ABSTRACT. Knowledge about particle amount and size is of high interest for condition monitoring of machine elements. Especially by these means, an early detection of wear failures is possible. This paper describes instruments and methods of particle counting and gives examples of practical application.

1. INTRODUCTION

In earlier papers in this volume the usefulness of particle separation and investigation for condition monitoring was shown. Besides this, it was found that the particle size and its increase is an indicator for a beginning failure. As an example, the ferrography is based on this knowledge. The same idea is used for engine filter checks. On these filters mainly large particles are collected. By visual inspection the number of these large particles can be counted and used for engine overhaul decisions. Besides this, particle counting is used in many industrial areas as a dirt control. One of these applications is the monitoring of the cleanliness of hydraulic fluids and systems (1, 2).

2. COUNTING TECHNIQUES

For its application in early failure detection, there are two counting methods based on different principles. By the first, the particles can be separated from the oil and counted on a plane surface. According to the size of the particles normally an optical or electron microscope is used for this purpose. The second method allows the particles to be counted directly in the oil. A distinction must be drawn between static techniques, for which the oil is placed in a vessel, and dynamic techniques, i.e. where the oil flows past a sensor. The sensor serves as a device to determine the number and size of the particles suspended in the oil. The sensors
currently in use work either on the principle of the reduction in the amount of light from a bulb or on the reflection of a laser beam by individual particles.

2.1 Particle Counting by Microscopic Methods

Particle counting with the bare eye is the easiest and oldest method. The smallest particle which can be investigated by these means is about 100 μm. For smaller ranges microscopic methods are necessary. The particle size range down to 0.1 μm can be counted with optical microscopy. Electron microscopy gives possibilities down to 0.001 μm particle size.

For contamination control in hydraulic fluids the worldwide used standard method for obtaining precise information is the microscopic technique described in ARP 598 and US-Federal Standard 791a (3, 4). Usually the range is between 5 and 100 μm, subdivided in the channels larger than 5, 10, 15, 25 and 50 μm. For this reason optical microscopy is in most cases sufficient for particle counting. Nowadays, direct counting by eye is rare. More and more counting is done from microphotos or with the aid of a TV-camera, together with automatic or semi-automatic devices. The main principle in early methods is that the particles pass through a light beam, which then falls on a photocell (5, 6). Changes in the intensity of the light beam are monitored and recorded. The instruments are categorized as spot scanners and slit scanners (6). The spot scan methods are based on the spot microscope of Roberts and Young. Here a moving spot of light is projected through a microscope on the specimen. When a particle interrupts the light beam a photocell is activated and the particle is recorded. The scanning spot of a television camera is used at the M.R.-particle size distribution analyser. The instrument records the number of intercepts of the spot by particles. The output from the television camera is displayed on a screen for easy selection and focusing. The theory of slit scanning has been covered by Hawksley (7). The method is based on the projection of the image of a slide onto a slit using a conventional microscope. By the mechanical scanning of the slide the signals produced as the particle images pass over the slit are electronically recorded. In the last years, the tendency is more and more towards the image analyzers which have many advantages. Also for this type, the particles are scanned by television camera. The measuring parameters are counts and size distribution by area or some statistical diameter. From these, several secondary parameters may be evaluated. The measured features and