Abstract

In general, Magnetic Chip Detectors (MCD) are used to collect (“catch”) ferrous debris for further analysis. The analysts should use microscopic examination of debris morphology characteristics such as shape, size, color, surface texture, thickness ratio, and edge detail as their principal analysis technique. Wear debris is also quantified and trends are plotted to support the visual examination and assist in diagnosis and corrective action. MCD ferrous wear particle analysis is a valuable diagnostic tool for condition monitoring. Samples of MCD are either submitted individually for evaluation of a special problem or over time to establish a baseline for use as a predictive maintenance tool. When trending quantitative debris analysis results over time, machinery component(s) degradation and wear rates can be monitored. Knowing these critical characteristics one can make maintenance decisions and be assured that the right steps will be taken to prevent catastrophic failures of vital machinery.

Keywords: Chip detector, Wear particle

1. Introduction

Failure of a simple and cheap part in large machinery may directly or indirectly cause considerable losses. Thus prevention of a failure of a critical part is important. The aim of Predictive Maintenance (PdM) is to identify damaged parts and to repair or change them before they fail. There are many ways in which machine parts can fail. Prediction of failure is difficult if the failure appears fast. Wear is, however, usually slow and its progress can be followed, for example, with wear particle analysis techniques namely, Spectrographic Oil Analysis (SOA), Analytical Ferrography (AF)/Direct Reading Ferrography (DR), Magnetic Drain Plug (MDP) and so on.

The aim of this paper is to discuss the Magnetic Chip Detector (MCD) ferrous wear particle analysis for prediction of machine failures. The use of ferrous wear particle analysis for monitoring the condition of an gear sets is described.

2. Wear Particle Analysis

Change in the nature of wear can be detected by analyzing wear particles in used lubricants. A fast increasing of wear particles concentration and size indicated that wear is changing from mild to severe wear mode. The severity of the wear and the wear mechanism can be determined from the size distribution and also in conjunction with their morphology as shown in Figs.1 and 2 respectively. [1-2].

As it is evidenced that MCD is at its highest efficient at the attraction of ferrous wear particle size larger than 100 µm, hence, in a light microscope it is possible to distinguish between mode of wear and/or wear mechanisms i.e. adhesive, abrasive, fatigue, tribochemical reaction etc. As wear can be mild to
severe, the change from mild to severe wear mode is associated with the surface deformation in the contact [3-5]. In severe wear the particles loosen from a heavily deformed layer. The particles are large and the wear rate can be thousand folds compared with that of mild wear region.

3. MCD Ferrous Wear Particle Analysis

MCD wear debris analysis comprises: (a) collection of wear debris from MCD (b) examination of debris and (c) assimilation of information into an assessment of component condition. Traditionally the composition of individual wear particles has been used to identify possible wearing components and the size, morphology and quantity of these particulate have been used to assess the extend of damage.

In power transmission such as engine crankcases or final drives, failure of one part will cause a chain reaction of secondary failure. If “impending failure” can be identified at an early stage, then Suitable
preventive measures can be planned in advance. This identification is the objective of the MCD through ferrous wear debris monitoring at strategic positions in the lubrication system. Typical MCD and ferrous wear particles from passenger car are shown in Figs. 3 to 4.

In this particular section, apart from ferrous debris from passenger cars, three industrial gearboxes in paper processing plant are selected. The gearbox components are elastohydrodynamically lubricated with ISO VG 220 mineral based lubricating oil. It should be noted that the oil is supplied to the gears via an oil pump from a wet sump. Prior to traversing main supply pump the oil passes a Magnetic Chip Detector (MCD). This device is used primarily for filter-out ferrous wear particle, hence off-loading strainer and on-line oil filter. However, in fact it can be used for monitoring the wear of ferrous components in the gearbox and provides an off-line indication to the maintenance staff of potential abnormal wear. The MCD used on the gearboxes consist of circular magnet mounted on a steel housing. Typical ferrous debris extracted from the MCD and gear worn surfaces from each particular gearbox are shown in Figs. 5 to 7 respectively.
Debris from gearbox No.1 was examined and found to contain small free ferrous wear particles. These debris ranged up to 30 µm in major dimension, were flat, featureless flakes and were considered representative of normal gear wear. Examples of some of these particles are shown in Fig. 5(a). In conjunction with wear debris characteristic, typical normal gear worn surface was observed as shown in Fig. 5(b).

In contrast, wear particles from gearbox No.2 contained large free ferrous wear particles that ranged up to 1000 µm in major dimension and likely originated from macro-fatigue wear mechanism within the pitch line of gear mating surfaces. It was concluded that these particles were very large and therefore was a sufficient to indicate abnormal wear. Typical wear particles are shown in Fig. 6(a). This conclusion was also confirmed by the assessment of actual gear worn surface whereby progressive pitting is evident as shown in Fig. 6(b).

Wear debris from gearbox No.3 has been assessed. In this particular case, a large number of severe adhesive wear particles are observed as illustrated in Fig. 7(a). Worn surface of gear component is also evident of severe metal transferred possibly from lubricant starvation. This can easily be depicted as shown in Fig. 7(b).

4. Concluding Remarks

The MCD wear debris analysis program has been implemented for passenger car and industrial gearboxes of paper processing plant have proven to be a useful diagnostic tool for condition monitoring. It is able to distinguish between normal wear of

Fig. 6 Typical wear debris and gear worn surface from gearbox No.2.

Fig. 7 Typical wear debris and gear worn surface from gearbox No.3.
industrial gearbox and potentially damaging abnormal wear situations and, in the case of abnormal wear, is able to identify possible wear mechanism(s).

References