## Abstract

An electrostatic oil filter can remove submicrometer-sized contaminants such as the oxidation products of additives from oils. By virtue of this characteristic, it has contributed to lengthening the lives of lubricating oils and to decreasing waste oil as well as failures of machines including hydraulic systems. The filtration principle of the electrostatic oil filter is based on the fact that solid particles in liquid are usually charged positive or negative due to the preferential adsorption of ions in liquid and the dissociation of dissociative groups on the surfaces of the particles. All the contaminant particles, however, are not charged enough and there are cases where oils can not be sufficiently purified.

It is well known that electric charges can be injected into dielectric liquids by applying a high electric field using, e.g., a needle-plate electrode configuration. If the amount of the electric charges on the surfaces of contaminants can be augmented by the charges injected, the magnitude of Coulomb force exerted on the contaminants becomes larger and the contaminants may be easily captured on the electrodes and collectors. In this research, a charge injection type of electrostatic oil filter is proposed aiming at increasing the filtration speed. The phenomenon of the charge injection has not been utilized for electrostatic oil filtration so far. Even though electric charges can be injected into oils, it is not clear whether the injected charges are adsorbed on the surfaces of the contaminants.

In order to examine whether the filtration speed can be increased by injecting electric charges into oils or not, filtration experiments are conducted using a simple filter model consisting of an emitter electrode with sharp projections and two smooth electrodes and many types of oil. The experiments show that the filtration speed is increased to a great or some degree for most of the oils and that for the majority of the oils, the electrification polarity of a few tens to one hundred percent of particles can be inverted by injecting electric charges with the opposite polarity to the original electrification polarity of the particles. It is also shown that a weak correlation can be

seen between the conductivity of oil and the filtration speed under charge injection.

In order to find out the optimal electrode configuration, the effects of various mechanical factors on the filtration speed are examined. The effects of the spacing between the emitter and smooth electrodes, the number of the projections, the applied voltage and the oil temperature on the filtration speed are examined using a simple filter model and various types of oil. Numerical simulation of electrostatic field is done in order to make clear the effects of the mechanical factors on the filtration speed. In addition the motion of oil caused between the electrodes due to ion dragging is observed using a charge coupled devise (CCD) camera and is analyzed using a particle image velocimetry (PIV) technique. It is shown that part of the particles captured on the smooth electrode is detached by the ion drag flow. Taking this and the results of the filtration experiments into consideration, an optimal electrode configuration and operating condition are proposed.

It is important to be able to predict the flow and electric fields in filters of various configurations by numerical simulation, e.g., to minimize the bad influence of the ion drag flow. Numerical simulations of two-dimensional flow and electric fields are done and are compared with the experimental obtained using a two-dimensional filter model. It is shown that the flow fields obtained by numerical simulation agree relatively well with measured ones. It is expected that the numerical simulation contributes to designing an actual three-dimensional filter with a better performance.

The advantage of charge injection on the filtration speed has been demonstrated. An optimal electrode configuration and operating condition are proposed in order to increase the performance of the electrostatic oil filter. The results obtained from this research contribute to designing an electrostatic filter with higher filter efficiency. Hence, the this type of oil filter can become widely to be used in the industry as a standard in protecting the machines as well as the hydraulic systems from the failure caused by contaminants in oil and, therefore, reduce the cost for the maintenance and increase the quality of the product.