RE-INVENTING TURNING

FOR THE FUTURE FACTORY, TODAY

SANDVIK COROMANT TECHNICAL PAPER

"Close to 70 million cars are produced globally every year, and the numbers are growing year by year. To cope with the competition, smooth production lines with few stops are critical."

Håkan Ericksson,
General Turning Product Manager, Sandvik Coromant

In all the dialogue and literature about "Industry 4.0" today, two words come up repeatedly: **productivity** and **flexibility**.

To this we must also add sustainability.

Productivity, loosely defined as GDP per hour worked, has dogged some countries and sectors for decades. The Conference Board and Eurostat figures for productivity by nation puts Germany at 7th, Sweden at 11th and the United Kingdom at 13th, a long way off Norway and Luxembourg at the top. Successful manufacturing companies can find these figures baffling, having spent decades becoming much leaner machines and temples of continuous improvement. Research by EEF, the UK manufacturers' organisation, shows that productivity in manufacturing is ahead of services. But the bald numbers are still there.

Flexibility is linked to productivity. Machine shops and engineering companies will need to use more technology that can adapt to changing customer needs mid-run, or even within batch, as both customer service and mass personalization become hallmarks of how businesses differentiate.

In an engineering environment, all the component parts of the shop floor – the machines, conveyors, tooling, metrology, material handling equipment, sensors – are striving to reduce cycle times and increase profits to keep the owners of these technologies competitive.

Machining centres have developed faster spindle speeds, twin turrets and twin pallets. Tools for optimum material removal rates can be selected using special tooling guides in cloud platforms, a Sandvik Coromant innovation. Workholding devices grip tighter and can be released quicker, non-contact metrology devices scan components for flexible, portable measurement, "smart" kanban systems replenish goods autonomously. The smart machining centre depends on fast, accurate cutting technology.

But while there is a lot of talk today about smart factories, precision engineers don't have to take a quantum leap into the future to increase productivity. Small but crucial changes to their processes and tooling can produce a measurable improvement in output for the same or reduced costs.

For metal removal, a process that is constrained by the hardness of the material, imagine the gains for engineering companies if they could double metal removal rates on the same machine. "Customers often think their machining efficiency is between 70% and 80%. But when you interrogate it we think the industry, on average, is operating at machining efficiency below 50% on actual cutting time," says Francis Richt, Manager for Digital Machining Business at Sandvik Coromant.

Enter Sandvik Coromant's new PrimeTurning™ and CoroPlus® solutions, the outcome of a five-year

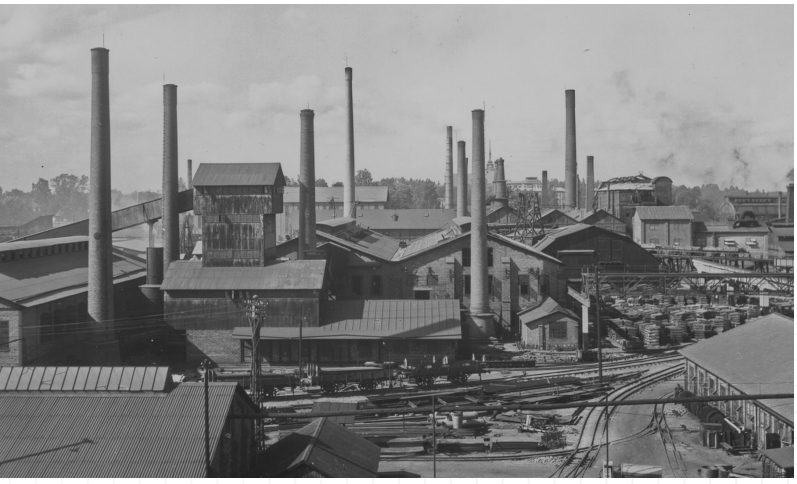
development journey to create essential elements of the next generation of metal removal technology.

Running underneath the modern machining principles of productivity and flexibility is sustainability. "We believe in driving the ambition of a more sustainable supply chain by reducing waste, in the design and planning of cutting but also in the machining," says Richt. "In the design and planning phase we measure waste of between 10% to 30% combined with typical machining efficiency below 50%. There is a lot of work to do here."

TURNING PRINCIPLES AND HISTORY

Conventional turning typically includes a non-rotary tool removing material as it moves from the end of a rotating component towards the chuck.

Records of an early industrial lathe exist from 1772, when a horizontal boring machine was installed at the Royal Arsenal, a former armaments manufacturer in Woolwich, London. It was horse-powered and featured a workpiece that turned, rather than the tool, making it technically a lathe.



Between the late 19th and mid-20th centuries, electric motors started to take over as the main power source. Then, beginning in the 1950s, servomechanisms were applied to the control of lathes, which were subsequently coupled with computers to yield computer numerical control (CNC).

Turning today has been refined to a trade-off between cutting angle and speed of cut.

The smaller the lead angle between the cutting edge and the feed direction, the greater the opportunity to increase feed, which means higher productivity.

Conversely, a small lead angle prevents the cutting edge from reaching the shoulder, and will provide long, curved chips that are difficult to control. This relationship between lead angle and productivity is an established fact – until now.

A shift from "Business as usual" turning

While experienced machine operators know that factors such as small entry angles permit increased feeds, they are restricted to around 90° in conventional turning in order to reach the workpiece shoulder and avoid the long, curved chips that small entering angles characteristically provide.

Parallel or simultaneous machining employs more than one cutting tool on a workpiece. It offers a potential increase in material removal rate/ productivity due to an increased number of tools. Parallel turning is in use in industry but requires more tools, therefore higher costs, is not as versatile as single-tool turning and is not in mainstream use.

In 2012, two Sandvik Coromant engineers decided to interrogate the lead angle–reach dilemma. Adam Johansson and Ronnie Löf's idea was simple but radical; for longitudinal turning to start at the chuck end and cut material 'backwards' as the tool traverses towards the end of the component. This would immediately solve the challenge of reaching the shoulder with a small lead angle.

"If turning is a bottleneck operation, the company is suffering a restriction on the number of components produced per run. And if machine utilisation is low, the potential to make more components in less time is being missed. PrimeTurning can help."

Håkan Ericksson,
General Turning Product Manager, Sandvik Coromant

Although some machine shops have already tried such a method, the problem has always been chip control, as the small lead angle still provides long, curved chips, regardless of the turning direction.

With an expanded engineering team, including Joe Truong and Krister Wikblad, Johansson and Löf solved the chip formation problem. Code generation software was developed.

The results: **the industry-defining PrimeTurning solution.**

THE CHALLENGES FACED BY THE PRECISION ENGINEERING COMPANY

- The need to reduce costs per part to stay competitive
- Seeking to increase cutting parameters – turning is slowing down their operations
- Some companies may find the turning operation to be a bottleneck in their production
- Looking for ways to shorten downtime by reducing tool setups and machine changes

THE BENEFITS

Many turning machine operators will know of just one, standard way of turning. The benefits of PrimeTurning over the normal method are:

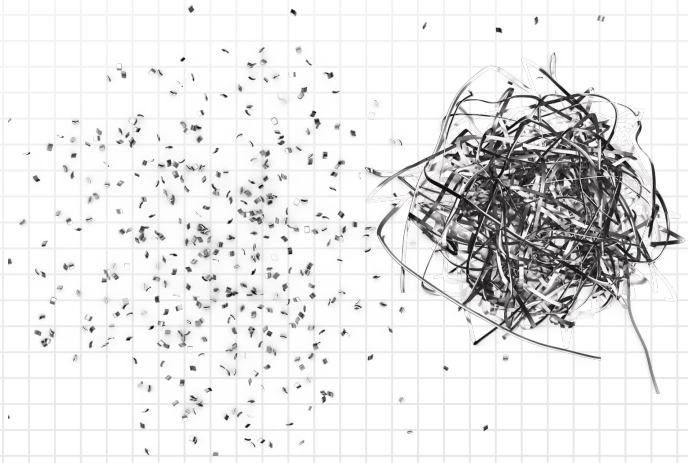
- PrimeTurning tools and code generator offers more than 50% productivity increase as compared to conventional turning
- An industry first: All-directional turning for extraordinary productivity
- MORE PARTS PER RUN – Doubling speed and feed rates enable faster metal removal rates
- Excellent chip control of thinner chips, even with small entering angle
- Longer lasting inserts due to small entering angle and efficient edge utilization
- Increased profitability through lower capital expenses and reduced cost per component
- Higher machine utilization due to less setup time, fewer production stops and tool changes

THE BUSINESS CASE FOR A SMARTER TURNING SOLUTION

Any machine shop that is not maximising its productivity is not as competitive as it could be. If turning is a bottleneck operation, the company is suffering a restriction on the number of components produced per run.

Similarly, if machine utilisation is low, the potential to make more components in less time is being missed.

New machining technology such as PrimeTurning helps companies accelerate machining and increases throughput. You can make more product with the same input.



"True innovation is when something new actually changes the way we do things rather than improves it."

NEW SYSTEM | NEW DESIGN | SMARTER MACHINING

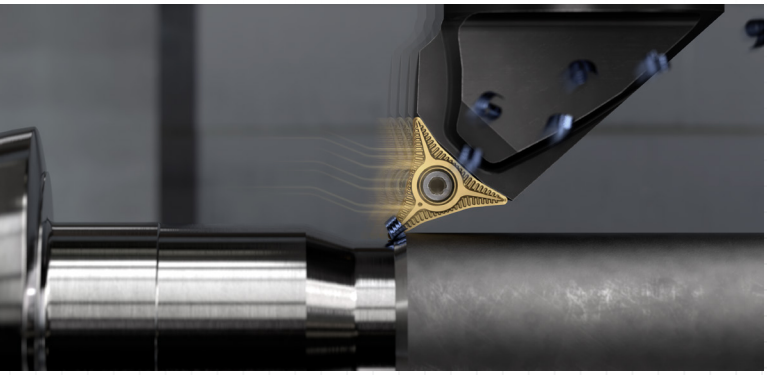
A new paradigm: PrimeTurning

Sandvik Coromant's PrimeTurning completely redefines turning, which has remained a uni-directional operation for over 200-years.

PrimeTurning has introduced a completely new turning method, and new turning tools together with a new code generator unlike anything ever seen before. The system allows you to machine in all directions.

In contrast to conventional longitudinal turning, the new process sees the cutting tool enter the component at the chuck and remove material as it travels towards the end of the component. Turning 'backwards' in this manner allows a small entering angle to be applied, which in turn provides considerable productivity gains.

The potential exists to effectively double feed rates and increase speed in comparison with conventional turning.



CoroTurn Prime – as cutting is performed in the direction moving away from the shoulder, there is no danger of chip jamming.

This is because small entering angles or higher lead angles create thinner, wider chips that spread the load and heat away from the nose radius, resulting in increased cutting data and/or tool life. Furthermore, as cutting is performed in the direction moving away from the shoulder, there is no danger of chip jamming, a common effect of conventional longitudinal turning.

"PrimeTurning achieves a productivity increase of more than 50% in many existing turning operations"

KEY FEATURES OF PRIMETURNING

- Small entering angles, without long, curved chips
- Efficient edge utilization. The CoroTurn insert has a wider cutting edge as compared to a conventional CNMG insert
- No chip jamming. This leads to longer tool life
- Higher speeds and feeds than any conventional turning operation

PrimeTurning, however, also allows for all-directional turning, which means that conventional turning can be used with the same tools. Conventional turning will only provide conventional productivity results though.

CODE GENERATOR SOFTWARE

Sandvik Coromant understands that NC code changes can be problematic to many machine shops. With the aim of simplifying adoption of the new process, the inhouse-developed code generator facilitates changing from conventional toolpath programmes to PrimeTurning. It also helps to maximise output through the application of optimised parameters and variables, and ensures process security with suitably adjusted feed rate and entry radius data.

GREATLY EXTENDED TOOL LIFE

Longitudinal turning uses the corner radius and a small part of the insert side to create the chip, whereas PrimeTurning uses just the side to create a thin and wide chip. For facing operations, conventional methods continue to rely on the corner radius, thus further increasing wear. In contrast, PrimeTurning uses the other side of the insert, delivering efficient edge utilization and longer tool life.

WHO SHOULD USE PRIMETURNING?

The PrimeTurning method and CoroTurn Prime tools can be implemented by Sandvik Coromant customers in their existing machining set-up, as long this is capable of operating tools at higher cutting speed data, with stable clamping and component set-up to secure maximum output. About 61% of nearly 7,000 users of turning machines who visited the Sandvik Coromant PrimeTurning campaign site felt that their production set-up is ready for PrimeTurning.

Applications: Any company performing conventional external turning in large batches – especially automotive original equipment manufacturers and tier one, two and three suppliers for example – as well as machine shops working in the aerospace industry, where several set-ups and tool changes are often required.

PrimeTurning will appeal especially to companies that know their cutting data and its current limitations, as well as those open to embracing new technologies and industry trends.

PrimeTurning is suitable for use on CNC turning centres, vertical lathe machines and multi-tasking turn-mill machines. Since its introduction, several customers have yielded impressive results.

CASE STUDY: CAST STEEL HUB

When turning a hub made from cast steel (SAE/AISI 1045) on a Gildemeister CTV 250 CNC turning centre, a machining company in Brazil achieve these benefits.

Using the same cutting speed (300 m/min, 984 ft/min) as a competitor insert, the adoption of CoroTurn Prime A-type inserts allowed feed rates to be increased from 0.25 mm/r (0.01 inch/r) to 0.4 mm/r (0.016 inch/r), and depth of cut from 1.5 mm (0.059 inch) to 3 mm (0.118 inch). The result was a 59% increase in productivity and 55% more tool life. With over 120,000 hubs a year being produced, the overall impact on profitability is expected to be considerable.

"There is no doubt that automotive OEMs and their tier one, two and three suppliers are set to enjoy a major boost in productivity and fast return on investment with PrimeTurning, not to mention better machine utilisation (due to less set-up time), substantially longer tool life, fewer production stops, less tool changes and reduced tool inventory."

Eduardo Debone, Automotive Business Segment Manager, Sandvik Coromant

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CoroTurn® Prime

INTELLIGENT INNOVATION FOR TOMORROW´S FACTORY

The key PrimeTurning technologies are the code generator and the tool insert design.

CoroTurn Prime is Sandvik Coromant's new tool, combining a tool holder and A-type or B-types insert, for PrimeTurning operations.

Two unique inserts are available: CoroTurn Prime A-types feature three 35° corners and are designed for light roughing, finishing and profiling, while CoroTurn Prime B-types with their ultra-strong corners are designed for roughing to finishing operations. The tools are purpose-designed for use with precision coolant.

CoroTurn Prime A-types come with under- and over-coolant provision, while CoroTurn Prime B-types offer just under-coolant. As a rule, under-coolant should always be applied for better tool life, with over-coolant is used for chip control.

THE BUSINESS CASE FOR COROTURN PRIME:

These inserts achieve the highest metal removal rates. Feed rates up to 1.2 mm/r (0.047 inch/r) and depths of cut up to 4 mm (0.157 inch) can be achieved, depending on the application.

CoroTurn Prime A-type tool with three 35° corners designed for light roughing, finishing and profiling

CoroTurn Prime B-type tool with strong corners designed for roughing to finishing operations

"CoroPlus improves the manufacturing process, cuts costs and reduces waste – all factors that truly affect the bottom line,"

Mats Lindeblad, Business developer – digital machining, at Sandvik Coromant told MetalWorking World in January 2017.

Machine suited to: Turning centres, vertical lathe machines and multi-task machines

Best suited for short and compact components and slender ones using tail stock

Good choice for mass production or components needing frequent set-ups and tool changes

NEXT STEP TOWARDS DIGITAL MACHINING

CoroPlus®

The CoroPlus platform gives you access to connected solutions that increase security and save time in design and planning. Connected tools and Internet of Things (IoT) devices enable you to monitor your machining performance and make well-informed decisions on how to optimize you machining processes. Cloud-based analytics and on-site systems allow you to make use of all the collected data in your machining operations.

"Enterprises that use the new cyber-physical technology early will have an easier ride into the future, and many manufacturers are getting prepared."

The clever CoroPlus ToolGuide, a software solution for tool and cutting data, supports users by recommending tools for their application, it was developed by a team led by Mats Allard, Sandvik Coromant over several years.

PrimeTurning is not specifically an Industry 4.0 technology for the connected factory. Companies operating normal machining operations with limited connectivity are well suited to PrimeTurning. But with the digital code generator, PrimeTurning fits within the CoroPlus ToolPath, a group of solutions for NC code generation.

A-type

B-type

PRODUCTIVITY + SUSTAINABILITY = INDUSTRY 4.0

In summary, it comes back to the holy trinity of productivity, flexibility and sustainability.

If the engineering industry, as a broad average, is operating at a machining efficiency below 50% on actual cutting time, there is a high amount of work to do. Sandvik Coromant wants to be part of – and lead – a technology revolution that saves companies money, time but also material resource and reduces waste.

"We have to and want to work with different partners," says Francis Richt, Sandvik Coromant. "We have close cooperation with CAM software and machine tools suppliers to do this together and make sure that our solutions are connected, to build a better ecosystem. Eliminating waste is the driver because the current modus operandi is not sustainable."

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