AUTONOMOUS AND ELECTRIC VEHICLE

RV Reducer

The component structure of RV reducers is extremely complex, requiring a complete integration of design, manufacturing, and assembly to ensure precision. Currently, domestic RV reducer manufacturers can only achieve accuracy and backlash, mostly within 2 to 4 arc. min.

Technical Advantages and Features

High Precision

- Transmission accuracy within 1 arc. min. (Industry average accuracy is 2 to 4 arc. min.

Design and Production Counselling

- Developed since 2015, this technology has yielded four cases of technology transfer and consulting, providing comprehensive industry solutions.

Performance Inspection of RV Reducers

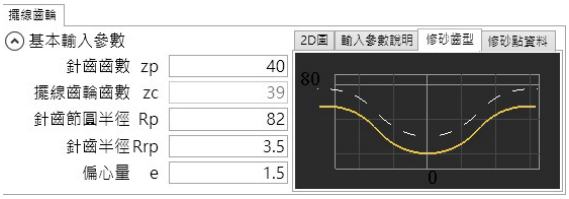
- Establishing an RV Reducer Performance Testing Laboratory to offer testing services to the industry.

Industrial Benefits and Business Opportunities

- **Industry Applications:**

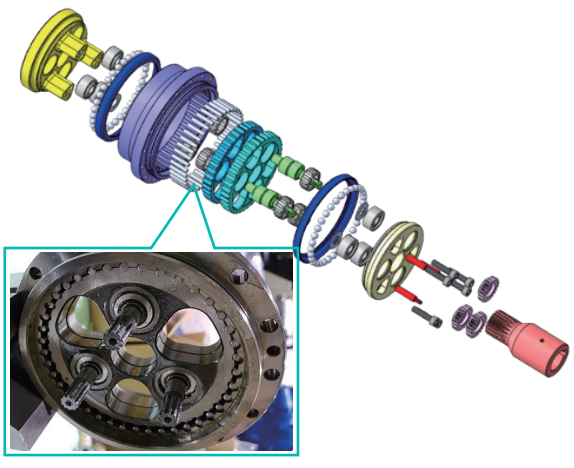
  Ship Industry, Automated Robotics Industry (e.g. AGV), Wind Power Industry.

- **Application Examples:**
  - The technology was transferred to Luyang Technology Co., Saynen Industrial Co. and Yonford Gear Industry CO., assisting them in designing RV reducers and establishing manufacturing processes. Luyang Technology Co. applied the technology to AGV and has successfully entered the Central Taiwan Erlin Science Park.
  - In collaboration with Transcyko, we helped the company identify the best methods for producing RV reducers and provided product verification services, enabling their reducers to be successfully sold in international markets.



Key Component Design of RV Reducer

Performance Inspection of RV Reducer



Internal Structure of RV Reducer

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High Precision Profile Grinding Service

Recently, the precision machinery industry has demanded higher accuracy in part contours and shapes, often requiring varied and small quantities. This technology enables manufacturers to perform high-precision grinding of inner and outer diameters and to offer customized, flexible production.

Technical Advantages and Features

Special Hole/Shaft Grinding Services

- Capable of grinding eccentric shaft holes, non-circular spindles, and special bearing surfaces.

Grinding Capability

- Utilizing STUDER's multifunctional grinding machines from Switzerland, suitable for producing high-precision components.
- Processing capabilities include a minimum internal diameter of 30mm, external diameters from 3mm to 200mm, and lengths up to 800mm.
- Processing capability can reach 0.002 mm.

Customized Small Quantities Services

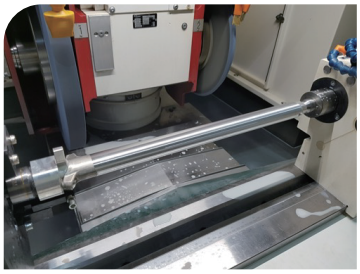
- Development of grinding processes for specialized shaft and hole components.
- Offering spindle repair services.
- Offering customized processes and small quantities services.

Industrial Benefits and Business Opportunities

- **Industry Applications:**

  High-Precision Components for the Machinery Industry (e.g. Flexible bearings, eccentric shafts for RV reducers and harmonic drive reducers, high-precision multitasking spindles, camshafts, and high-performance positioning modules.

- **Application Examples:**
  - Collaborated with Swiss bicycle manufacturer BMC to grind hollow, oval aluminum seat posts with a 1 mm thickness and 400 mm length, achieving a grinding precision of 0.03 mm and an average surface roughness of 0.15.
  - Developed a special-shaped inner diameter grinding process for bearing components in military drones, achieving geometric accuracy within 0.01 mm and average surface roughness below 0.1.
  - Developed grinding processes for RV and HD reducer components and CAPTO spindles, achieving precision up to 0.004 mm.



Grinding of Aluminum Oval Seat posts

Grinding of Non-Standard RV & HD Transmission Components

CAPTO Spindle Inner Hole Grinding Techniques & Measurement Results

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High-Precision Embedded Intelligent Gearbox

A reducer, a mechanical device, converts high-speed rotational power into low-speed, high-torque output. Maintenance is typically manual and scheduled, using external sensors to assess health and collect data. However, this method requires extensive transmission wiring, which interferes with signal collection if space around the machine is limited.

Technical Advantages and Features

High Precision and Efficiency

- When operating, a reducer's gear gap decreases precision. This technology reduces gear backlash from 8 to 4 arc. min, boosting precision by 50%.
- An autonomously designed high-efficiency gearbox operates at 3100 rpm and 81 Nm torque, achieving 98.4% efficiency, surpassing the industry standard of 97%.

Embedded Sensors

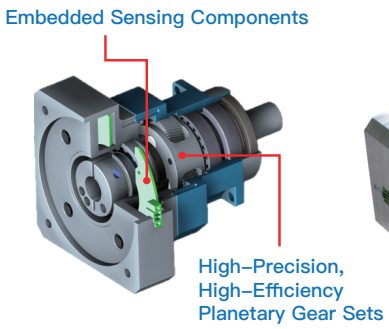
- Embedding sensing components, such as 3-axis accelerometers, temperature sensors, and WiFi transmission, in the reducer decreases its volume by approximately 40%.

High Precision Verification Platform

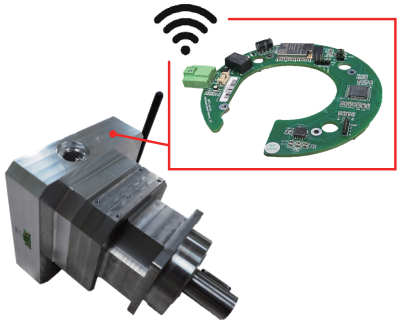
- Using a high-precision verification platform, we test for efficiency, gear backlash, torsional rigidity, and transmission accuracy, achieving errors under 5 arc seconds.

Industrial Benefits and Business Opportunities

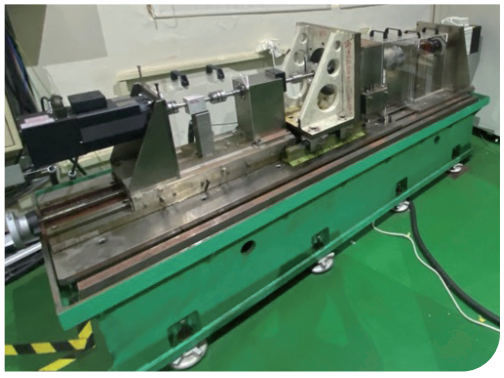
- **Industry Applications:**
  Gearbox Industry, Panel industry (e.g., transportation panel equipment).
- **Application Examples:**
  Verified by the top three domestic panel manufacturers, this solution addresses excessive equipment wiring and limited space, reduces manual inspection time, and enhances labor efficiency by over 20%, advancing smart manufacturing.



Intelligent Reducer
Internal Structure



Intelligent Reducer with
Embedded Sensing Components



High Precision
Verification Platform

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Transmission System Design and Analysis for EV

Designing electric vehicle transmission systems is complex, tailored to the specific vehicle model, chassis, and usage scenarios. It entails customizing component layouts and mechanisms, including the number of gear teeth, gear profile, and gear requirements, to meet product longevity, dimensions, and NVH (noise, vibration, and harshness) standards. This meticulous process is time-intensive and costly.

Technical Advantages and Features

Accurate Calculation of Gearbox Lifetime

- Products are designed with a multibody dynamics model and a design database to achieve mileage lifespans typically between 200,000 and 400,000 kilometers.

Patented Two-Speed Gearbox

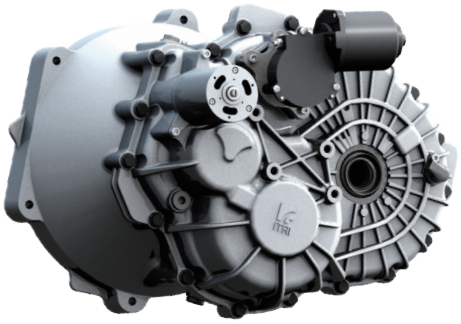
- Patented two-speed gearbox design, superior to typical single-speed electric vehicle gearboxes, meets real-world road requirements (low/high speed) with gear shifts under 0.4 seconds.
- Custom gear ratios and mechanism solutions are tailored to client specifications for vehicle model and performance.

Optimized Gear Design

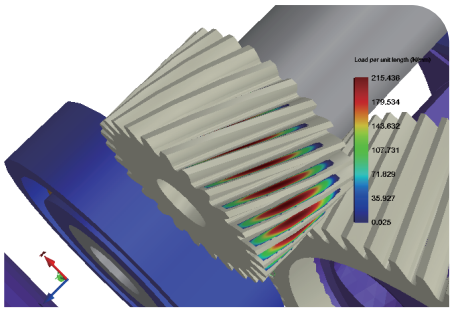
- Gear contact surfaces reduce pressure by up to 20%, extending gear life.
- Transmission error is reduced by up to 30%.
- Gearbox noise is reduced by 10 decibels, typically from 50 to 90 decibels with increasing speed.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Electric Vehicle and Vehicle Industry.
- **Application Examples:**
  This technology has been transferred to BATOM and CHENTA, and has also assisted ZEPT, GOGORO, and TDCM in becoming suppliers of power modules and components for electric vehicles, electric motorcycles, and electric-assist bicycles, both domestically and internationally (e.g., TESLA, CMC, GOGORO, BROMPTON).



Two-Speed Transmission Module Prototype



Gear Tooth Modification Simulation Analysis Diagram

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Electric Vehicle Digital Communication Conformance Testing Technology

During the charging process of electric vehicles, continuous message exchanges between the vehicle and the DC power supply equipment are necessary to ensure safety. However, due to the presence of various electric vehicle and DC power supply equipment manufacturers in the market, this technology is essential for digital integration to guarantee a safe charging process.

Technical Advantages and Features

Capable of Measuring High-Power DC

- Capable of providing high-power/voltage/current DC testing services up to 500 kW/1000 VDC/1200 A (typically 400 kW/1000 VDC/500 A), suitable for testing large electric buses.

Support Common Communication Standards

- Support commonly used communication protocols, charging methods, and charging interfaces.

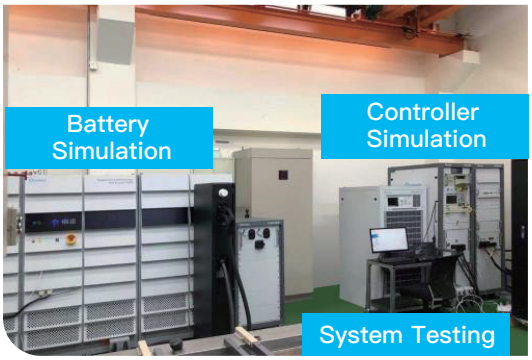
Approved by the Bureau of Standards, Metrology and Inspection

- Approved by the Bureau of Standards, Metrology and Inspection, it is the most comprehensive laboratory in the nation for testing equipment and specifications.
- According to international testing standards, the laboratory can test 100% of the vehicle classifications on the market.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  EV Industry, EVSE Industry.
- **Application Examples:**
  This technology has been transferred to numerous domestic manufacturers, assisting them in acquiring capabilities for "new product development verification" and "certification testing services", including EVSE suppliers: eTreego Co., Ltd, Delta Electronics, Allis Electric Co., Ltd, Mobiletron Co., Ltd., Aiox Innovation Company; and electric bus manufacturers: DE FINE BUS AND TRUCK CO., LTD, Master Transportation Bus Manufacturing Ltd., Tron Energy, TONG YING MOTOR CO., LTD.

E-Bus



Automated Testing System for Digita Communication Conformance

DC Charging Equipment

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Autonomous Driving

The transportation industry has faced challenges such as a shortage of professional drivers, long working hours, and risks of night operations in recent years. Therefore, autonomous driving systems assist the industry in automating and transforming to meet the rising demand while improving road safety.

Technical Advantages and Features

Autonomous Full-Speed Range Suitable for Multiple Vehicle Classifications

- Full-speed range suits various vehicles (sedans, trucks, buses, tractor-trailers, etc.).
- Applicable to vehicles with different power sources (diesel, electric, hybrid).
- Suitable for urban areas and highways.

Large-Scale HD Mapping

- Equipment installation and removal are straightforward and suitable for various vehicle classifications.
- Only 10% of the industry's hardware cost is needed to produce maps that meet the Ministry of the Interior's accuracy specifications.
- Centimeter-level positioning, unaffected by tunnel/bridge obstructions.

Implementation of International Standards for Verifying Cyber-Physical Systems

- Implementing International Safety Standards (IEEE 2846, ISO 21448) to ensure the safety of autonomous driving decisions.
- Customized high-fidelity traffic scenarios integrated with real traffic data.
- Verifying Cyber-Physical Systems to ensure the safety of real-vehicle testing in open fields.

Industrial Benefits and Business Opportunities

- **Industry Applications:**

  Logistics Industry, Intercity Bus Industry.

- **Application Examples:**
  - In cooperation with Transurban, Australia's leading road operating company, the autonomous tractor-trailer was conducted at night on Melbourne's M1 freeway. It was Australia's first highway autonomous driving test case and Taiwan's first international export of open-road for autonomous driving.
  - In collaboration with Taoyuan International Airport, autonomous vehicles have provided shuttle services between Terminals 1 and 2, establishing Taiwan's fastest operational autonomous vehicle service. This initiative, alongside Waymo's service at Phoenix Sky Harbor Airport, represents the second global case where autonomous vehicles operate on the airport's open roads.
  - In partnership with HCT Logistics Company, the autonomous logistics service was implemented between fixed business locations and customer sites in Hsinchu City, marking it Taiwan's first self-driving logistics application.

Australia Transurban
35-ton Container Tractor Trailer Truck

Taoyuan International Airport
Autonomous Shuttle Service

HCT Logistics 5-ton
Autonomous Logistics Vehicle

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Digital Twin Technology and High-Fidelity Vehicle Model

For vehicle manufacturers, accurately predicting performance and handling during the early stages of vehicle development is a challenging task. Previously, validating with actual vehicles required significant testing resources and was time-consuming, leading to excessively long product development cycles.

Technical Advantages and Features

High-Fidelity Vehicle Model

- Using multibody dynamics to construct models, the accuracy of control simulations exceeds 90%.
- The battery's SOC (State of Charge) estimation accuracy is up to 97%.

Full Vehicle System Simulation

- Based on model development and employing Functional Mock-up Units (FMU), this approach ensures model sharing and interoperability.
- Reducing models from 3D to 1D retains 80% accuracy and achieves real-time simulation calculations.

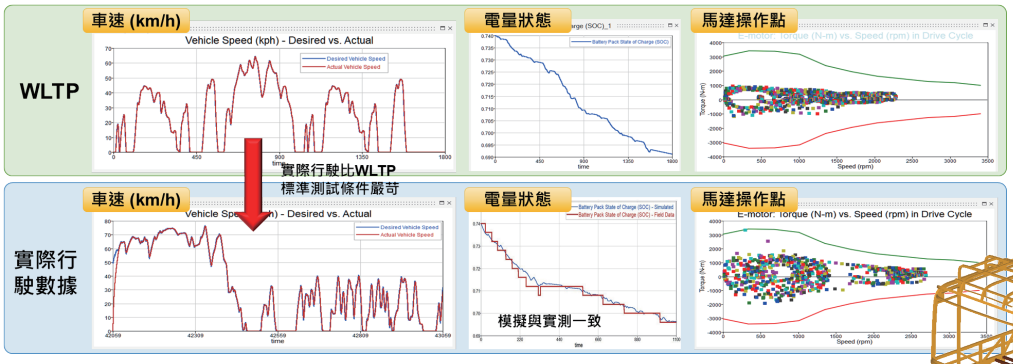
Electric Vehicles Database

- Suitable for electric vehicles. Customized vehicle/power system modeling.
- 7~12 meter buses.
- 3.5~26 tons trucks.

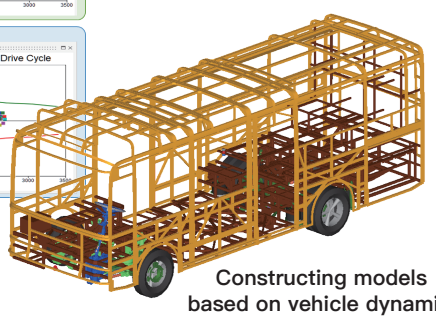
Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Electric/Fuel cell commercial vehicles (buses/trucks).

- **Application Examples:**
  - This technology has been transferred to the electric bus manufacturer Tron-e, which has obtained Lane Keeping Assist CSF/ACSF certification, enhancing safety.
  - For electric buses operating on specific routes, whole-vehicle simulations were conducted; the battery status simulations correlate with actual test results.



Energy Consumption Simulation



Constructing models based on vehicle dynamics

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Motor Controller Technology

Most electric vehicles use AC motors as their driving core, but the batteries supply DC power. Therefore, it is necessary to use a motor controller to convert DC into AC. The conversion process incurs power losses, which increase proportionally with the rise in driving power.

Technical Advantages and Features

Taiwan's First SiC Motor Controller

- Characterized by low switching losses, it is capable of reducing power consumption by 50%.
- Featuring variable frequency with a small size and high efficiency, achieving a power density of 60 kW/L (compared to the current domestic industry standard of 26 kW/L).

Integrated Cooling System

- Cooling of key components such as power modules and capacitors is conducted simultaneously, increasing the motor's rated power (continuous output) by 10%.
- Integrated design reduces the volume of water channels and lowers the cost of the cooling system by 50%.

Multi-Core High-Efficiency Processor

- Established a multi-core high-efficiency processor platform capable of handling high-frequency, high-speed application scenarios.
- In response to market demand, an all-in-one power system has been assembled, integrating components such as the motor, gearbox, and drive controller.

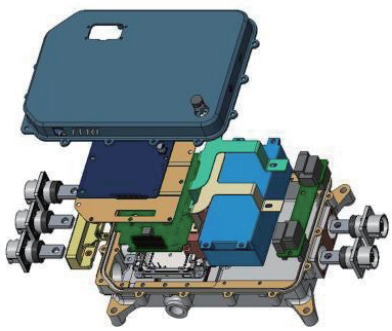
Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Electric Mobile Vehicle Industry (e.g. Electric Vehicles, Boats, Drones).

- **Application Examples:**
  This technology has been transferred to major Taiwanese power motor manufacturers, including Shihlin Electric & Engineering Corp, Tatung, TECO, and Actron Technology Corporation, successfully accelerating the domestic self-sufficiency of critical modules. The CMC Veryca E300 utilizes this core technology. Additionally, the technology has been transferred to the top five Taiwanese ICT electronics manufacturers, aiding the domestic ICT industry in entering the electric vehicle supply chain.

Transferred to TECO, Tatung, Shihlin Electric & Engineering Corp
IGBT Motor Drive Controller Technology

Derivative Technology Facilitated by CMC
Launch the newly redesigned e-VERYCA E300



Transferred to Major ICT Companies
≥200 kW SiC Motor Drive Controller Technology

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