

NSK Develops World's Fastest Ball Bearing for EV Motors



MOTION & CONTROL™
NSK

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Location: The Bearing Show 2022, Essen

Presenter: Peter Kohl, NSK

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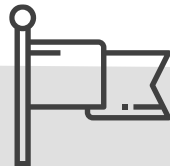
1. Introduction to NSK
2. Movement of automotive industry
3. Required functions for Electric Vehicles
4. Trend of high speed rotation
5. Technical challenges for high speed and development
6. Design method for new cage shape
7. Features of developed cage (Gen3)
8. Performance of developed cage (Gen3)
9. Further development (Gen 4)
10. Summary

1. Introduction to NSK - Global Company Profile

NSK Ltd., Japan (Nippon Seiko K.K.)

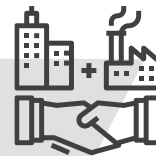
1916

Established in Japan



Group Companies

19 in Japan, 72 outside Japan



~30,577*

Employees global

* excl. temp. employees, Note: per March 2022



Sales of
~ € 6,3 bn

56%	Automotive
40%	Industrial
4%	Other Markets

Japan No.1
Global No.3

Bearings



Electric Power Steering Systems

Global No.2

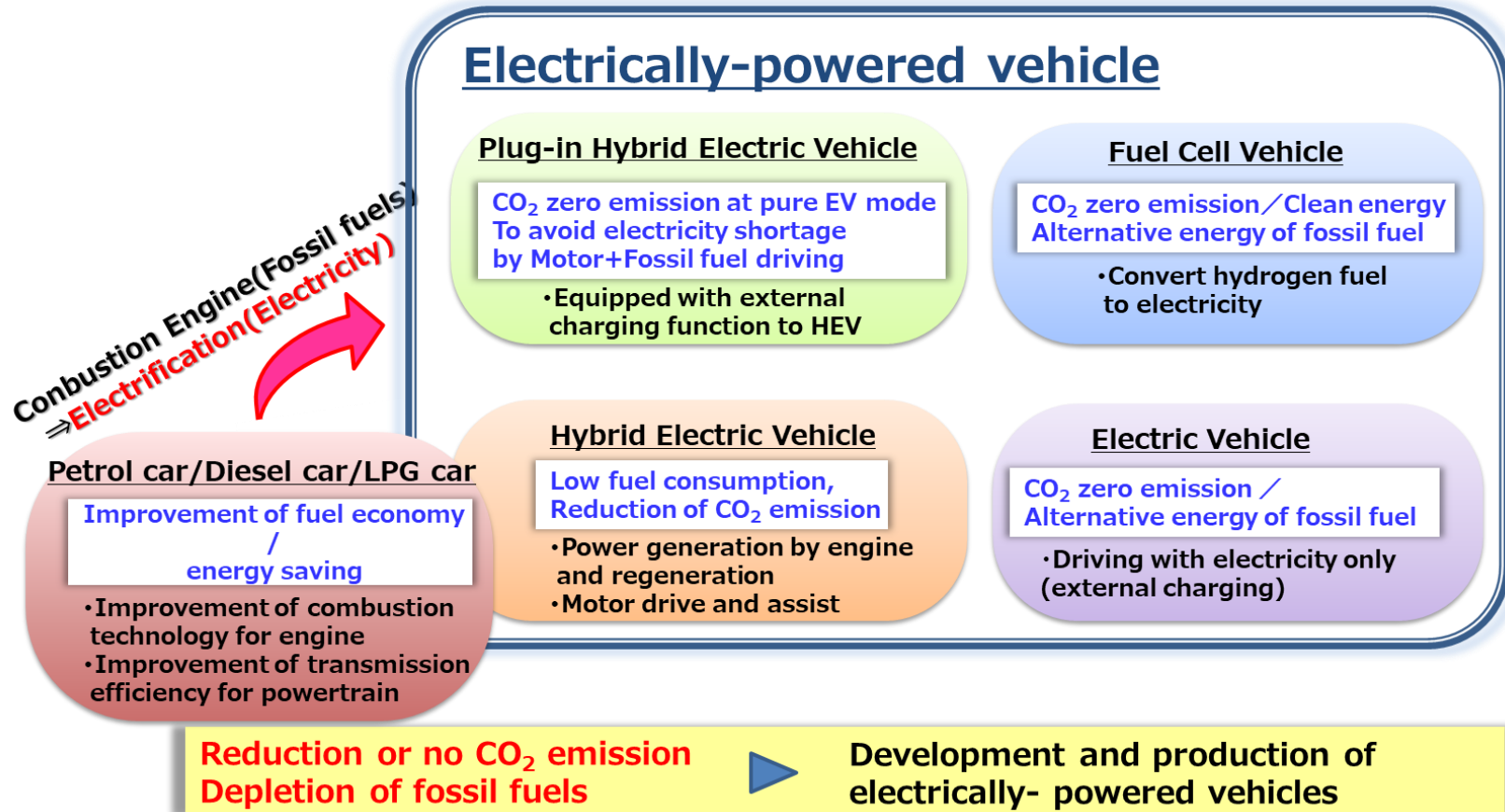
Ball Screws

Global No.1



Source: NSK Annual Report

2. Movement of automotive industry



3. Required functions for Electric Vehicles



Electric Vehicle Requirements

Improved Efficiency & Power Consumption

Countermeasures for depletion of fossil fuels

Extended Range

Adequate battery mounting space

Improved Comfort

Larger Vehicle Cabin

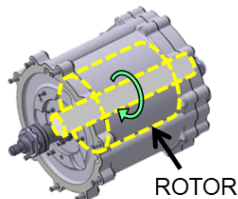
Electric Motor Requirements

Compact & Lightweight

High Speed Rotation

Required Bearing Functions

High Speed Rotation

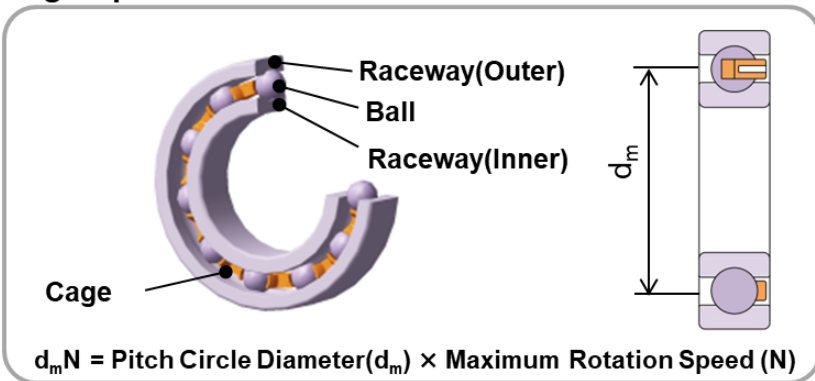


$$\text{Motor Power} = [\text{Angular Velocity}] N \times [\text{Torque}] T \\ \propto [\text{Rotation Speed}] N \times [\text{Rotor diameter}]^2$$

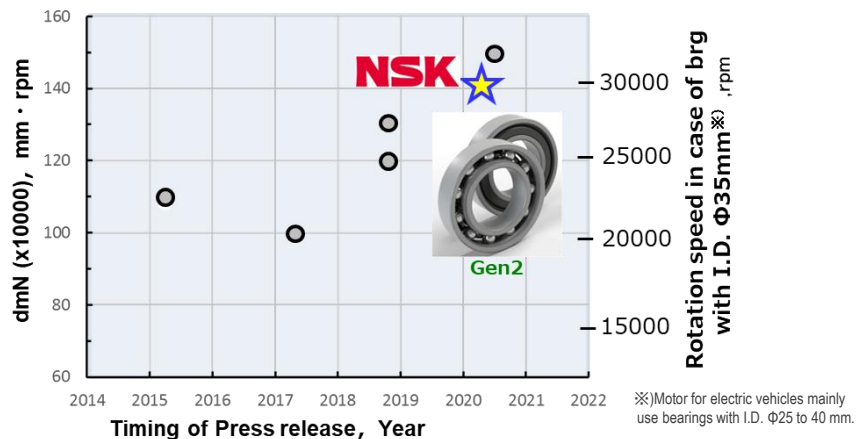
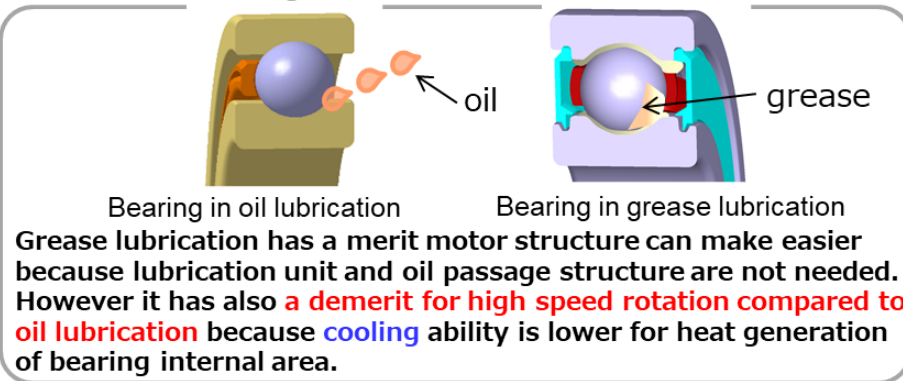
Increasing the rotation speed reduces the required rotor diameter for the same motor power output $\Rightarrow$ Motor size and weight can be reduced

4. Trend of high speed rotation

High Speed Rotation Index



Merit / Demerit of grease lubrication



NSK developed high speed bearing (Gen.2) allowed $d_m N = 1.4M$ at grease lubrication

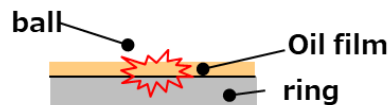
March 2020

Higher speed bearing allowed more than $d_m N = 1.5M$ for future EV uses is needed to develop.

5. Technical challenges for high speed and development

Issue for High Speed Rotation

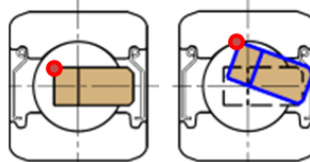
① <Seizure>



As rotation speed increases, internal heat generation increases reducing oil film and leading to the risk of seizure.

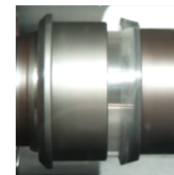
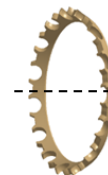
Higher anti-seizure performance by high speed grease

② <Cage deformation>



Before Deformation

After deformation



Cage tip (●) deforms due to centrifugal force and contacts outer ring and seal

Challenges are Cage design and production to prevent too much deformation

NSK Development for High Speed Capability

		Standard spec.	High speed spec. Gen1	High speed spec. Gen2	High speed spec. Gen2
Grease		Standard type	High speed type	High speed type	High speed type
Cage	Shape				
	Material	Steel	Standard plastic	Standard plastic	New plastic material
Max. dmN		0.55M	0.80M	(1.3M)	1.4M

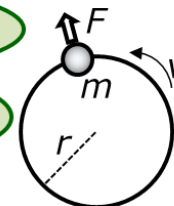
$$F = m \times v^2 / r$$

F : Centrifugal Force

m : Mass

v : Rotating Velocity

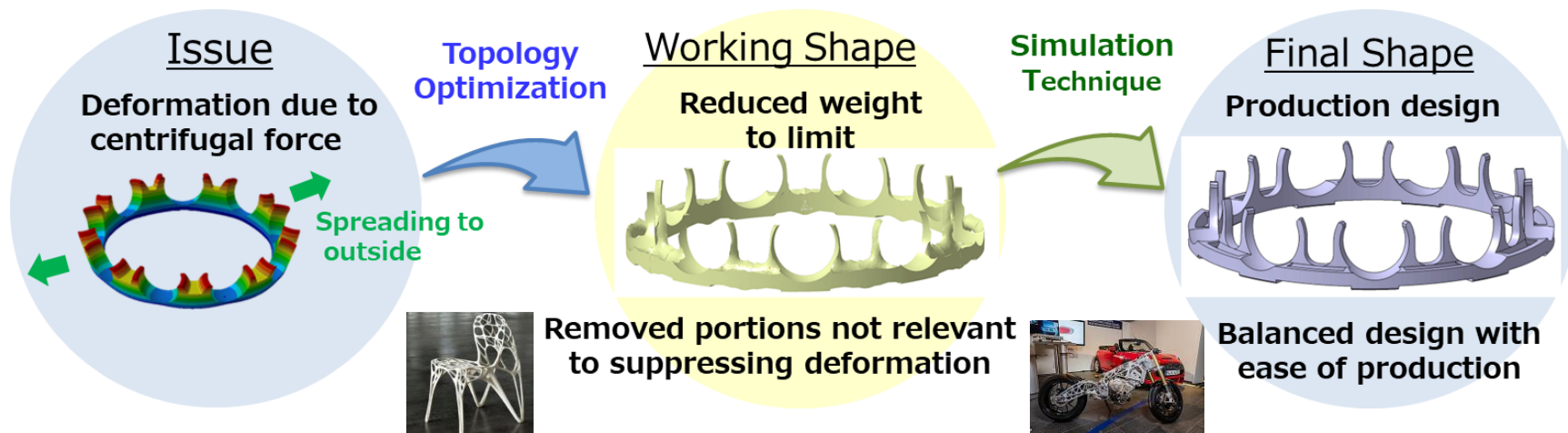
r : Rotating Radius



Smaller centrifugal force

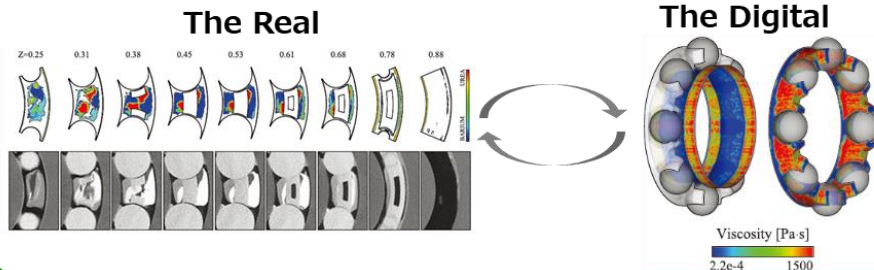
Higher Stiffness

6. Design method for new cage shape

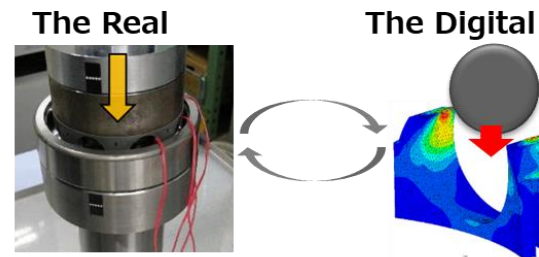


Simulation technique

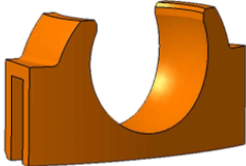
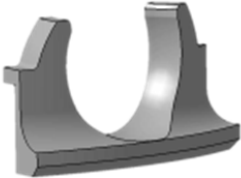
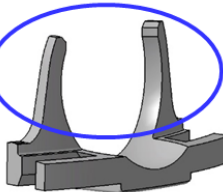
Example of functional confirmation : Grease flow analysis

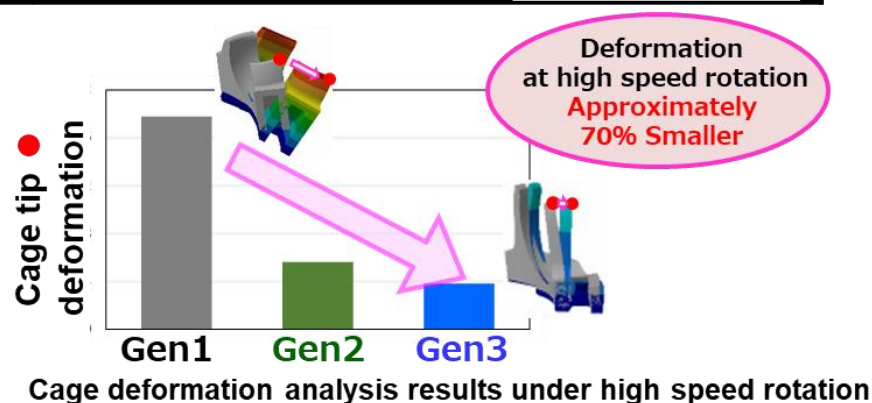
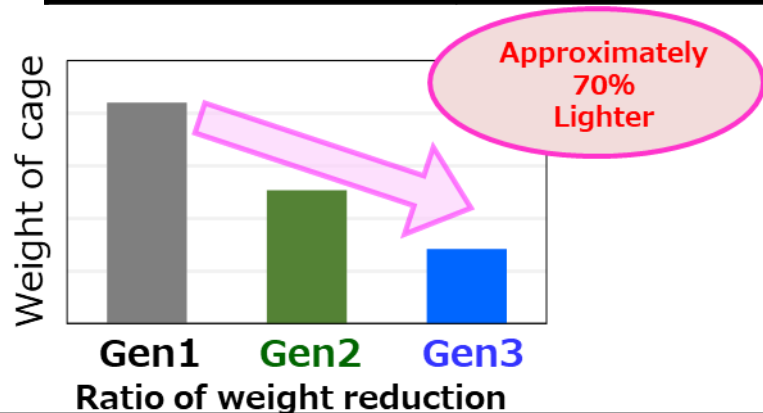


Example of massproductivity confirmation : Ball inserting analysis



7. Features of developed cage (Gen3)

High Speed (Gen1)	High Speed (Gen2)	Development Gen3	
		Adopted high stiffness (undeformable) material as same as Gen2	
		Reduced centrifugal force to save weight of cage outer Diameter side (Designed by topology)	

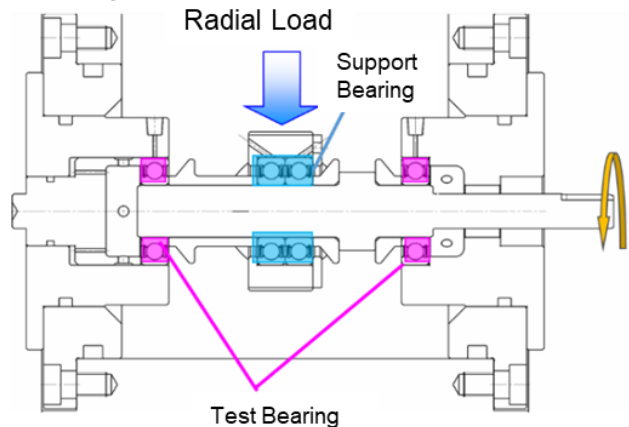


8. Performance of developed cage (Gen3)

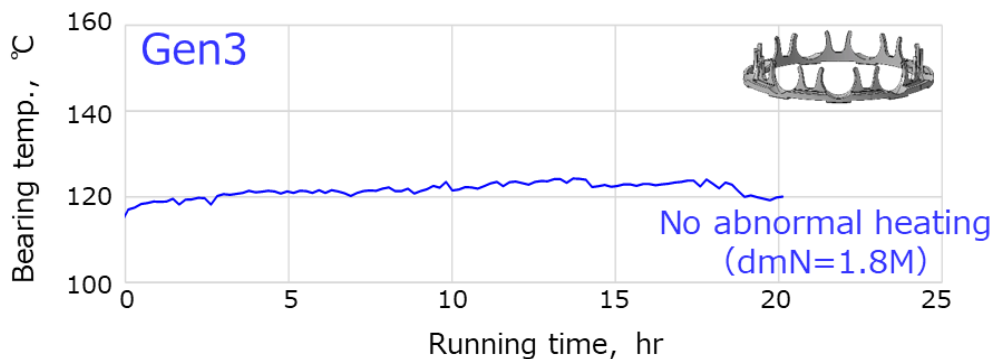
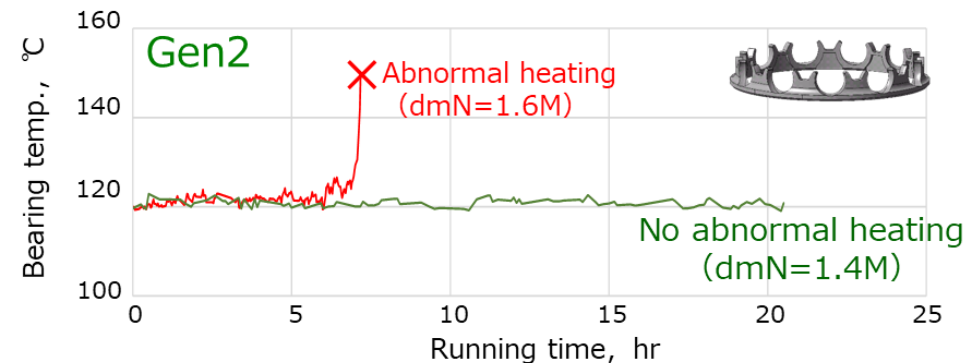
Test condition

Cage spec.	Gen2		Gen3
dmN	1.4M	1.6M	1.8M
Temp.	120°C		
Time	20hr		

Test rig setup



Test result



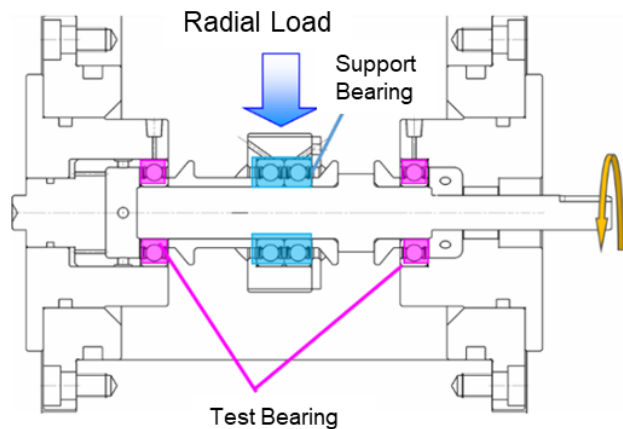
No abnormal heat generation → Achievement of high speed capability **dmN = 1.8M**

9. Further development (Gen4)

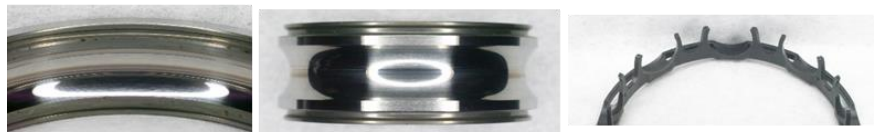
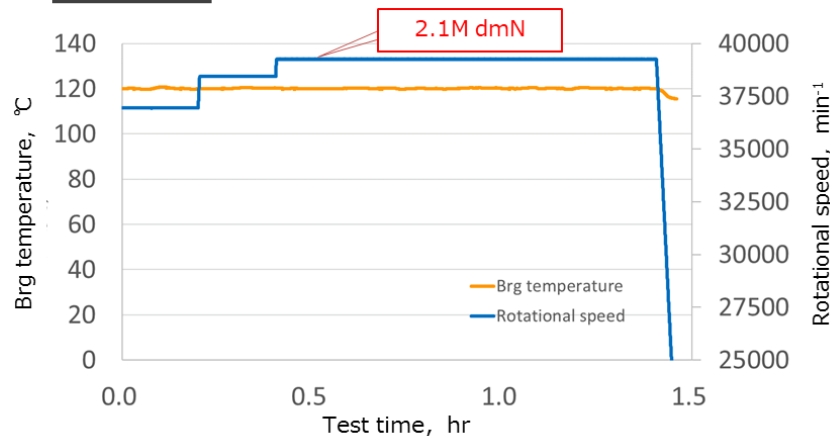
Test condition

Cage spec.	Gen4
dmN	2.1M
Temp.	120°C
Time	1hr after reaching 2.1M dmN

Test rig setup



Test result



◆ Appearance after test

No abnormal heat generation for >1hr → Achievement of high speed capability **dmN = 2.1M**

High speed rotation DGBB Gen3 for EV motors:

- has achieved high speed rotation of $dmN = \text{over } 1.8M$
- utilizing topology technique and designing optimised cage shape with reducing deformation due to centrifugal force.
- Gen3 improved approx. 1.3 times higher allowable rotation speed than Gen2. and approx. 3 times higher allowable rotation speed than standard bearing
- The adoption of this bearing makes it possible to reduce the size of the drive motor unit.
- It contributes to improve fuel and electric efficiency of electric vehicles, to extend cruising range, and to improve comfort.
- NSK is also developing the Gen4 bearing for further high-speed rotation