Development of Multi-Material Molding Gear Technology

Nichiei

Outer ring gear

Sun gear

Planet gear

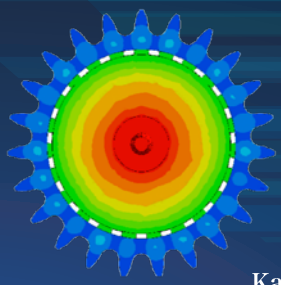
Development Concept

By overmolding the surface of a metal gear with fiber-reinforced resin using injection molding, the performance of the gear is significantly improved. Specifically, through innovative design of the resin flow path within the mold, weld lines are concentrated at the tooth tip to prevent a decrease in the strength of the tooth profile. Simultaneously, by orienting the fibers within the resin along the tooth profile, the sliding characteristics are enhanced.

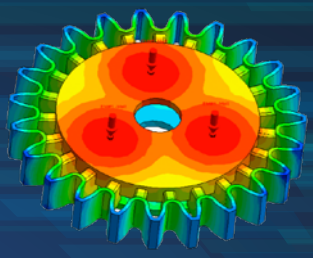
Patent acquired (registration number JP7624671)
Co-applicant: Plalink Co., Ltd.

Validation of concept

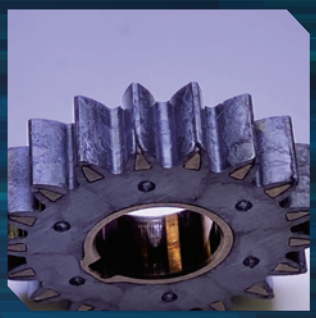
By strategically designing the flow path, weld lines are concentrated at the tooth tip, preventing a reduction in the durability of the tooth flank.



CAE Analysis



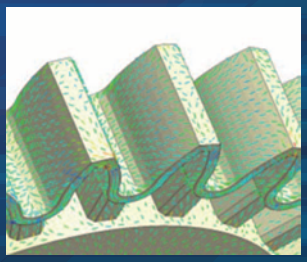
Kanazawa Institute of Technology, Yamabe/Seto Laboratory



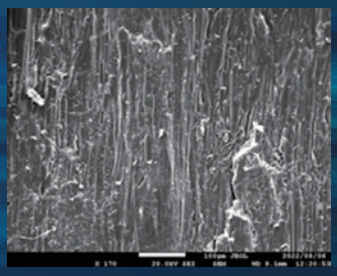
Weld formation

Fiber orientation analysis

along the tooth profile, the carbon fibers within the resin are oriented in the sliding direction of the tooth flank, thereby improving the durability of the tooth flank.



Maximum internal height Y direction: 0.76



Fiber orientation observation

Tooth Tip

Resin flow direction

Tooth Root

Features of dissimilar material molded gears

vs. Resin Gear

- Metal improves tooth base strength and dimensional stability

vs. Metal Gear

- Improved sliding properties of tooth surface due to fiber-reinforced resin

Performance comparison: Gears made of different materials vs. conventional gears

	Core material	Surface material	Dimensionally stable	Quiet	Lubricant-free	Durability	Lightweight
Conventional gear	Metal		◎	×	×	◎	×
	Resin		×	◎	◎	×	◎
Gear made of different materials	Metal	Resin (Sliding grade)	◎	◎	◎	○	○*
	Resin (High strength low shrinkage grade)	Resin (Sliding grade)	○	◎	◎	○	◎

※Dissimilar material molded gears can be made lighter by using a material with a low specific gravity, such as aluminum alloy, for the core material.

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Development of Speed Reducers for Robots

(FY2024 New Aichi Creative Research and Development Subsidy Program)

Nichiei

Development organization

Plalink Co., Ltd.
Joint research coordination,
Gear design using composite

Meijo University
Enomoto Laboratory
Experiments and analysis of sliding characteristics

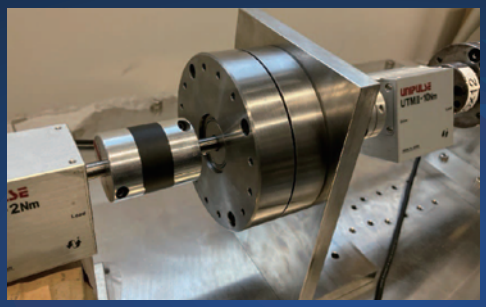
Nihei Co., Ltd.
Development and prototyping of gears molded from different materials Development, prototyping, and commercialization of gears

Okayama University
Fujii Laboratory
Experiments and analysis of gear

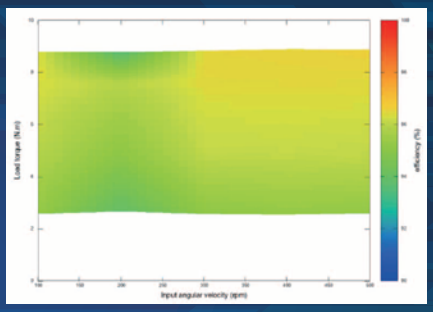
Yokohama National University
Fujimoto Laboratory
Gear specifications, design, evaluation, analysis

Improved energy efficiency —Achieved 97.97% without lubrication—

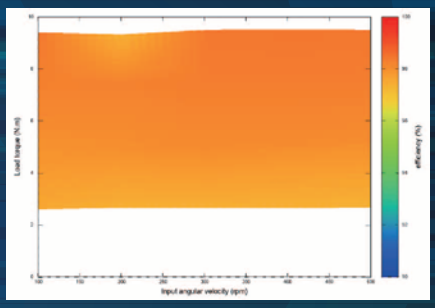
An efficiency improvement of 2.21% was achieved compared to the metal gear reducer (metal gear reducer: 95.76%).



Input speed was varied from 100 rpm to 500 rpm in 100 rpm increments, and load torque from 2.5 Nm to 10 Nm in 2.5 Nm increments. Input torque, output torque, input speed, and output speed were measured. Input and output power were calculated, and reducer efficiency was determined from their ratio.



Metal gear reducer measurement results (with grease)



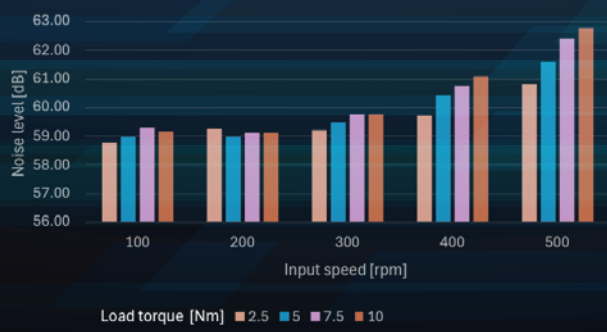
Measurement results for dissimilar material molded gear reducer (without grease)

Silence

A noise reduction of 3.6 dB was achieved compared to the metallic reduction gear.

Noise level [dB]		Input speed [rpm]				
		100	200	300	400	500
Load torque [Nm]	2.5	58.78	59.26	59.20	59.72	60.82
	5	58.98	58.98	59.52	60.45	61.62
	7.5	59.30	59.12	59.78	60.77	62.40
	10	59.16	59.10	59.78	61.10	62.80

Metal



Noise level [dB]		Input speed [rpm]				
		100	200	300	400	500
Load torque [Nm]	2.5	58.36	58.72	58.56	58.88	59.50
	5	58.36	58.18	58.48	58.60	59.30
	7.5	58.36	58.24	58.73	58.75	59.44
	10	58.54	58.44	58.46	58.60	59.16

Plastic w/o grease