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Condition Monitoring as Tool of Engineering Management

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Abstract

With the increasing demand for the machinery's availability, it becomes critical to have a periodic check on the health status of the machinery. The process of periodic check consists of collection, processing and decision making. Condition monitoring is the process of periodic checks of the health of machine elements. The condition monitoring consists of two main components: diagnosis and prognosis. In the present work, the discussion on condition monitoring as a tool of engineering management was carried out.

Keywords: *Management tool, condition monitoring*

Introduction

In today's time, goods are subjected to severe competition. The demand for environment-friendly, energy-efficient products emphasizes quality, reliability, health and safety during the design and manufacturing stage of the product [1]. The increased demand brings the engineer's attention to designing a product that can fulfil the above criteria along with good design life. In practical application, the product operates under varying stress or load and fluctuating operating conditions [2]. The product deteriorates over time, no matter how good the product is. Most engineers support that prevention is better than cure and use the previous knowledge and historical data of machinery failure to predict and eliminate the machinery failure [3–5]. Most of the maintenance work relies on the human senses. In the past, the survey reports indicate that catastrophic incidents happened because of poor maintenance[3]. In today's time, the complex system brings more interdependence among the system elements (bearings, gear, cam, shafts etc.). The failure of one element shuts the whole system down [4–6]. In the past, researchers carried many works on the tribological performance of the bearings [7,8,17–26,9,27–36,10,37–46,11,47–56,12,57,58,13–16] and gear condition monitoring [59–67]. The research shows that the failure combines technical and management decision elements (communications, supervision and organizational shortcoming) [3].

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The present work focuses on using the condition monitoring tool as the engineering decision-making or engineering management tool.

2. Process of diagnosis and decision making

All the interacting mechanical elements are prone to degradation over time[41,66]. The mechanical failures are classified as lubricated (pitting, wear etc.) and non-lubricated or strength-related failures [4]. The failures need to be avoided or prevented for the longer service life of the component, so the following parameters are considered before designing a component:

A) Type of motion (kinematics of the system)
B) Pseudo-static (assumed at the state of rest) and dynamics- force, displacement
C) Material, surface characteristics, and lubricant (physical and chemical)
D) Working conditions

All these parameters together combined to explain a failure mechanism. All forms of failure are time-dependent phenomena. The geometry provides information on relative contact and velocities; kinematics defines the set of motion at the contact, and contact defines the load sharing. Each component in a system is interdependent for the proper working of the component.

Analyzing these factors brings more complexities to system equations[68]. The non-linear behaviour is due to engagement, profile modification, manufacturing errors, and externally imposed conditions[69–71].

The diagnosis of a system consists of three main steps.

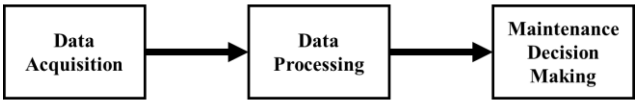

Fig. 1 Diagnosis steps [5]

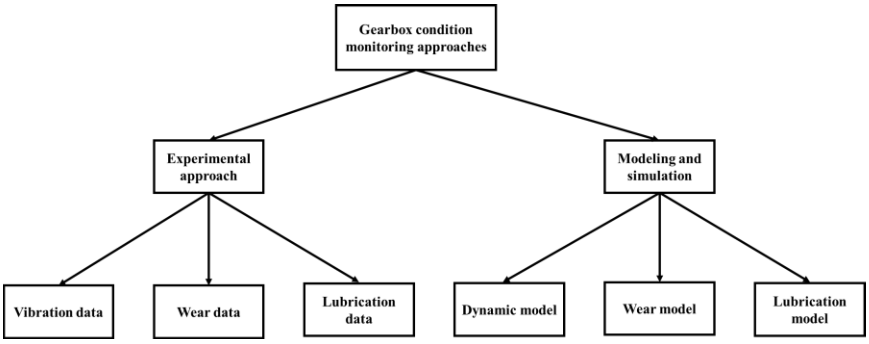

Fig. 2 Gearbox condition monitoring approaches

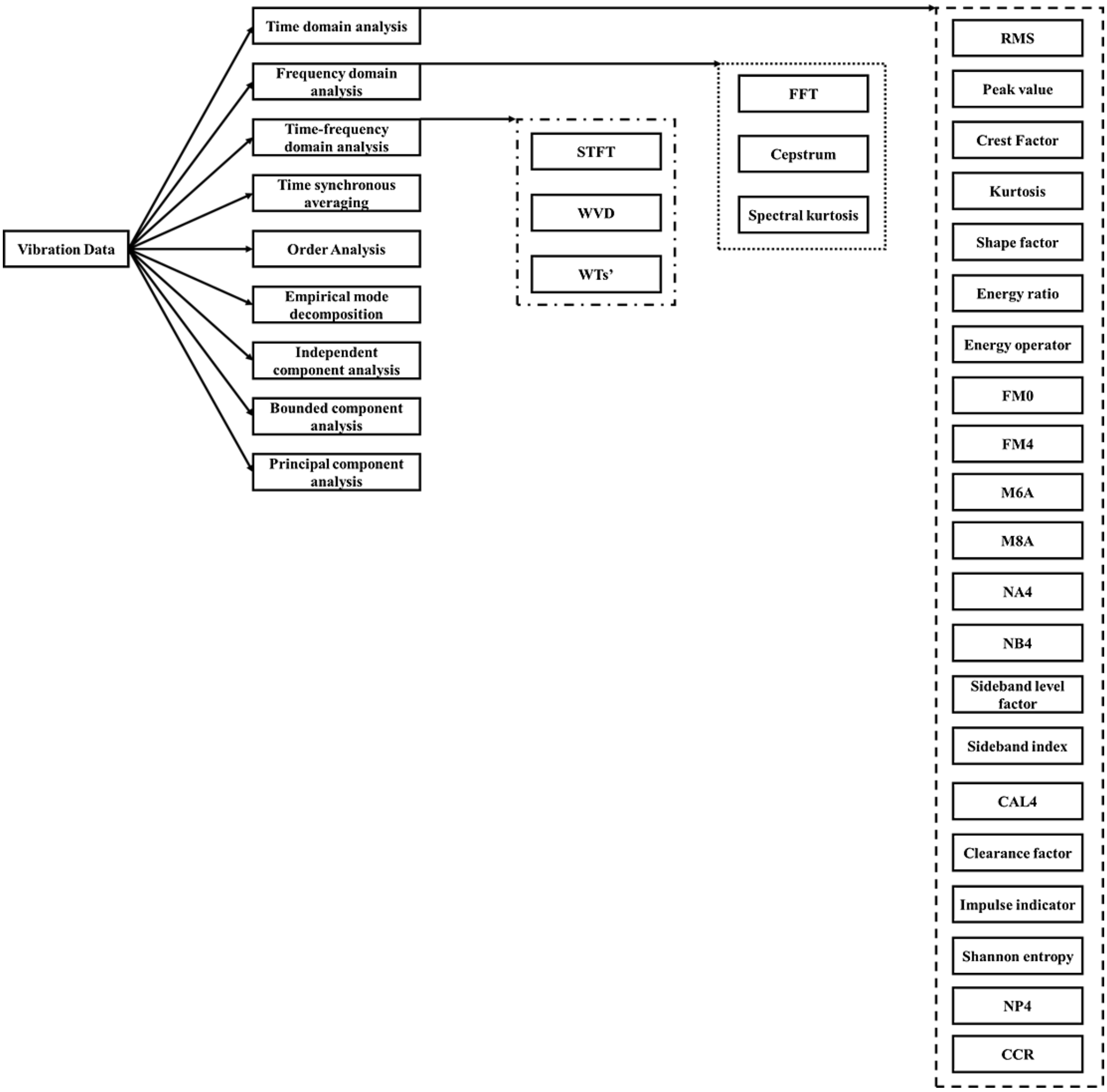

Fig 3 Gearbox faults assessment based on vibration parameters analysis

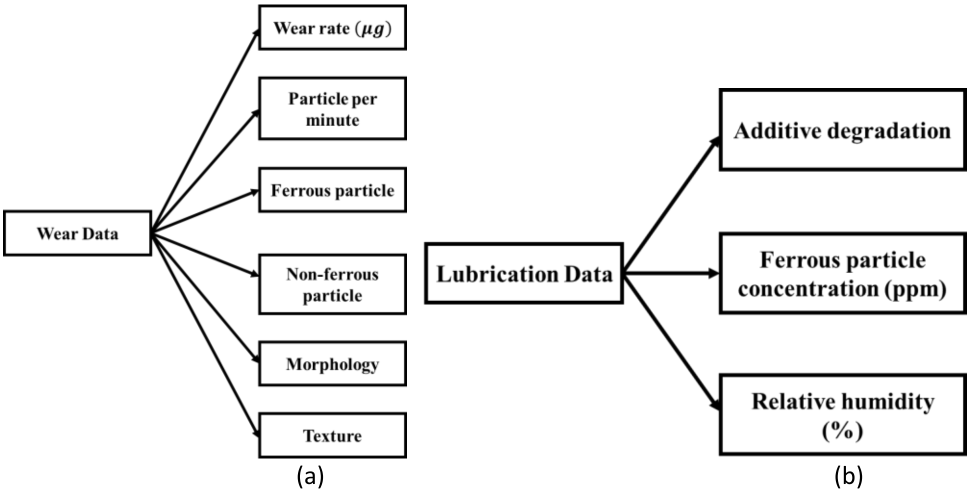

Fig. 4 Gearbox faults assessment based on tribological analysis (a) Wear data analysis, (b) Lubricant oil data analysis

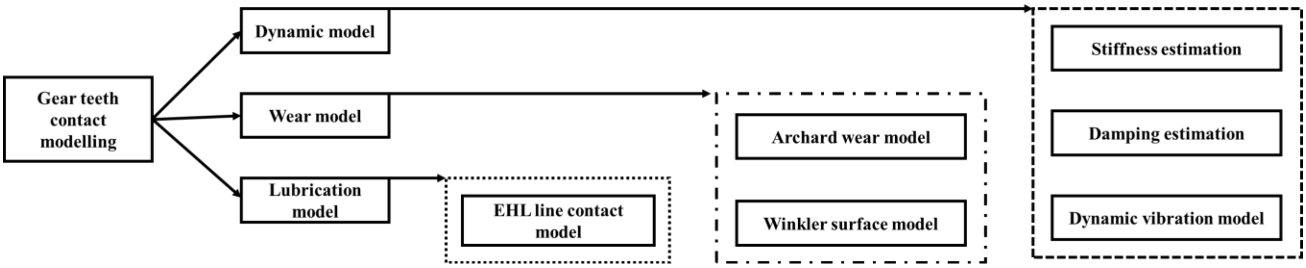

Fig. 5 Gear teeth contact modelling

The data is processed to take the preventive decision. Let's take the case study of the gearbox fault diagnosis. Diagnosing the gearbox faults is a two-way process: experimental and modelling. Further, these are divided into different data types like vibration data, wear debris data, lubrication (quality) data etc. These data can be collected from the running gearbox by connecting suitable sensing devices. The modelling is a function of all affecting parameters like forces acting, velocities and displacements, properties of the interacting surfaces etc. Figure 2 depicts the different gearbox condition monitoring approaches; Figure 3 depicts the vibration-based fault indicators and the denoising techniques. Figure 4 (a) and Figure 4 (b) depict the wear debris analysis and the lubricating oil analysis. Figure 5 depicts the gear modelling based on the vibration, wear and lubrication effects.

The failure of the gearbox has to be prevented the increasing the overall life of the gearbox.

In the same way, a systematic approach is used to identify all the possible system parameters to get complete information and failure possibilities of the system. Then these parameters and existing monitoring tools are integrated into the system's design.

3. Condition monitoring as engineering management

Every physical system or element is prone to be degraded with time. So, it is crucial to have a check on the current health status of the system. Condition monitoring is the process of keeping the check on the health state of the system and, based on that state, deciding on the maintenance actions. The maintenance techniques are either time-dependent or time-independent. Preventive maintenance and condition-based maintenance (CBM) is time-dependent techniques. The breakdown maintenance is a time-independent technique. The breakdown maintenance is also called run to failure maintenance because it can only be implemented at the system's breakdown. In preventive maintenance, the maintenance is carried out on a periodic time interval basis, irrespective of the system's health status. Breakdown maintenance and preventive maintenance are not cost-effective, as the demand for reliability, availability and quality increases the maintenance cost. The solution to the problem is CBM. The information collected during the condition monitoring is used to make maintenance decisions. The CBM has two essential aspects diagnostics and prognostics.

In diagnostic, the detection (to indicate whether something is wrong in the system), isolation (locate the element or component) and identification (the nature and type of fault)[72]. In prognostic predict useful life of the component under specific conditions based on prior system history. Prognostics is a probability-based approach. The difference between diagnostics and prognostics is one post-event analysis and another preliminary event analysis. Diagnostics came into the picture when the prognosis prediction failed [3,5].

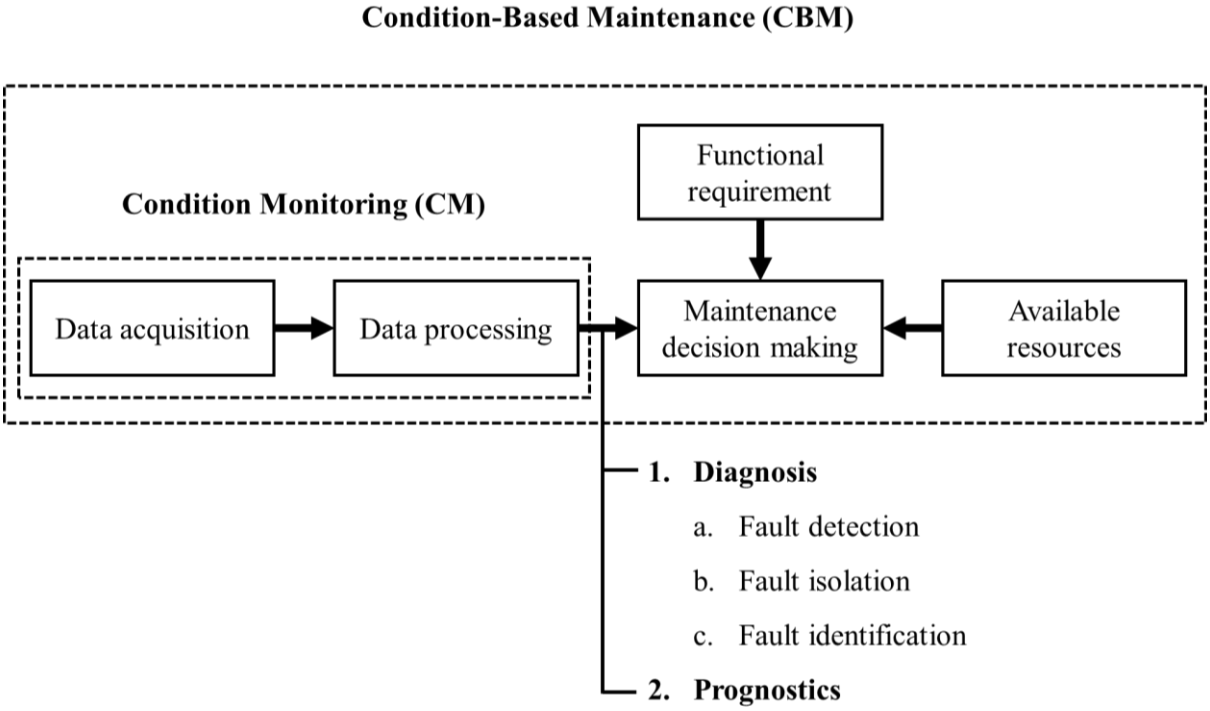

Fig. 6 Condition-based maintenance (CBM) Process [73]

Conclusions

The above discussion on the maintenance strategies shows that one should need to take a maintenance decision. To take such a decision, one needs to understand and better predict the system's behaviour in real-time. The collected information from the maintenance activities needs to be controlled, and proper execution to achieve quality, reliability and availability of the system is optimised depending upon the decision-makers managerial quality. So, condition monitoring is an engineering management tool for the system's availability.

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