CLAIMS

1. A method of fault detection in synchronous machines; the method comprising:

using at least one sensor to determine parameters linked to the magnetic field generated within the synchronous machine including parameters based on one or more of magnetic field strength, rotor current or voltage, stator current or voltage, and vibration;

processing the sensor measurements to identify data artefacts linked to the magnetic field, wherein the processing includes one or more signal processing techniques based on time, frequency, and both time and frequency; and

analysing the output of the signal processing in order to identify and categorise irregularities in the magnetic field that are indicative of a fault in the synchronous machine, wherein the analysing includes recognising patterns in the processed sensor measurements, via use of computer aided pattern recognition techniques;

wherein the method is carried out during a time period in which there is a transient magnetic field of the type that arises during start-up or shut-down of the machine; and

wherein the using at least one sensor comprises using one or more existing sensors comprising one or more voltage or current sensors configured for use during operation of the synchronous machine for monitoring and/or control of the machine.

2. A method as claimed in claim 1, wherein the method is for detecting faults linked with one or more of eccentricity faults, damper winding faults, and short circuit faults.

3. A method as claimed in claim 1 or 2, wherein the method is for fault detection in hydropower generators.

4. A method as claimed in any preceding claim, wherein the at least one sensor includes at least one non-invasive sensor.

5. A method as claimed in any preceding claim, wherein at least one non-invasive sensor provided as a part of a fault detection system, where this sensor is temporarily placed with the machine for performing the fault detection method.

6. A method as claimed in any preceding claim, wherein the method does not require any physical modification to the synchronous machine to place or attach a new sensor.

7. A method as claimed in any preceding claim, wherein the sensor measurements do not include any data transferred from the moving parts of the rotor.

8. A method as claimed in any preceding claim, comprising using a sensor provided for the synchronous machine at a potential transformer thereof.

9. A method as claimed in any preceding claim, including determining a radius of gyration for the rotor of the synchronous machine and using the radius of gyration to identify and categorise irregularities in the magnetic field.

10. A method as claimed in claim 9, including obtaining the radius of gyration data obtained via time series data mining and using the radius of gyration data for detecting a damper winding fault or an eccentricity fault.

11. A method as claimed in claim 9 or 10, including mapping a phase space for induced voltage in a field winding of the synchronous machine.

12. A method as claimed in claim 11, wherein the induced voltage is determined or measured via a sensor at a potential transformer.

13. A method as claimed in any of claims 9 to 12, including seeking to identify a damper winding fault in the form of a broken damper bar, wherein the analysing step includes a comparison of the measured radius of gyration compared to equivalent measurements of radius of gyration for a healthy synchronous machine.

14. A method as claimed in any of claims 9 to 13, including seeking to identify an eccentricity fault, wherein the step of analysing the output of the signal processing includes determining a normalised radius of gyration with reference to a radius of gyration for a machine that is known to be healthy, with the normalised radius of gyration being defined as the difference between a radius of gyration for a healthy synchronous machine and the measured radius of gyration, with this difference being divided by the healthy radius of gyration.

15. A method as claimed in claim 14, comprising automated identification and categorisation of possible eccentricity faults by assessing the value of the normalised radius of gyration compared to a threshold value.

16. A method as claimed in any preceding claim, wherein the computer aided pattern recognition techniques are based on a machine learning algorithm trained with a plurality of processed sensor measurements that are known to relate to fault free machines as well as a plurality of processed sensor measurements that are known to relate to machines with a fault.

17. A fault detection system for fault detection in synchronous machines, the fault detection system comprising: a data processing apparatus for connection to at least one sensor in order to receive parameters linked to the magnetic field generated within the synchronous machine including parameters based on one or more of magnetic field strength, rotor current or voltage, stator current or voltage, and vibration;

wherein, during a time period in which there is a transient magnetic field of the type that arises during start-up or shut-down of the machine, the data processing apparatus is configured to:

process the sensor measurements to identify data artefacts linked to the magnetic field, wherein the processing includes one or more signal processing techniques based on time, frequency, and both time and frequency; and

analyse the output of the signal processing in order to identify and categorise irregularities in the magnetic field that are indicative of a fault in the synchronous machine, wherein the analysing includes recognising patterns in the processed sensor measurements, via use of computer aided pattern recognition techniques;

wherein the at least one sensor comprises one or more existing sensors comprising one or more voltage or current sensors configured for use during operation of the synchronous machine for monitoring and/or control of the machine.

18. A fault detection system as claimed in claim 17, comprising at least one non-invasive sensor.

19. A fault detection system as claimed in claim 17 or 18, wherein the fault detection system uses sensors without any data transfer from the moving parts of the rotor.

20. A large synchronous machine acting as a hydropower generator, the synchronous machine including the fault detection system of any of claims 17 to 19.

21. A computer programme product comprising instructions that, when executed within a fault detection system as in any of claims 17 to 20, will configure the data

processing apparatus thereof, during a time period in which there is a transient magnetic field of the type that arises during start-up or shut-down of the machine, to:

process the sensor measurements to identify data artefacts linked to the magnetic field, wherein the processing includes one or more signal processing techniques based on time, frequency, and both time and frequency; and

analyse the output of the signal processing in order to identify and categorise irregularities in the magnetic field that are indicative of a fault in the synchronous machine, wherein the analysing includes recognising patterns in the processed sensor measurements, via use of computer aided pattern recognition techniques.