GCX LINEAR SKIVING SOLUTION

A practical closed-loop solution for producing the highest quality skiving tools.

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TX machine platform, Gear Tools

ANCA

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Growth of electric vehicles is up

10 million

electric cars on the world's roads at the end of 2020

41%

increase in **EV registrations** in 2020

40%

increase from 2019-2020 in electric car models

18 out of 20 largest global OEMs are **increasing sales** of EVs

EV30@30 –

30% market share

target for EVs by 2030: goal of **245 million EVs** in stock

GEAR UP FOR SKIVING

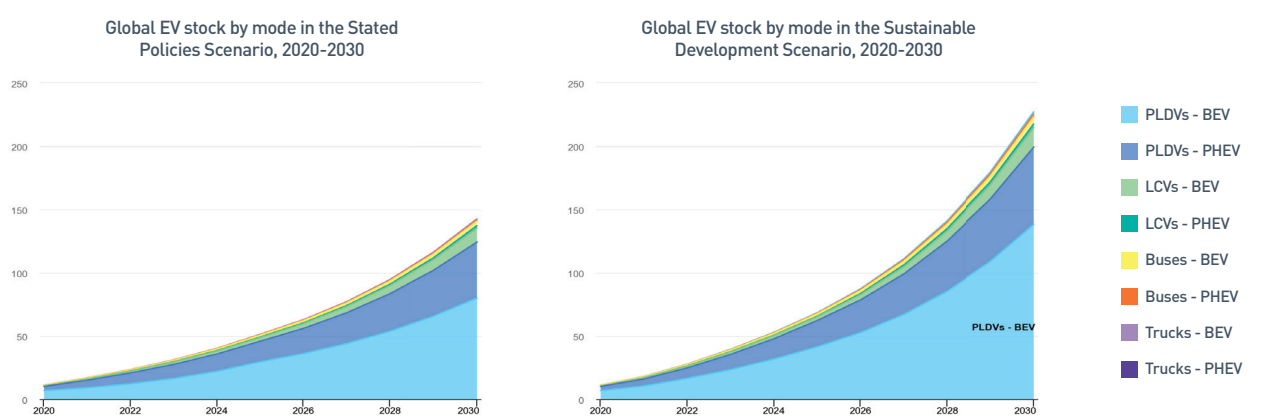
EV30@30

The popularity of skiving is driven by electric cars. According to the Global Electric Vehicle (EV) Outlook 2021 report, there were 10 million electric cars on the world's roads at the end of 2020, following a decade of rapid growth. Electric car registrations increased by 41% in 2020, despite the pandemic-related worldwide downturn in car sales in which global car sales dropped 16%.

Worldwide, about 370 electric car models were available in 2020, a 40% increase from 2019. 18 of the 20 largest Original Equipment Manufacturers (OEMs), such as the BMW and GM Groups, have committed to increasing the offer and sales of EVs.

Manufacturers' electrification targets align with the International Energy Agency's (IEA's) Sustainable Development Scenario, aiming to reach 245 million EVs in stock, 30% of the market share, by 2030.

Passenger cars drive the growth of electric vehicles to 2030



Notes: PLDVs = passenger light-duty vehicles; BEV = battery electric vehicle; LCVs = light-commercial vehicles; PHEV = plug-in hybrid electric vehicle. The figure does not include electric two/three-wheelers. For reference, total road EV stock (excluding two/three-wheelers) in 2030 is 2 billion in the Stated Policies Scenario and 1.9 billion in the Sustainable Development Scenario. Projected EV stock data by region can be interactively explored via the Global EV Data Explorer. Source: IEA analysis developed with the Mobility Model.

From DIN 10 to DIN 6

45% of all gear production is for vehicle transmission. The rise of EVs is changing the requirement for the gear industry. The high engine speed of up to 20,000 rpm means a higher gear ratio is required for efficiency. The planetary gear set is more prevalent in the new design.

In a planetary gear set, also known as the epicyclic gear train, the sun and planet gears are external gears assembled inside a ring gear. The external gears are produced by hobbing then grinding. The internal ring gear, traditionally produced with shaping or broaching, shaping is slow, while broaching relies on cumbersome tooling.

Another trend driven by the more compact new transmission design is multiple gears on one shaft that are very close to each other; due to the interference, the smaller ones on the shaft can not be manufactured by hobbing.

Efficiency poses multiple challenges, but EV's noise emission is also of much higher priority for customers. Gears for EV need to meet even tighter tolerance - increased from DIN 10 to DIN 6; the gear industry sees hard skiving as a revolutionary process to produce the millions of gears needed for the new EVs.

Skiving is a continuous material removal process, combining the rolling motion and milling motion. While meshing with the gear as a pinion cutter, the cutter simultaneously travels along the gear's axial direction. It is as efficient as hobbing, reportedly five to 10 times faster than shaping.

Skiving forms shorter chips, skived gears show higher quality, with lower surface roughness. The most challenging solid carbide skiving cutters are needed in the hard skiving process after heat treatment.

GCX Linear for skiving cutters

Responding to the market demand, ANCA brings a complete solution for manufacturing and sharpening skiving cutters. The GCX Linear sets the new standard for producing the highest quality skiving tools in both carbide and HSS.

Its integrated gear tool measurement system provides an accurate closed-loop manufacturing process, an industry-first innovation.

The GCX Linear solves the challenges for producing high-quality skiving tools:

CHALLENGE 1. COMPLEX GEOMTERY

GCX Linear's comprehensive software package solves the geometry

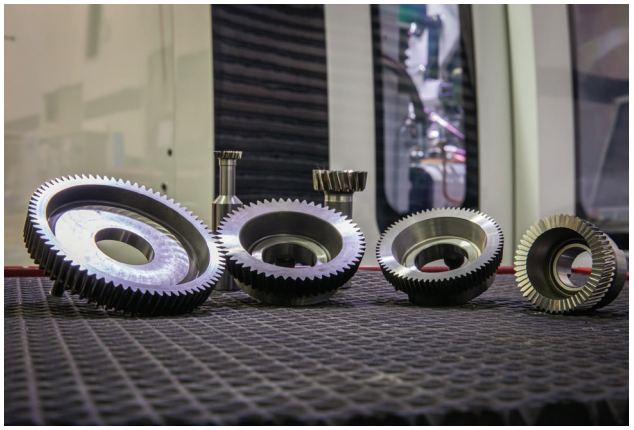
Powerful design software

The GCX Linear comes with parameterised design software, it calculates cutter geometry directly from gear parameters, provides collision analysis and grinding simulation.

Various forms of skiving and shaper geometry can be designed: topping cutter, non-topping cutter, semi-topping or chamfer cutter, and free form such as cycloidal gear tooth can be imported directly as DXF.

Gear cutting tools, such as skiving and shaper cutters have complex geometries. The design process relies mainly on iterative optimisation. The cutter can be designed from basic gear workpiece data or the transverse section of the enveloping gear on the design station.

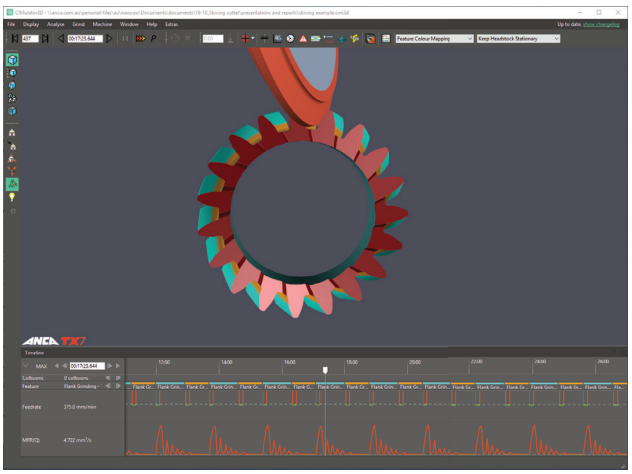
The skiving kinematics can also be simulated to verify the cutter design and potential collision rectified.



A complete package

The GCX Linear software package also includes multiple software components for manufacturing and resharpening pinion type gear cutters. It includes design, simulation, grinding sequence programming, wheel editing and wheel dressing, supporting full virtualisation of the manufacturing process.

Virtualisation of the entire manufacturing process reduces setup time and scrap, allowing streamlined manufacturing.



CHALLENGE 2. TIGHT TOLERANCE

ANCA offers a suite of technology purposely built for skiving cutter grinding

GCX Linear achieves DIN AA quality with a suite of breakthrough technologies based on ANCA's flagship TX platform: MTC (Motor Temperature Control), AEMS(Acoustic Emission Monitoring System), high accuracy headstock, large envelope, LinX linear motor on all linear axis, iBalance and variable coolant control.

MTC

MTC is a patent-pending innovation built into the motor spindle drive firmware. An intelligent control algorithm actively manages and maintains the temperature of motorised spindles in the GCX Linear.

MTC is the cure for the "one heartbeat" symptom, where the pitch of the tool shows a sudden jump due to thermal variations. GCX routinely achieves AAA and AAAA class quality on tooth spacing, thanks to the stable machine condition.

High accuracy headstock

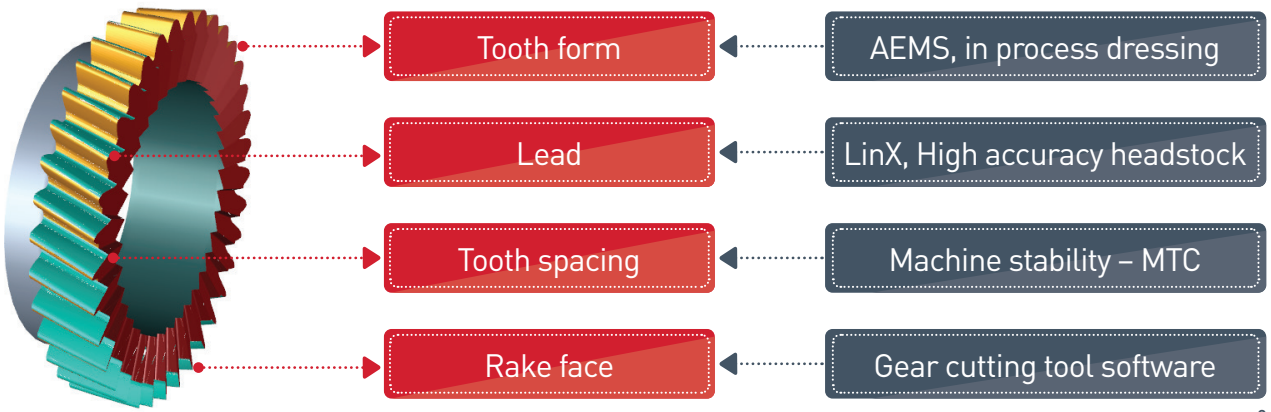
Large disk type skiving cutters and shaper cutters require higher indexing accuracy, as the impact of A-axis positional error will linearly increase with diameter. This enhancement improves the A-axis accuracy by a factor of 10. The positional accuracy is now ±0.00034 degrees.

Example pitch measurement report of a skiving cutter produced on GCX Linear with individual pitch error fp measured around 1µm, adjacent pitch error fu measured less than 2µm.

Powered by LinX®

In conjunction with linear scales, ANCA's LinX® linear motor technology for axis motion (X, Y and Z axes) achieves superior precision and performance. Specially designed for a lifetime of operation in harsh grinding environments, the LinX® motors have a cylindrical magnetic field which means there is no additional downforce on the rails or machine base.

With no temperature variations (meaning no need for a separate chiller unit) and sealed to IP67, there is minimal wear and tear so that the machine accuracy remains over the lifetime of the machine. The LinX® linear motor has higher axis speed and acceleration, reducing cycle times while maintaining a smooth axis motion.



CHALLENGE 3. MEASUREMENT

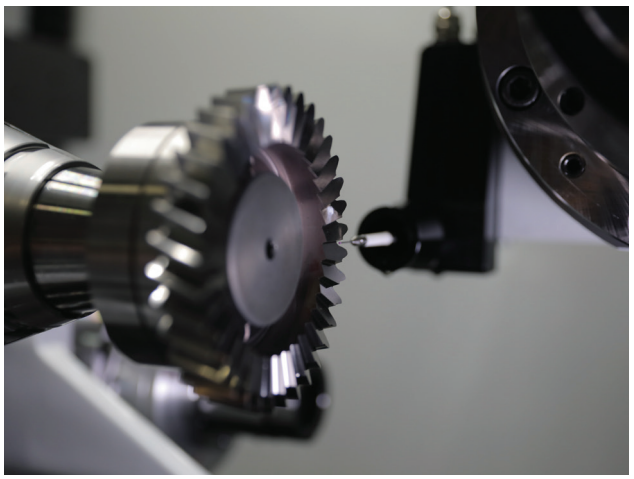
Industry-first integrated gear tool measurement system measures the tool in the machine

GCX Linear is the only CNC grinding machine equipped with onboard gear tool measurement system. It can evaluate the tooth spacing and form according to the DIN 1829 standard without unclamping the tool.

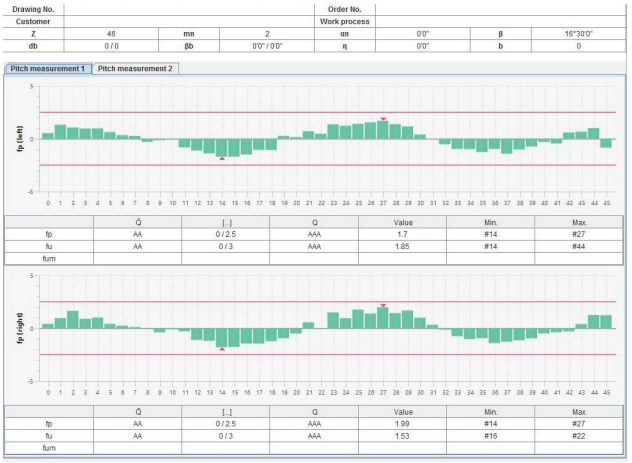
Tooth spacing

Tooth spacing measures the pitch, fp is the individual pitch error, which is the deviation of a particular tooth to tooth pitch from the nominal value. Cumulative pitch error Fp is the cumulated result of adding the previous tooth errors together. fu is the adjacent error. On a typical measurement report, tooth spacing measurement is illustratrated as a bar chart, with a bar for each tooth.

With GCX Linear's pitch measurement operation, the operator can quickly verify the pitch accuracy instead of taking the tool out and moving it to the measurement machine. It uses the digital function of the probe to touch the flank close to the pitch diameter.



The chart generates instantly as the probing continues; the report is neat and clean, user-friendly and interactive. The measurement result is comparable to the measurement machine.



Tooth form

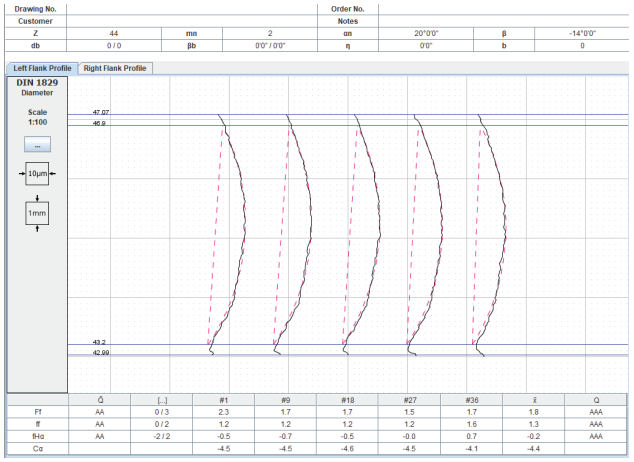
The concept of tooth spacing is relatively straightforward, so is the measurement. The tooth form, however, is more complicated. To compare a skiving cutter with a shaper cutter, although both are classified as pinion type gear cutters, the relative movements between the gear and the tool are different.

The principles of the shaper cutter are based on a pair of parallel axes gears. In contrast, the skiving cutter's is based on a pair of gears with crossed axes. Subsequently, the profile and geometry of a skiving cutter are more complex than a shaper cutter.

Although they are indistinguishable to the eye, the skiving cutter tooth profile is different from the shaper cutter.

Due to the novelty of the skiving cutter, many industry benchmark GMMs (gear measurement machines) have yet to develop in-built mathematical models for evaluating the cutter profile. ANCA's onboard tool measurement can evaluate directly against the cutting edge's correct mathematical form in the machine, which is a leap forward for the industry.

The profile measurement operation calculates the analogue probe's path, and the probe scans the tooth profile at a given depth. The charts are drawn on the report window instantly. The report is much easier to decipher.



CHALLENGE 4. WHEEL DRESSING

Dress diamond wheel into complex forms within micron accuracy

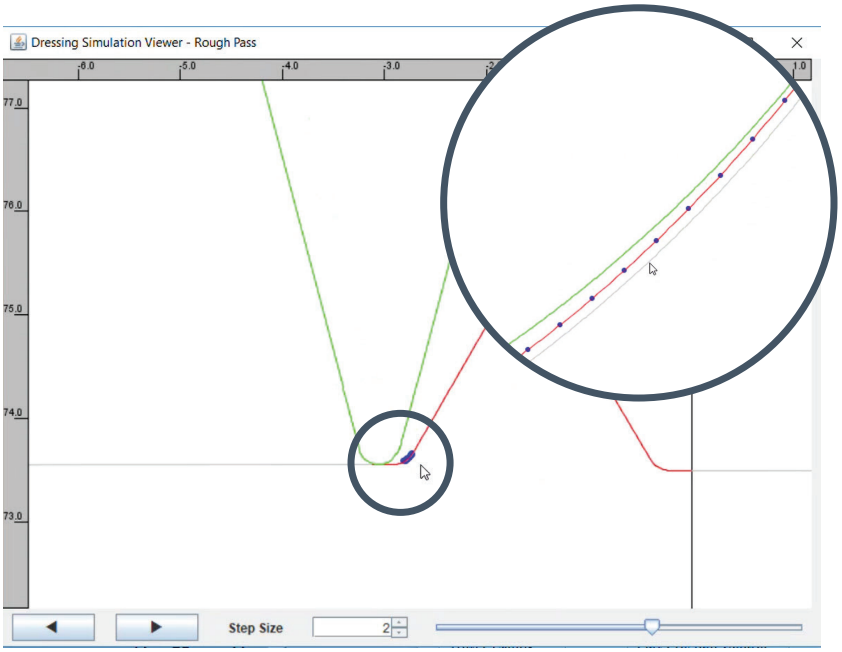
AEMS

Dressing the complex wheel profile is critical for the skiving application; ANCA developed the latest acoustic emission monitoring system (AEMS). AEMS can be taught to pick up the right sound of perfect dressing in a noisy production environment. AEMS utilises a supervised machine learning algorithm, which ensures the wheel profile is dressed within micron accuracy, this minimises cost and improves efficiency.

Dressing diamond wheels

To manufacture solid carbide skiving tools requires diamond grinding wheels, which are extremely difficult to dress. ANCA's advanced software derives simplified wheel form, reducing the cost of dressing significantly. The intelligent software can also import the wheel measurement report directly from a Zoller measurement machine, analyse the error and automatically compensate for the subsequent passes.

It even comes with dressing path simulation. Typically the most critical geometry of the wheel is the flank, whereas the tip and root area can afford relatively larger deviations. With the simulation, the user can set the tolerance, and the program can highlight the problematic area automatically.



CHALLENGE 5. QUALITY CONTROL

A complete closed-loop production: Grind – Measure – Compensate all inside the machine without the need to unclamp the tool

Measure in process

The in-process measurement significantly improves the process control. For example, when the tooth profile shows different patterns between different teeth, this often indicates that the wheel wear during the finishing cycle is too much; the wheel did not hold the form.

By measuring the profile between the roughing and finishing operations, the user can monitor the wheel wear and proactively manage the grinding wheel's dressing and sticking. It can help determine the dressing frequency and reliably control the infeed, grinding feedrate and other process parameters. This improves the overall quality and controllability.

Closed-Loop production

To reduce the dressing frequency, ANCA developed direct path compensation on the machine. The design process for skiving cutters requires iterative design. After carefully choosing the compromises, the software produces a wheel profile and a grinding path.

These files are sent to the grinding machine to grind the tool. If there are errors in the cutter after measurement, the previous method to compensate is to recalculate the wheel profile and redress it onto the wheel.

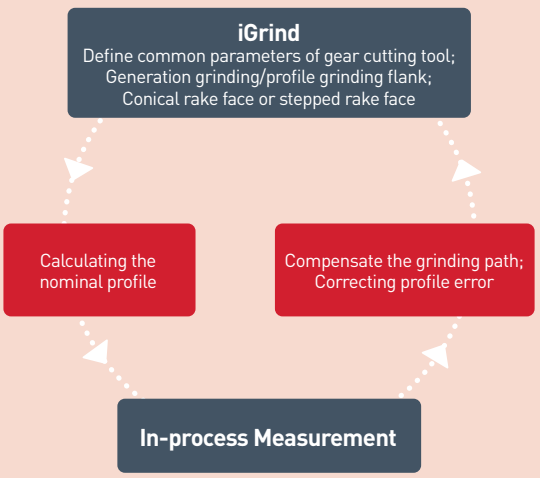
Which requires multiple back and forth between the design station, the grinding machine and the measurement machine; it is time-consuming and makes it extremely challenging to establish a stable process. The GCX Linear approaches the compensation differently; instead of changing the wheel profile, the software compensates directly on the grinding path. With the in-process measurement, it localises the closed-loop all on the GCX Linear.

Without taking the tool or the wheel out of the machine, it can compensate for errors in one clamping.

In summary, in-process measurement significantly improves the manufacturing process of skiving cutters: the machine can evaluate the profile against the correct mathematical form, which is a leap forward for the industry. Together with direct compensation, skiving cutter grinding on GCX Linear is an efficient, practical closed-loop solution.

GCX LINEAR

- On machine direct path compensation
  - No need to redress the wheel
- In process measurement
  - No need to take the tool out



CHALLENGE 6. KNOWLEDGE GAP

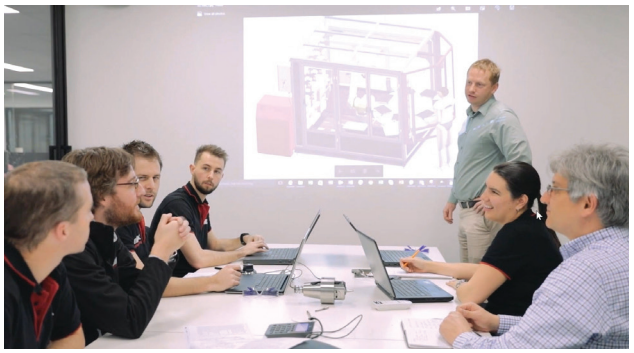
ANCA application specialists are here to help every step along the way

Gear cutting tool design

Gear and gear cutting tools require preknowledge for basic gear terminologies. Skiving cutters especially have very complex geometries. The cutter can be derived from target gear workpiece data or the transverse section of the enveloping gear.

Although the software is powerful and intuitive, the design process is an iterative optimisation process that can take some time to master. Design engineers need to understand the tradeoffs to make the best compromises – considering skiving kinematics, critical requirements and many practical limitations.

It might seem daunting, but ANCA's team of application specialists are here to help. They provide training programs and recommend learning courses to help the engineer/operator step into the exclusive gear cutting tool world.



Developing and sharing process knowledge

The stringent tolerance and complex geometry make skiving cutters one of the most challenging applications known to the tool grinding field to date, especially the solid carbide cutters.

The suite of the technology built into the GCX Linear can achieve the highest DIN AA quality, but the process and setups are also essential to success. The application specialists in ANCA with extensive field experience offer complete process knowledge: from wheel selection, grinding infeed, dressing frequency to coolant pressure adjustment and more.

Our customers' success is our success; service and training are integral parts of ANCA's core values. Our team will help adapt the standard process to the customer's factory environment and equipment.

Innovation is in ANCA's DNA; we are proud to contribute to advancing the next level of grinding technology to enable the adoption of the skiving process. A more efficient production process of gears will help roll out the millions of EVs needed for a net-zero emission future.

About ANCA

The ANCA Group of companies consists of ANCA CNC Machines, ANCA Motion and ANCA Sheet Metal Solutions. The ANCA Group invents technology to keep businesses innovating through the design and manufacture of Machine Tools, Motion Control Systems and metal fabrication.

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