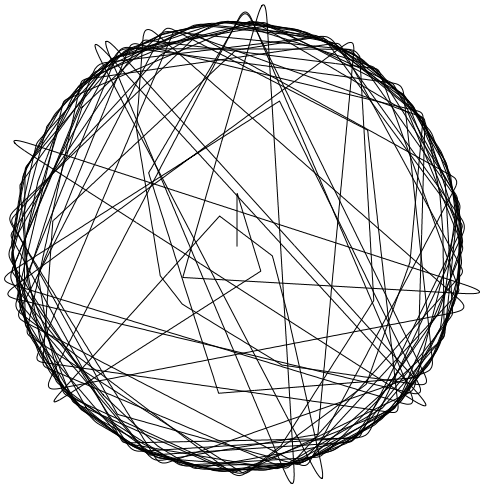
What is cage instability?

The role of the cage (or separator) of a ball bearing is to prevent the rolling elements from interacting with each other. It also prevents all kind of direct interaction between the balls. The cage is a light, simple and not robust structure. As a result, the cage cannot endure loads as intense as those of the Hertzian pressure at ball/race contacts. Hence, clearances are mandatory in order to avoid such forces. This means that the separator moves freely between the rolling elements and the two rings of the bearing.

Nevertheless, this free motion inside the bearing is quite small. Indeed, cage/ring and cage/ball clearances are so tiny that contacts are numerous throughout the ball bearing's life. These successive impacts inevitably lead to an erratic[1] behavior of the cage that is buffeted, following the bearing rotation. To illustrate it, the figure hereunder zooms in a typical displacement of the cage's center of gravity within the bearing.



Typical displacement of the cage's center of gravity

This incoherent displacement of the cage is actually not an issue. The weight of the cage is about a few grams only for a ten centimeter bore ball bearing. This very low mass bounces in a tiny space, which is about some tenths of millimeters. Even if the motion is erratic, such a lightweight component cannot produce impact forces greater than a few newtons, at worst.

Contrary to what intuition may suggest, this lack of organization in the cage motion preserves its integrity. If an impact is likely to increase the speed of the cage within the bearing, then another one will produce the opposite effect and so on. As a result, despite an anarchic motion, the speed of the cage is limited as well as the failure risk. The motion is *stable*.

It is when the cage motion becomes coherent that concerns appear. In such a situation, the alternate sequence between acceleration and deceleration of the separator disappears. The rise in the cage

[1] See our article *Mastering chaos*

speed within the bearing is then continuous. The cage stores more and more energy, which is nothing less than the picture of its speed increase. The motion is *unstable.*

In order to set these ideas down, a stable behavior of the cage implies that the rotational speed of its gravity center rotates around the bearing axis at a speed that is close to that of the group of balls. If the separator is unstable, then its center of gravity may rotate at a speed that is approximately hundred times bigger than the stable configuration.

Consequences of cage instability are significant. Energy exchanges during impacts of the cage are big enough to deeply affect the ball bearing frictional torque. In the worst case scenario, the cage may fail if it is unable to endure the repeated shocks.

APO-GEE identified the different mechanisms that lead to the occurrences of dynamic instabilities of the cage. Mastering these phenomena has been possible by developing unique computational tools, which are experimentally correlated. The deep understanding of the physical aspects and the specific know-how of APO-GEE are the foundation of a new cage design, which counteracts every single start of unstable phase.

Confusion is source of stability. Could you have imagined that?

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APO-GEE ENGINEERING SRL has solved the CAGE INSTABILITY PROBLEM, to which no fully satisfactory response has been possible for more than 50 years (patent pending EP22191261). See www.apo-gee.tech.