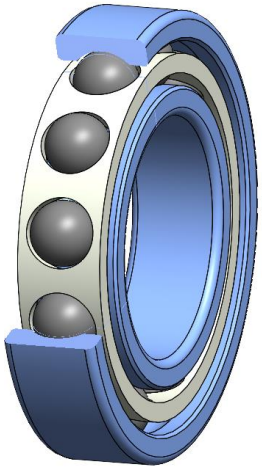
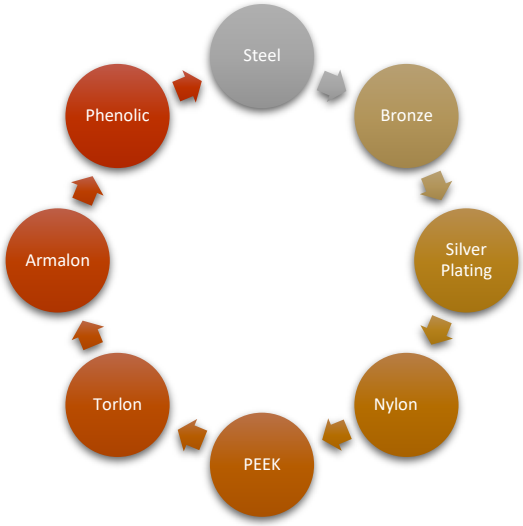
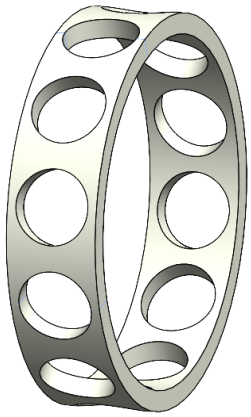
Subject: Bearing Cage Design and Materials

The bearing cage or “separator” is a highly engineered part that can be responsible for success or failure. This can make bearing selection difficult and iterative. The cage is what keeps the rolling elements inside of a bearing from contacting each other. It can also function as an aid in bearing lubrication depending on the type of cage. It comes down to the application requirements to choose the right cage. If the bearing does not have adequate lubrication, it may require a cage that is self-lubricating and provides a transfer film to the rolling elements and raceways. Other applications may require a cage that is rated for high or low temperature extremes while others may need a cage built for high speed that doesn’t lose structural integrity or stability.







Since the cage is a free body, relative to the raceways and rolling elements, its movement is driven by contact with the rolling elements. A kinematic analysis of the relative motion between raceways and rolling elements is necessary to design an appropriate cage. Load condition, rotational speed, bearing internal geometry and frictional characteristics all influence the movement of the ball as it travels around the raceways, both in and out of load zones. The rolling elements will ‘move’ differently around the circumference they travel. The rolling element can experience advancement and excursion from pure rolling motion. As a result, the pocket that retains the rolling element needs to be sized appropriately to offset excessive forces, deformation and potential wear. Also, it must be considered what surface the cage is riding on, the rolling elements or the inner or outer rings. If the cage is ring land riding, which is the case for most high-speed bearings, controlling that clearance is critical to cage stability. To choose the correct bearing-cage combination it takes a detailed understanding of the loading conditions and environment. Additionally, the right material selection will result in a bearing that can mitigate or even eliminate the problems that the application throws at it. Beyond advanced calculations, the industry relies heavily on heritage for common applications.

Bearing lubrication plays an important role in choosing the right cage material and overall design. Cage design, lubrication method and application conditions must be evaluated collectively to ensure sufficient oil is available at the appropriate locations to develop a hydrodynamic film, manage wear of cage contact surfaces and provide adequate heat dissipation to maintain a stabilized thermal condition. Successful management of these conditions allows a bearing to achieve a life consistent with L10 life calculations where failure is derived from subsurface fatigue. An inability to achieve the correct balance can lead to surface-initiated failure, which is unpredictable and premature relative to calculated life expectancy.

Cage selection is just another step along the way to proper operation. To settle on the best option, it takes analysis of the bearing mechanics as well as knowledge of the materials that are available for bearing cages. For more information on cage material or for help in analyzing which cage is best, contact Andrew Hvizdzak (ahvizdzak@nesbearings.com) or Tim Asquith (tasquith@nesbearings.com) at NES.