loss, additional current due to the one or more mechanical anomalies, and overall vibration velocity in a database;

optionally wherein computing the additional operating expenditure over the time frame further comprises,

computing a trend of the overall vibration velocity based on the computed overall vibration velocity stored in the database;

determining from the trend of the overall vibration velocity, the instance when an overall vibration velocity of the electrical machine is at the defined unacceptable range; and

computing the additional operating expenditure over the time frame.

18. The method of any one of claims 11 to 17, further comprising inputting parameter values of the electrical machine, said parameter values comprising number of poles, full-load current, full-load slip, electricity tariff, stator resistance, rotor resistance, and RMS value of actual current due to mechanical anomaly signatures in the phase or line current.

19. The method of any one of claims 10 to 18, further comprising

prior to the extracting of online anomaly indicator value from the set of online signals,

obtaining an overall vibration velocity of the electrical machine from the at least one vibration signal;

comparing the overall vibration velocity with a recommended value or range of values for the vibration velocity of the electrical machine; and

triggering a signal for maintenance when the overall vibration velocity deviates from the recommended value or range of values.

20. A non-transitory computer readable storage medium having stored thereon instructions for instructing a processing unit of a system to execute a method of estimating an additional operating expenditure due to one or more mechanical anomalies in an electrical machine, said method comprising,

acquiring a set of online signals from the electrical machine over a period, said set of signals comprising at least one vibration signal, at least one magnetic flux signal and at least one current signal;

extracting an online anomaly indicator value from the set of online signals;

comparing the online anomaly indicator value with a baseline anomaly indicator value of a corresponding loading condition;

determining presence of mechanical anomaly when the online anomaly indicator value deviates from the baseline anomaly indicator value by a threshold; and

computing the additional operating expenditure over a time frame, said time frame starting from an instance when the mechanical anomaly is detected until an instance when an overall vibration velocity of the electrical machine reaches a defined unacceptable range.