Wear Particle Atlas CD-ROM

Database of Wear & Contaminant Particles in Used Lubricants

Introduction

The Wear Particle Atlas CD-ROM is a new comprehensive computer database of wear particles found in all types of oil lubricated equipment. It combines the traditional ferrogram techniques with the more recent filtergram technique and contains close to 1,000 color pictures with detailed descriptions. The combined use of both ferrogram and filtergram methods has improved the reliability of failure prediction for both ferrous and nonferrous components and thus maximizes the strengths of microscopic wear particle analysis.

The Wear Particle Atlas CD-ROM is designed to:

- *Assist the professional laboratory engineer to identify wear particles and to analyze machine wear conditions.*

- *Assist plant lubrication engineers to keep equipment in their best operational order based on the wealth of information contained in the lubricant wear debris.*

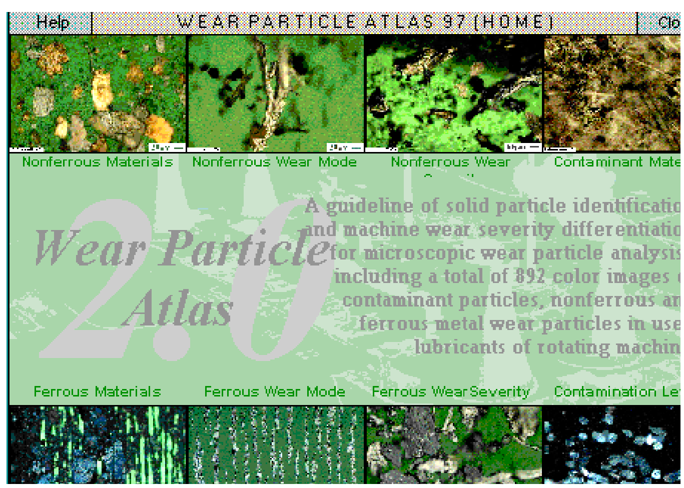
Key Features

The Wear Particle Atlas CD-ROM main features include:

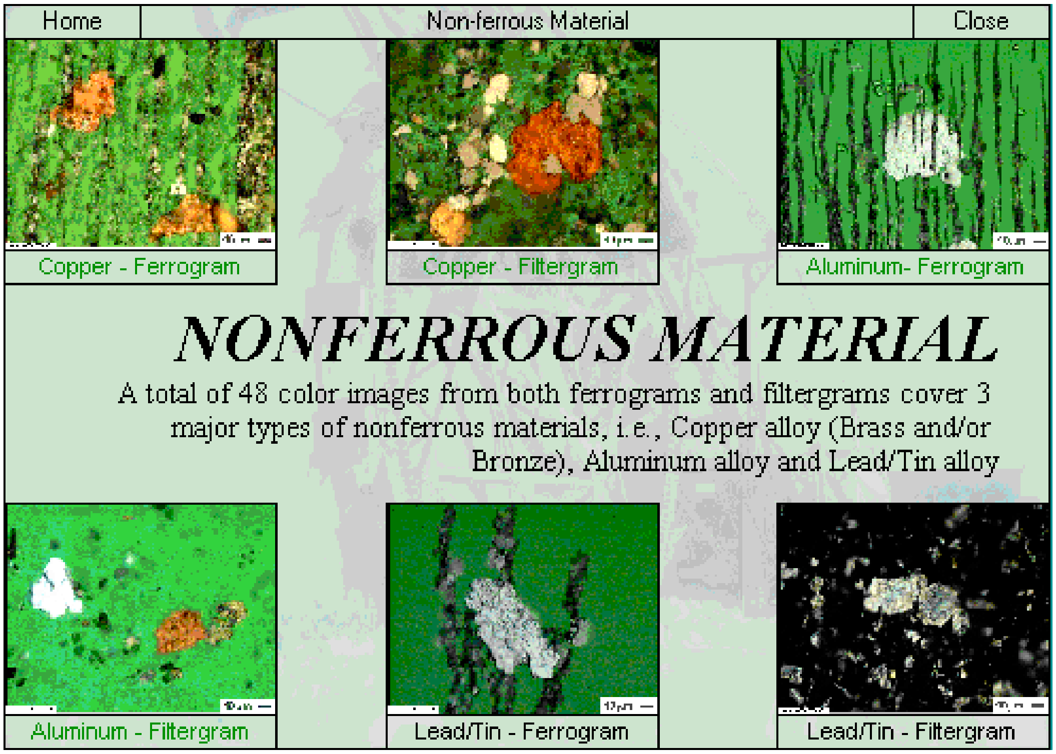
1. A Picture Guide for Wear and Contaminant Particle Image Description
2. The Stages of Machine Deterioration based on Wear Severity Levels
3. Oil Cleanliness Determinations
4. Integration of Ferrogram and Filtergram Methods

1. Picture Guide

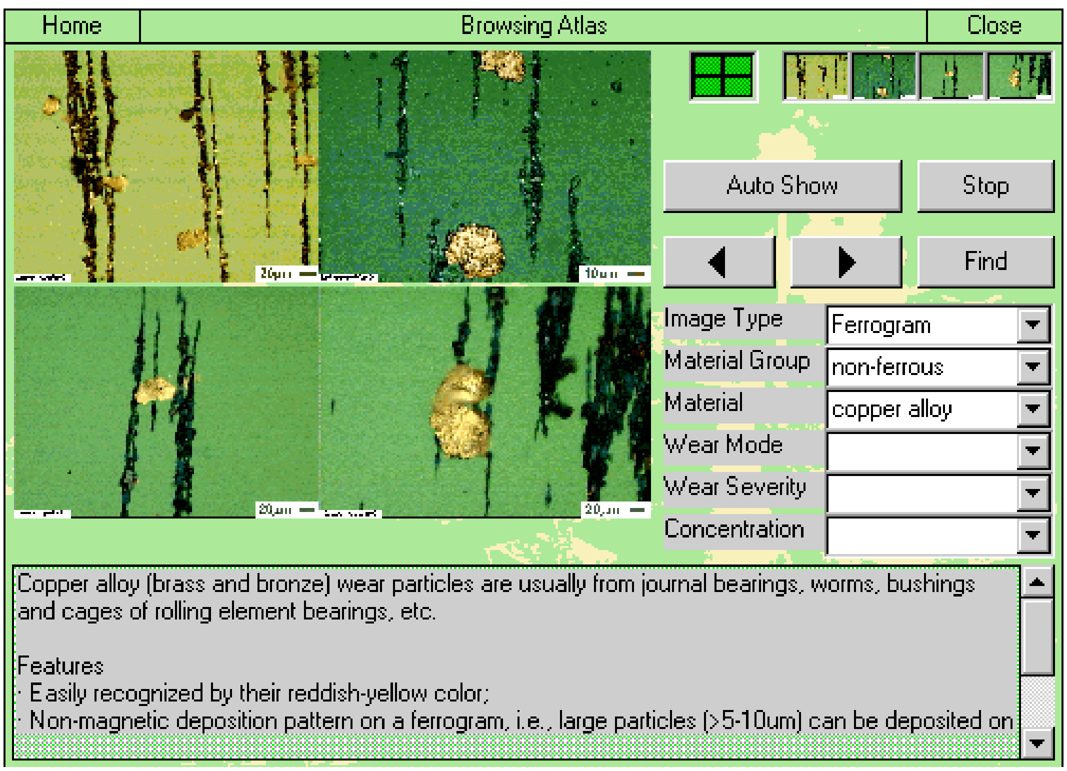
The Picture Guide page helps to locate the relevant or matching Atlas page by allowing the user to compare the main characteristics of the sample micrograph with those of the Atlas pictures. A total of 14 Image Guide pages are available to aid in the particle type identification process.



When Atlas is first started, the Home Page as shown on the right appears. On this page there are 8 wear particle images which are representative of 8 sub-categories, respectively. By clicking each image, the corresponding sub-category page will appear. The sub-category contains representative particle images depicting additional sub-categories that can be clicked until the Browsing Atlas page is displayed and the correct particles are found. The following example illustrates this process. On the Picture Guide Home Page, select "Nonferrous Material". The Picture Guide Page, “Nonferrous Materials” as shown below will appear.



Select "Copper-Ferrogram" and the Browsing Atlas Page for copper particles will appear. It contains several sets of copper ferrogram pictures.



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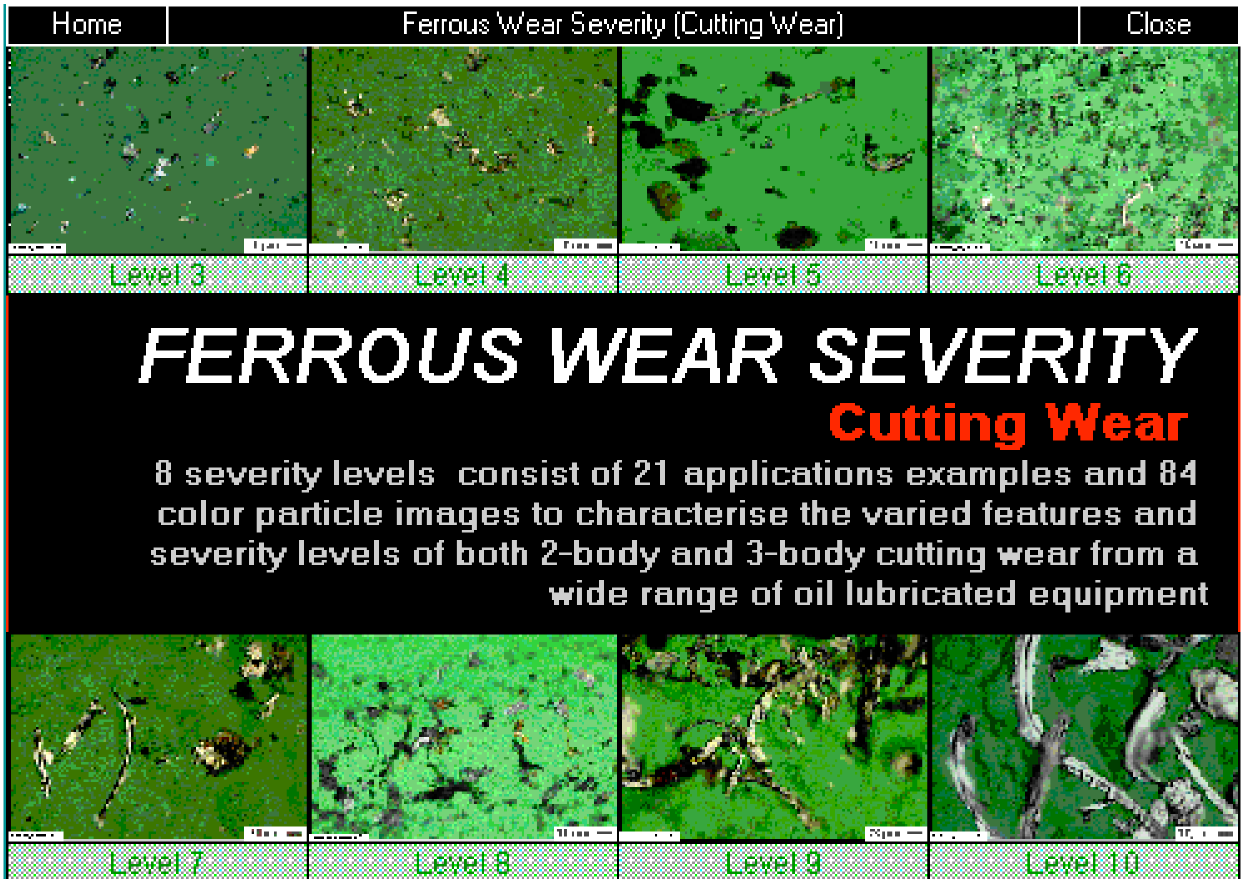
2. Wear Severity Classification

In order to differentiate machine wear severity levels with improved consistency, the Wear Particle Atlas CD-ROM provides an exclusive filtergram-based wear severity differentiation component which embraces 456 images and over 100 application cases. The wear severity levels are divided into either 10 levels (from Level 1 to Level 10) or 8 levels (Level 3 to Level 10). Each characterizes wear deterioration from initial wear to severe wear. An example for cutting wear particles is shown below.



Example of Cutting Wear Severity Index

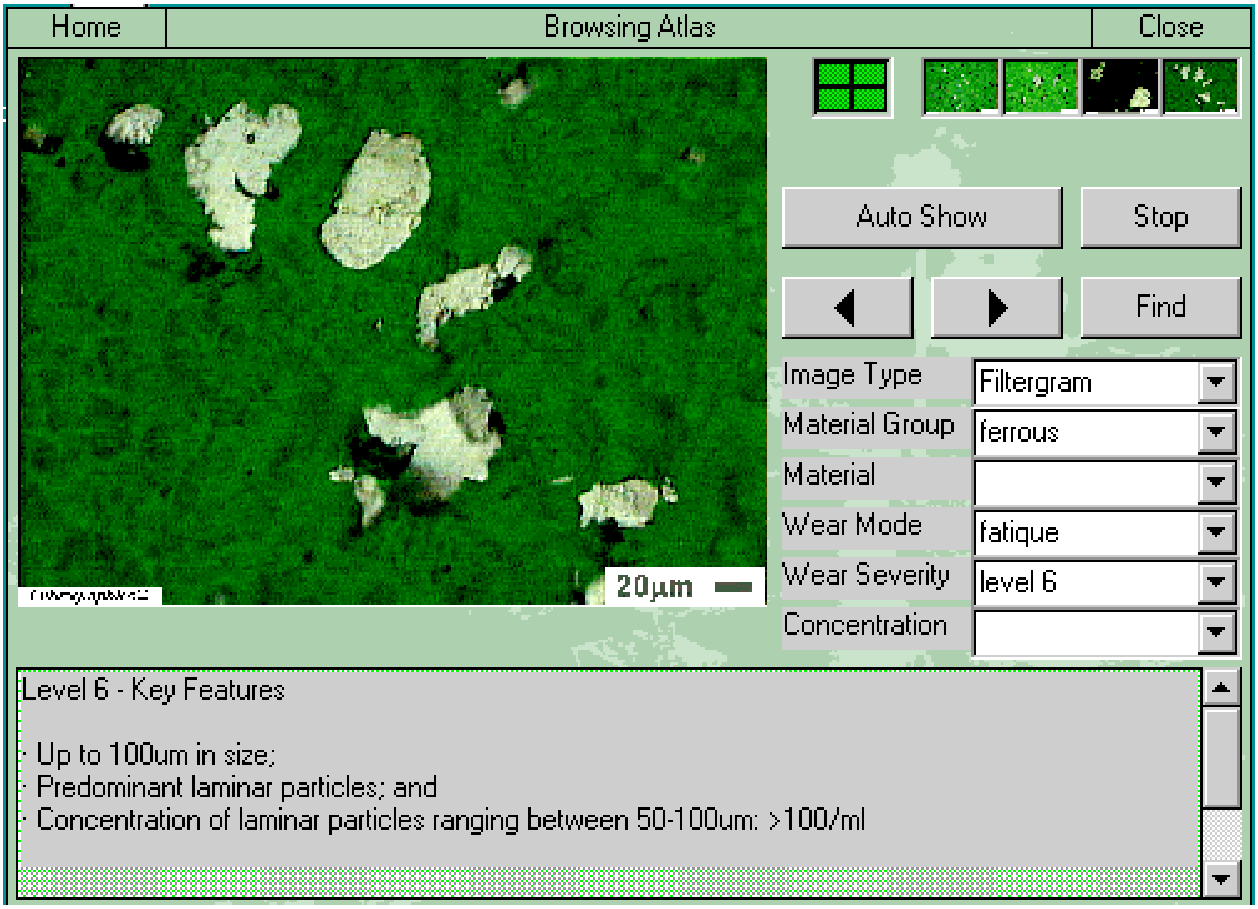
To be objective in its differentiation, the Atlas first defines the "key features" for each severity level. This is the quantitative, measurable criterion based on the size distributions and wear-mode-related type distributions of the wear particles. Second, the Atlas provides 1-5 wear cases at each severity level that approximately meet the criteria of the designated severity level. Each example consists of 4 representative wear particle images. By matching both measurable criteria and visible images, a random wear particle sample can be coded with a certain severity level number. For example, the metal particles in an oil sample are:

- ferrous fatigue wear particles;
- the size of the fatigue wear particles is up to 100 µm, and
- the concentration of the fatigue wear particles ranging between 50-100 µm in size is 200-300/ml.

The quantitative features of this sample meet the criteria for Level 6 of the fatigue wear severity. Further, the features of the wear particles of this sample are equivalent or similar to those of the examples (cases) in the Atlas. Therefore, the wear severity level of this oil sample can be differentiated as 6.

As can be seen from the example below, the criteria of fatigue wear severity level 6 is:

- Up to 100m in size;
- Predominant laminar particles; and
- Concentration of laminar particles ranging between 50-100µu: >100/ml



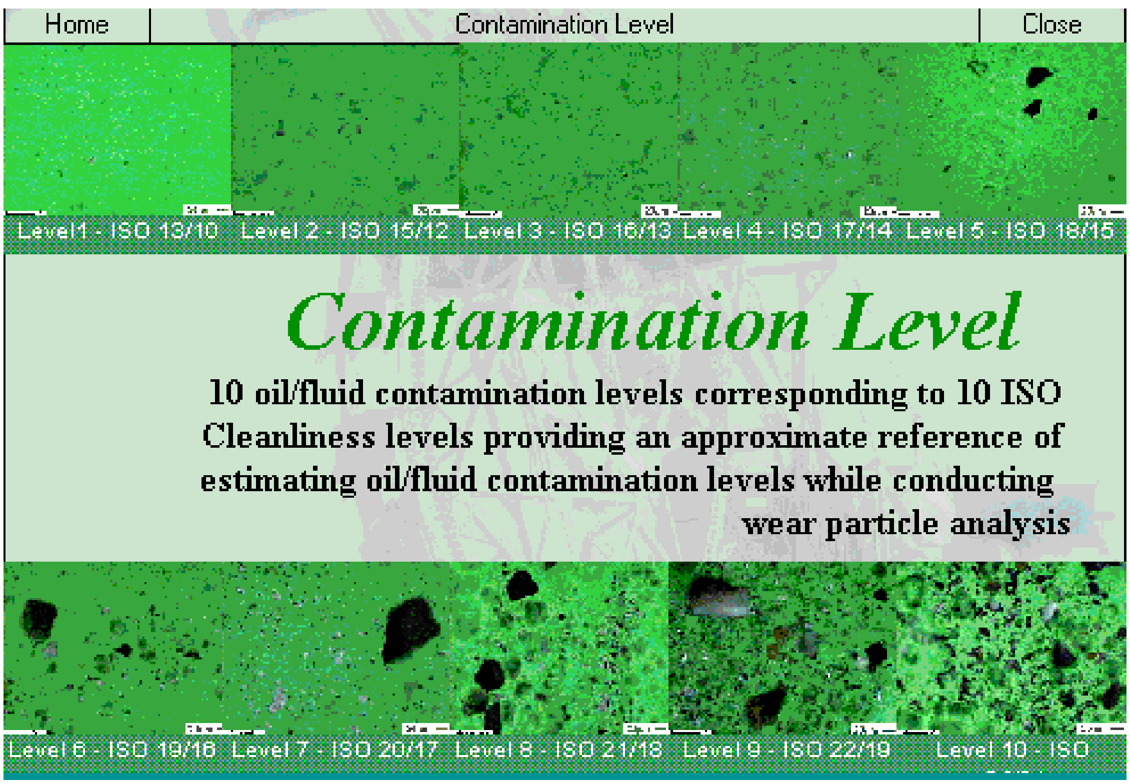
Example of Fatigue Wear, Severity Level 6

This differentiated Level 6 is a universal wear severity level. It can be defined as a "normal", or an "abnormal" or even a catastrophic condition. The determination depends on the criticality, operation environment, and expected life of the machine from which the particles came. For example, if this sample came from a large slow rolling bearing, this severity level 6 may be defined as a "mildly abnormal" wear condition. However, if this sample came from a critical gear system, this Level 6 may be specified as an "unacceptable" or even a "severe" condition. It is from this perspective that the wear severity differentiation in Atlas provides an approximate yardstick for measuring machine severity. This enables an activity, which currently is subjective, to be quantitative and standard.

3. Contamination Level and ISO Cleanliness

Wear Particle Atlas CD-ROM also provides a useful reference to estimate lubricant cleanliness. The cleanliness reference in Atlas consists of 10 contamination levels corresponding to the sequential ISO Cleanliness levels from ISO 13/10 up to ISO 24/21. An example is provided in the table and picture below.

Contamination Levels and Corresponding ISO Cleanliness	
Contamination Level	ISO Cleanliness
Level 1	IS013/10
Level 2	IS015/12
Level 3	IS016/13
Level 4	IS017/14
Level 5	IS018115
Level 6	IS019/16
Level 7	IS020/17
Level 8	IS021118
Level 9	IS022/19
Level 10	IS024/21



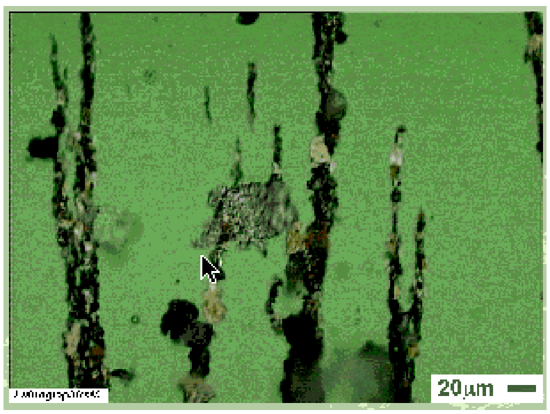
Example of Contaminant Level Page and Corresponding ISO Cleanliness

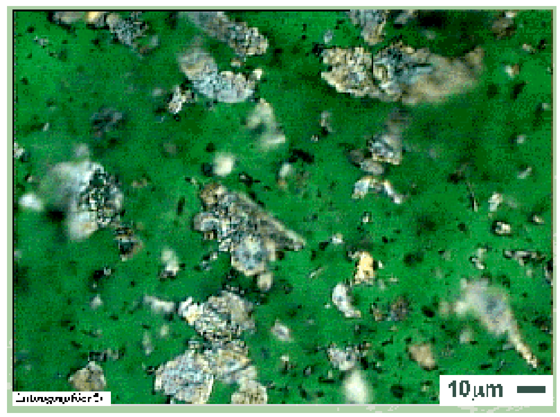
Each level contains 4 representative solid particle images grabbed from different areas of the filtergram with varied magnifications. This component can be used to correlate machine wear with lubricant dust contamination and to estimate the contamination levels of some very dirty, very viscous, or water contaminated oil samples. These types of samples are usually unavailable or inconvenient for analysis by automatic particle counting.

4. Integration of Ferrogram and Filtergram Methods

The ferrogram method is excellent in identifying the materials and the size and shape of solid particles, but is deficient in collecting nonferrous particles. The filtergram method collects all solid particles larger than the pore size of filter paper, but is restricted in identifying materials of solid particles. The Wear Particle Atlas CD-ROM exclusively combines the two types of analysis. It takes advantage of the best features of both the ferrogram and filtergram methods thus compensating for their respective limitations to maximize the strengths of microscopic wear particle analysis.

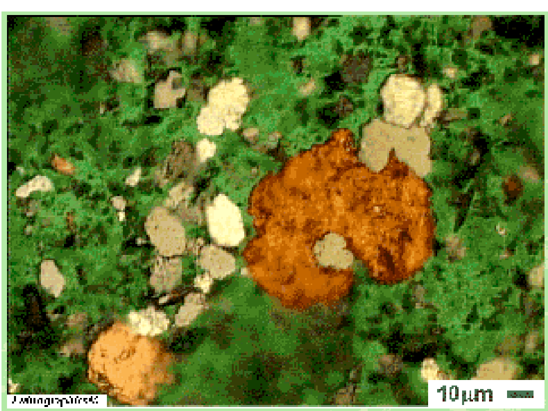
Figure (a) below shows an easy identifiable, nonferrous (Lead/Tin alloy) wear particle image on a ferrogram. Their non-magnetic deposition pattern makes the discrimination of the Lead/Tin particles from the ferrous particles easy. These nonferrous particles are difficult to identify on the filtergram. In this case, the color and brightness of both ferrous and Lead/Tin alloy particles are very similar, see figure (b), due to lack of the deposition features in orientation and locations as on a ferrogram, figure (a).



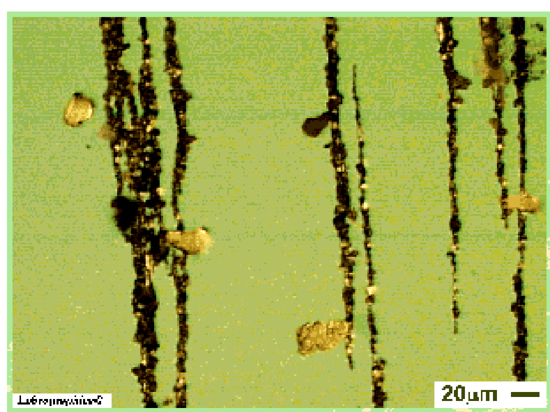


(a) Lead/Tin particles on a ferrogram

The filtergram method is, however, able to collect nonferrous metal particles with high efficiency. This capability contributes to its high reliability to detect the condition of nonferrous components. Figure (c) shows the massive rubbing copper wear particles on a filtergram from a worm gearbox, revealing a high wear rate of the copper worm gear. But the ferrogram, made of same volume of sample, shows a very low copper particle concentration, as shown in figure (d). It is estimated that the collecting efficiency of the ferrogram method for small copper particles is likely to be less than 10% in this case.



(c) Copper particles on a filtergram



(d) Copper particles on a ferrogram