

# High Performance Gears with JTEKT Only One Technology

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Concerns about environmental issues are accelerating the adoption of electrification in vehicles, and the demand for electric units (eAxle) is also rising rapidly. In addition, declining birthrates and aging populations are increasing worldwide, which is increasing the demand for industrial robots. JTEKT proposes gears with Only One technology that is not available from other companies, by combining the strengths of analysis technology (gear double digital twin) and manufacturing know-how cultivated in automobile parts, bearings, machine tools, etc. Aiming to be a comprehensive gear builder, JTEKT contributes to society by "delivering the gears the world wants".

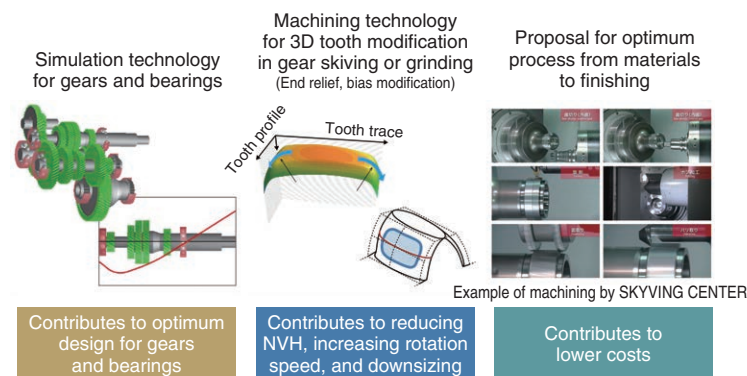
**Key Words:** gear, 3D tooth modification, gear double digital twin, gear machining, gear skiving, gear grinding, eAxle, industrial robots

## 1. Introduction

With growing global concern about environmental issues, the Japanese government has declared a goal of zero greenhouse gas emissions by 2050 for achieving carbon neutrality. In the automotive industry, carbon neutrality has become an unavoidable issue, and the demand for electric units (eAxle) is rapidly increasing in line with major transformations such as CASE and MaaS. At the same time, industrial robots are being increasingly adopted for the purpose of automation and labor saving in factories against the background of a shrinking workforce due to the global aging of society and falling productivity due to the COVID-19 pandemic. Recently, collaborative robots that work together in a human environment have started to be used. In this era of major innovations, the main units of automobiles and industrial robots have been undergoing major structural changes, but the fundamental elements and technologies used in these units remain unchanged. We believe that the competitiveness of

automobiles and industrial robots will be determined by their degree of technological superiority. As an approach to basic elements and technologies, JTEKT focused on gears, where it can take advantage of its analysis technologies and manufacturing strengths developed in the fields of automotive parts, bearings, and machine tools. Specifically, as shown in Fig. 1, we have prepared to provide customers with Only One technology that no other company has by integrating our strengths in gear and bearing simulation technology, 3D tooth modification machining technology in skiving and gear grinding, and optimal proposals for the entire process from materials to finishing.

In this report, as a comprehensive gear builder, we present the Only One gear technology that utilizes unit structure analysis technology combined with bearings under the concept of "Gear Innovation—Delivering your idea of gears to the world" and an overview of the Gear Innovation Center opened in November 2021.



**Fig. 1** Only One technology of JTEKT gears

## 2. Double Digital Twin for Gear Engineering (Simulation Technology)

With the growing shift to electrification of automobiles, the automotive parts used in these vehicles require even higher efficiency and quieter operation (Fig. 2). For example, for electric units (eAxle) used in electric vehicles, the need to normalize gear meshing under more severe operating conditions is expected to increase, along with the demand for downsizing and lower costs.

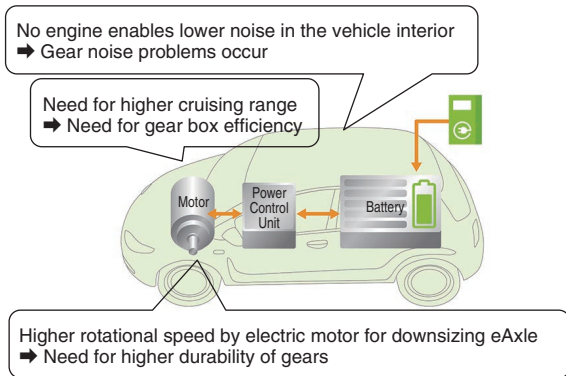


Fig. 2 Changes in the electric vehicle field

The JTEKT Group has world-class gear machining technologies such as skiving and gear grinding, and has taken on the challenge of mass-production for 3D tooth modification machining through the development of machining simulation technology for these machine tools. Also, a simulation system called the double digital twin for gear engineering was built by linking the digital twin\*1 in gear performance (sound, vibration, strength, etc.) with the digital twin in machining (shape, accuracy, time, etc.). This makes it possible to propose optimization

of structure and machining (Fig. 3). The digital twin for gear design combines each performance simulation and verification cycle to enable overall system optimization (Fig. 4). In the digital twin for gear machining, the machinability and accuracy for 3D tooth modification derived from the performance simulation are analyzed and verified by machining simulation based on experience (Fig. 5).

This will enable us to propose high-performance gears and reduction gears that are compact, durable, and low-noise and to work to develop new products and reduce the use of resources through miniaturization. In addition, JTEKT will flexibly respond to production fluctuations and process changes due to process consolidation by taking advantage of its strengths as a gear line builder. Moreover, we will propose efficient and stable gear production by providing solutions such as tool cost reduction through tool life prediction using AI technology.

\*1 Digital twin refers to a technology that reproduces various data collected from the real world on a computer like a twin.

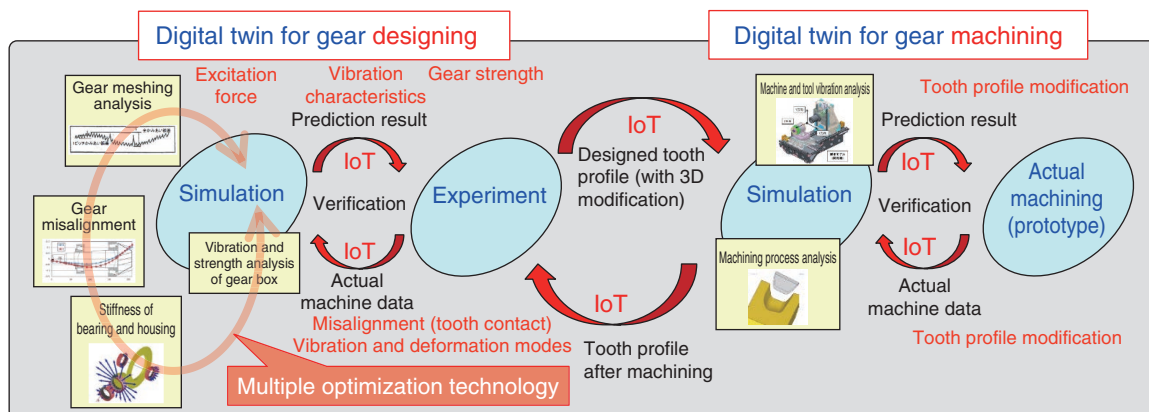


Fig. 3 Concept of Gear Double Digital Twin

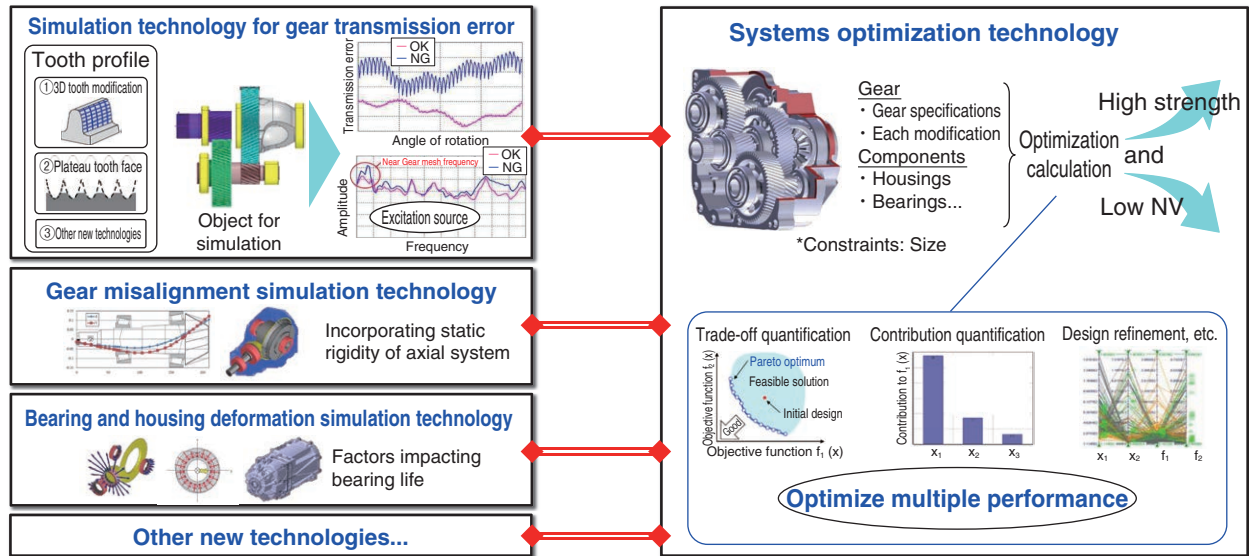


Fig. 4 Concept of digital twin for gear performance development

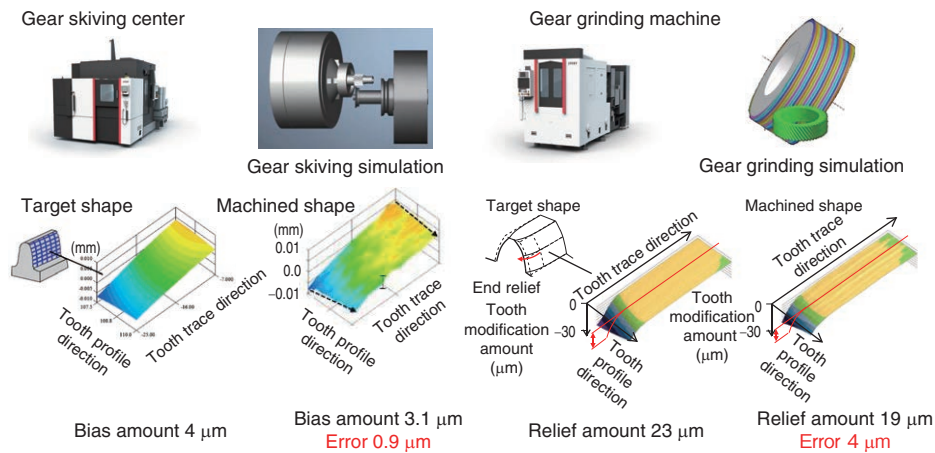


Fig. 5 Gear machining digital twin concept

### 3. Application Examples of Only One Technology (3D Tooth Modification Technology)

This report presents the results of the verification of the effectiveness of 3D tooth modification generated by skiving and gear grinding. Here, we show an example of applying 3D tooth modification to a gear that is cantilever-supported to reduce the size and weight of the eAxle (Fig. 6). This is a result of a tooth modification called end relief, which modifies the meshing and reduces wear on the tooth face.

The gear specifications were as follows: Center distance 65mm, module 1.55, pressure angle 22°, torsion angle 26.5°, number of teeth 15/61, effective tooth width 24.5mm, and overall meshing ratio 3.47.

The results of those incorporating end relief were compared with edge contact gears. The analysis shows

that applying the end relief reduces the surface pressure by about 22%, and the maximum position of the end relief is shifted from the edge of the tooth width toward the center of the tooth width. As a result of the durability evaluation, the edge contact gears showed significant wear progression at the tooth root of the drive gear due to trochoid interference, and pitting occurred at the tooth root side of the drive gear at 100 000 cycles, but the end-relief type showed less wear due to trochoid interference and no pitting occurred even at 250 000 cycles. Thus, it was shown that future gear systems can be downsized by applying gear analysis technology including bearing support rigidity and 3D tooth modification<sup>1)</sup>.

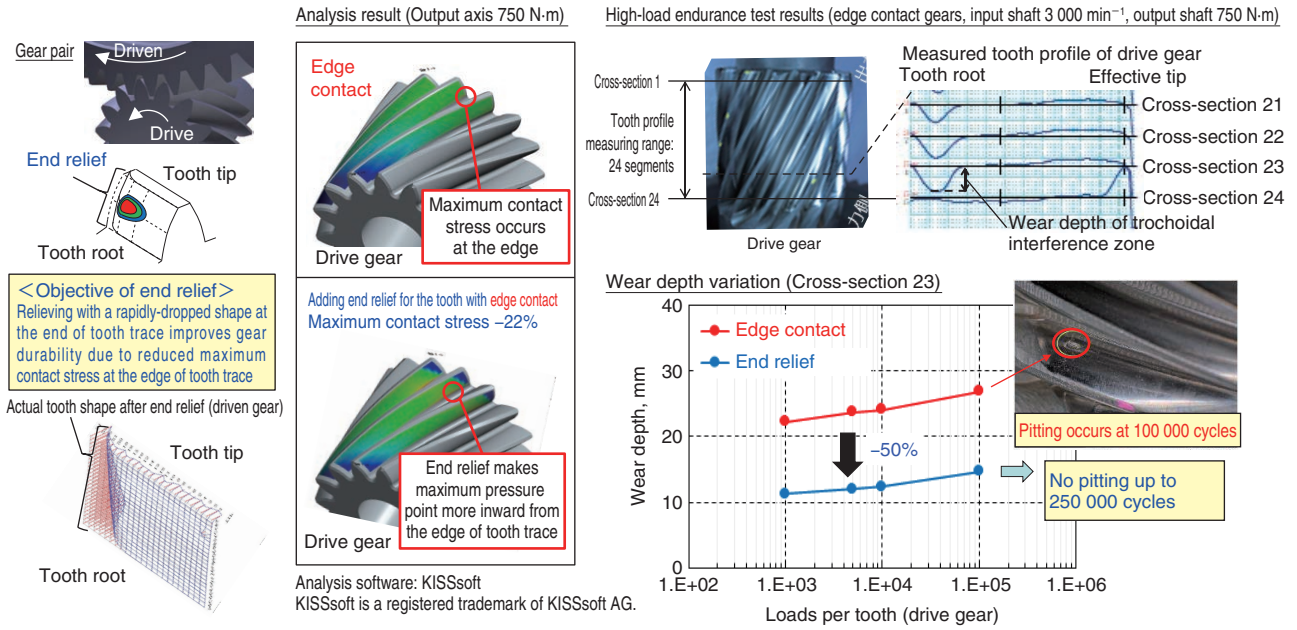


Fig. 6 Application example of 3D tooth modification

#### 4. Capabilities of the Gear Innovation Center

The Gear Innovation Center was opened in JTEKT's Kariya Plant, and the JTEKT Group has established a system to propose high-performance gears that meet customer needs in an extremely short period of time (Fig. 7).

This Center has lathes, gear skiving centers, cylindrical grinders, gear grinding machines, gear measuring machines, and other equipment permanently installed<sup>2)</sup>.

Also, in-house production of tools, mainly skiving tools, is possible at JTEKT's Sky Tool Factory.

This eliminates the need for customers to place orders with prototype manufacturers for each process and significantly reduces the labor required to coordinate prototypes through the process. As a comprehensive gear builder, JTEKT will contribute to the quick delivery of high-performance gears, including the above-mentioned 3D tooth modification prototypes (Fig. 8).

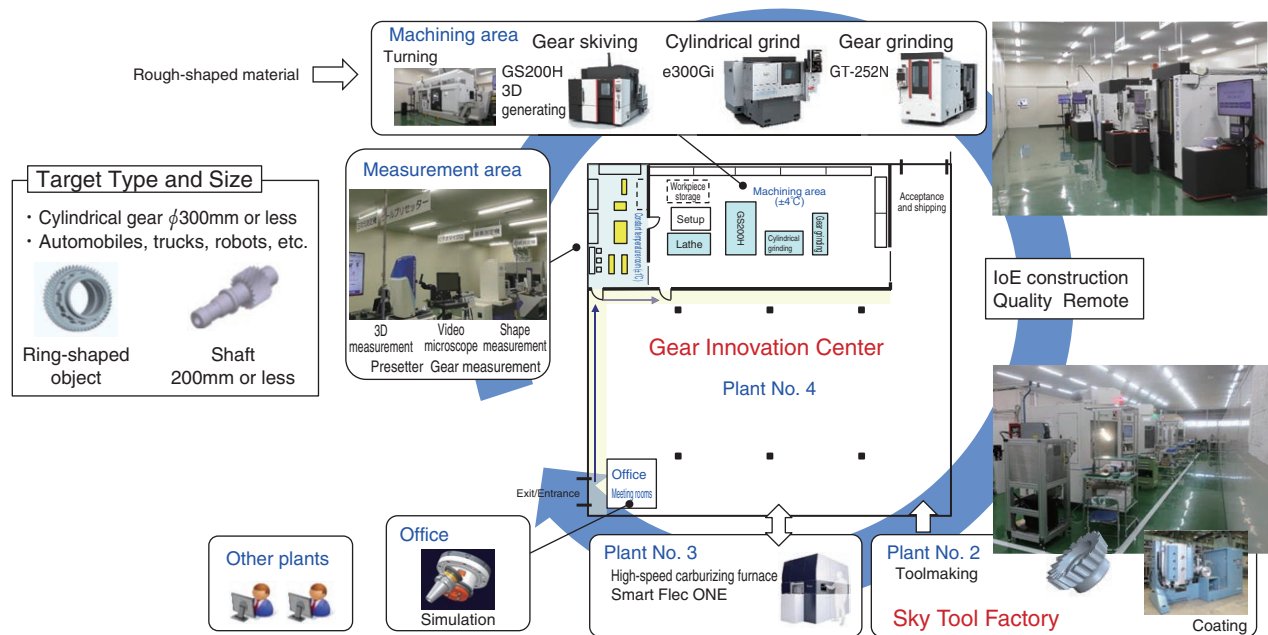
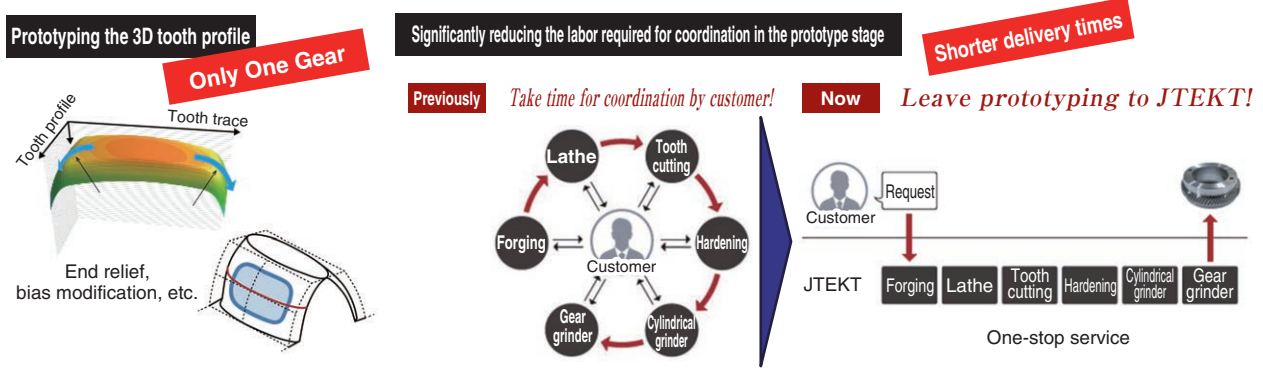


Fig. 7 Overview of Gear Innovation Center



**Fig. 8** Concept of Gear Innovation Center

### 5. Conclusion—Beyond a Comprehensive Gear Builder

By utilizing the gear analysis and machining technologies of the JTEKT Group and pursuing the Only One gear, we will work to contribute to the automotive and robotics industries and a wide range of other fields. Our goal is to create a world full of safe, secure, and comfortable products that are more useful and approachable to our customers. We would like to contribute to such a world by delivering your idea of gears to the world.

#### References

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