

How a R&D minded start-up *solved* a 50-year-old mechanical problem



APO-GEE launches the BUTTERFLY cage that copes with the cage instability issue (patent pending)

The BUTTERFLY Cage developed by APO-GEE, an intense IP focused start-up based in Belgium, is a new concept that leads to an unconditionally stable behavior of the cage during the complete life of the ball bearing. No matter the working

conditions encountered. Under certain constraints, the cage of a ball bearing may indeed exhibit an erratic movement or cage whirl. This is particularly the case for poorly lubricated or heavily stressed bearings. In the event of such dynamic instability (or bearing squeal), the energy exchanges involved can then lead to cage failure. This is a common problem with the reaction wheels of space probes or

satellites for instance, which can result in an unwanted change or termination of the mission. Cage instability may also occur in turbo pumps of launchers that endure very hard operating conditions. Although this phenomenon has been studied for more than 50 years, it had not been fully modeled or solved until recently. By precisely identifying the deep nature of the cage instability, APO-GEE did it

with the BUTTERFLY Cage for which a patent is pending (ref. EP22191261). Now both mathematically and experimentally validated, the BUTTERFLY Cage can be integrated into the aerospace and defense mechanisms for a drastic positive impact on bearing operations and lifespan.

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Christophe Servais
CTO of APO-GEE

Deep understanding leads to innovative solutions

Even though the company launched its activities at the beginning of 2022, its innovative solutions are based on more than 10 years of research in the deep understanding of the kinematics of the balls. Or to put it another way: intense research on how the balls effectively roll between the rings of a bearing.

“I started my PhD thesis with this question in mind” says Christophe Servais, CTO of APO-GEE. “I quickly realized that to understand the physics of the cage in a comprehensive way, I first had to understand how a ball bearing works without considering the cage. And as crazy as it seems, nobody knew exactly how the balls roll onto the rings!”.

Progresses have been made through the years by a lot of people concerned by the cage instability issue. But the different studies often focused on the development of dedicated software, repeatedly neglecting the physical aspects behind the cage instability.

“The ball bearing is a very common mechanical component. Nevertheless, despite the swarm of technical papers dedicated to bearings, I didn’t find a

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Sébastien Assouad - CEO of APO-GEE

clear answer to the question to know how precisely the balls roll onto the rings. How was it possible? The answer is: because everybody uses the same tool to access the kinematics of the balls, viz. the Newtonian formalism. As a result, I worked for years on establishing an efficient and robust method to determine ball bearing kinematics, no matter the working conditions it endures (loads, misalignment, speed,...) before I succeeded: I discovered a new variational criterion based on the power, especially dedicated to bearings. Using it led me to a unique description of the kinematics and the ball/race contacts of the bearing” explains Servais.

Based on this new understanding of the ball bearing behavior, and the discover of the impact of the balls on the dynamics of the cage, APO-GEE fully understands the mechanisms that govern the cage instability. Cage models have been developed and a test campaign has been performed to correlate its modeling with experimental results. It was a success. More than a correlation, APO-GEE got the confirmation that it masters the root causes that are at the origin of cage instability and also succeeded in provoking, on demand, stable or unstable behaviors. The resulting BUTTERFLY Cage is now officially a new concrete concept that leads to an unconditionally stable behavior. This definitely opens new perspectives notably for aerospace & defense projects and programs. APO-GEE has also begun to collaborate with the European Space Agency on the subject.

An innovation centric start-up

The cage instability problem solved by the start-up is just a beginning, new innovations await. The start-up has also developed a bearing that drastically improves the operation of miscellaneously loaded bearings. Those are often subjected to the Ball Speed Variation phenomenon

(ball advances at non-constant speed) induced by misalignment. This phenomenon can lead to cage failure, noise, vibration and excessive heat. “Current available bearings only provide a partial answer to this problem” says Sébastien Assouad, CEO of APO-GEE. Designers of mechanisms had to accept difficult compromises for decades, but APO-GEE can now offer them a solution which opens up new perspectives: the COBWEB Bearing. The design of this new bearing significantly decreases the bad effect of the misalignment. It is capable to support a combination of axial and radial loads, exactly as deep groove and angular bearing but with a considerably extended acceptable misalignment. “Yes, we have engineered the bearing that has the most precise functioning in the world so far” concludes Assouad.

This is undoubtedly a good omen for the young start-up.



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More information about APO-GEE - Ball Bearing Engineering can be found at www.apo-gee.tech