In a rotating machinery system like turbine engine, high speed rolling element bearings play an important role in supporting the rotating shaft or rotor, and need lubrication to insure their function. Except a small quantity of oil is needed to form the elastohydrodynamic lubricant film in the contact zone, most of lubricant remains in suspension in air, forming an oil/air mixture. This phenomenon leads to excessive parasitic hydraulic losses when rolling elements translate and rotate into the fluid environment, which may constitute a relatively large portion of the bearing's total power loss, named windage drag and churning losses. For high speed applications, i.e. for rotational speed up to $3*10^{\wedge 6}$ Ndm, the contribution of drag/windage loss to the total one may reach up to 50%. However, so far there are few approaches used directly for drag and churning losses estimation, which could only provide a rather gross approximation.

In this thesis, the Computational Fluid Dynamics (CFD) method is employed to analyze first the flow around one finite-length circular cylinder with two free ends in an open space. Then the model is changed to several in-line circular cylinders sandwiched by two flat walls, which represents a simplified approach. The fluid here is regarded as incompressible, representing an equivalent one-phase fluid for the oil/air two-phase flow inside the bearing cavity with specified fluid properties. The results indicate that the flow around the finite length roller element is perturbed by its two free ends, the surrounding rings, the cage and other rolling elements. A relationship between the drag coefficient and the Reynolds number suitable for circular cylinder in roller bearings ($1<L/D<6$) is proposed, as well as a formulation for churning losses prediction.

The oil/air two phase flow inside the bearing cavity with under-race lubrication is also studied in this work. The coupled level-set volume of fluid (CLS-VOF) method is employed to demonstrate the lubricant distribution along the bearing circumference. The effect of various factors is studied, e.g. the oil injection velocity, the nozzle diameter, the oil properties, and the oil injecting angle. Rotational speed of all the bearing components are studied particularly to quantify their influence to the oil volume fraction inside the bearing cavity. The results demonstrate that not only the inner-ring/cage relative rotational speed, but the cage speed itself could change the oil distribution. The results can be used for the precise lubrication design to optimate the oil distribution inside the bearing.