HEIDENHAIN

62 + 10/2015

Klartext

News from the World of HEIDENHAIN Controls

Maximum Transparency

TNC 640 controls complex large-part machining

Accuracy in any situation

Closed Loop Position Measurement **Page 8**

Editorial

Dear Klartext Reader,

In this edition of Klartext we focus on the topic of accuracy—a decisive competitive edge for companies using HEIDENHAIN controls. Of course, accuracy requirements are diverse.

Did you know that accuracy can suffer in small series production with alternating processing procedures? The reason for this is the thermal expansion of the ball screw drive. Read about how these fluctuations arise in the drive train and the measures that can be applied to eliminate them.

The Austrian company HELDECO is specialized in large part turning/milling. Here the TNC 640 guarantees absolute accuracy even with frequent switching between turning and milling modes.

In Italy, Persico Marine manufactures standard boats for the toughest round-the-world regatta—the Volvo Ocean Race. Discover how the iTNC 530 complies with the extreme specifications for precision demanded for the boat's hull.

We will inform you about the many new functions in software version 06 for the TNC 640. One exciting development, for example, is the new function VSC—Visual Setup Control in combination with the HEIDENHAIN Camera. In this way you always have control over the setup and machining process.

Read and enjoy, with best wishes from the Klartext staff!

The TNC 640 provides reliability and process safety for the machining of large parts.

In the Volvo Ocean Race 2014/2015, HEIDENHAIN technology ensures dimensionally accurate hulls.

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New

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Content

Turning in milling mode – without re-clamping.

Large parts— multiple challenges

The TNC control from HEIDENHAIN provides maximum transparency for complex large-part machining

To stand out as a make-to-order manufacturer, HELDECO CAD/CAM Fertigungstechnik, Upper Styria, Austria, has ventured into something special: the machining of large workpieces for offshore platforms, construction vehicles, hydroelectric power plants and the shipbuilding industry. Machining flexibility poses a great challenge with large machine tools and at the same time it is the key to success. As a matter of consequence, a new large multitasking machine from BIMATEC SORALUCE for milling, turning and grinding, enhances machining efficiency and accuracy. Naturally, the multiple functions of the machine demand the utmost from the HEIDENHAIN TNC 640 control.

Errors? Negative!

Prior to clamping a workpiece weighing tons, HELDECO plans the machining meticulously and checks everything with a machine simulation. Collisions and errors would be extremely expensive with such demanding components. Therefore the HELDECO machine operators must be in a position to react rapidly and easily during machining and where necessary make on-the-spot modifications to the machining program. In such cases, the TNC 640 milling/turning control makes things simple for the specialists at the machine.

The easy-to-understand operating concept of the HEIDENHAIN control is a boon considering the multiple functions of the new SORALUCE F-MT 4000. The mighty multitasking machining center in traveling column design unites the tasks of milling, turning, drilling and grinding. 5-side machining is equally as possible as vertical turning; in a very generous work envelope of 4000 x 1600 x 1400 mm the working components include a rotary head and rotary table in the machine bed.

New machine— new potential

The job order production of large workpieces requires a machine concept that permits flexible machining with as few clamping operations as possible. "We do not do off the rack," explains Helmut-Christian Dettenweitz, CEO of HELDECO. "At SORALUCE they are prepared to go down the paths we envisage." In this way, a particularly constructive relationship has built up over the years between the toll manufacturer and the machine manufacturer.

The custom F-MT 4000 facilitates complex machining in just the way that HELDECO wants. For example, take accuracy: the large workpieces could be deformed by the mechanical machining. Special machining strategies are designed to keep to the demanded tolerances for dimensions and fits. This often involves multiple switching between turning and milling operations. With these new large-dimension machines this can usually be done in one clamping setup which cuts out inaccuracies in radial runout, axial runout and

> “You can tell that the HEIDENHAIN user manuals are really written for the users and not for professors.”
>
> Helmut-Christian Dettenweitz,
> CEO of HELDECO

the center lines of a workpiece. This is an enormous plus for accuracy and time saving. "We shuffle milling and turning to achieve an optimum production flow. Then the part fits perfectly after manufacturing," says Dettenweitz.

The TNC 640 also facilitates the constant switching between milling and turning operations. The status display changes automatically when operations switch between MODE MILL and MODE TURN. Operators can depend on a uniform operating concept when switching from one mode to another. This is confirmed by power user Peter Lüttich: "The HEIDENHAIN turning cycles are logically structured and easy to comprehend." The control manual is all that the operators need and CEO Dettenweitz adds: "You can tell that the HEIDENHAIN user manuals are really written for the users and not for professors."

Machine operator Peter Lüttich also appreciates the continuity in the cycles: “I think it’s great that all the previous cycles run perfectly on the new TNC 640.” Continuity is important for HELDECO, which is why it has equipped most of its large machine tools with HEIDENHAIN TNC controls.

Special parts for adjusting the height of oil drilling rigs are—alongside components for the hydroelectric industry and the aircraft and shipbuilding industries—an example of the superior parts that HELDECO manufactures.

The intricate and expensive parts demand competent machine operators who can reliably monitor the machining process and intervene effectively if necessary. The programming skills of the HELDECO employees are invaluable here.

The HEIDENHAIN control with its clear and easily comprehensible display makes it easy to intervene no matter whether the machine is in milling or turning mode.

Seamless integration into the process chain

The TNC 640 is perfectly integrated into the processes at HELDECO so that the machine operator can quickly and reliably make changes on the control despite the CAD/CAM-generated programs. On the one hand, many HEIDENHAIN cycles are used in the program generation. On the other, the generated programs are structured into subprograms so that specific stages of the machining can be easily found on the control. If modifications are necessary, you can replace an entire program without inadvertently calling wrong tools or altering traverse paths. Because HELDECO defines approach paths, tool calls, speeds and cutting technologies in the main program. Dettenweitz is convinced that "this nesting works well and we can really put on speed."

Optimum safety through to the customer

HELDECO verifies the quality of the intricate process—from preparation, programming and simulation through to machining—in its own testing laboratory. The acceptance of manufactured parts is then also done preferably at the toll manufacturer's. To make sure that everything arrives perfectly at the customer's, HELDECO takes over responsibility in most cases for packing and transport. Nothing should be left to chance!

"Ideally we would like to have HEIDENHAIN controls on all our machine tools, because they make everything so simple," enthuses Dettenweitz. Because "customers expect us to deliver on time." If one machine is down or occupied, it should be possible to use the machining program on other machines. "Our customers also demand this emergency scenario," explains the CEO.

Conclusion: reliability counts

Feasibility, machining quality and on-time delivery are a real challenge with the large and usually very heavy components but at the same time they are the hallmark of the Austrian enterprise. The resulting investment in the F-MT 4000 is only logical: the multitasking machine tool boosts the efficient manufacturing of large workpieces, in particular through the combination of milling, turning and grinding. With regard to process safety, the TNC 640 from HEIDENHAIN raises the bar high and despite complex kinematics provides maximum transparency for the machine operators.

HELDECO CAD/CAM Fertigungstechnik

HELDECO CAD/CAM Fertigungstechnik GmbH with its headquarters in Au bei Turnau, Austria, manufactures components up to 12 m long and weighing up to 30 tons. The recipe for success: a special approach and highly motivated employees with extensive control know-how. In this way HELDECO meets all the demanding requirements of its international customers.

+ www.heldeco.at

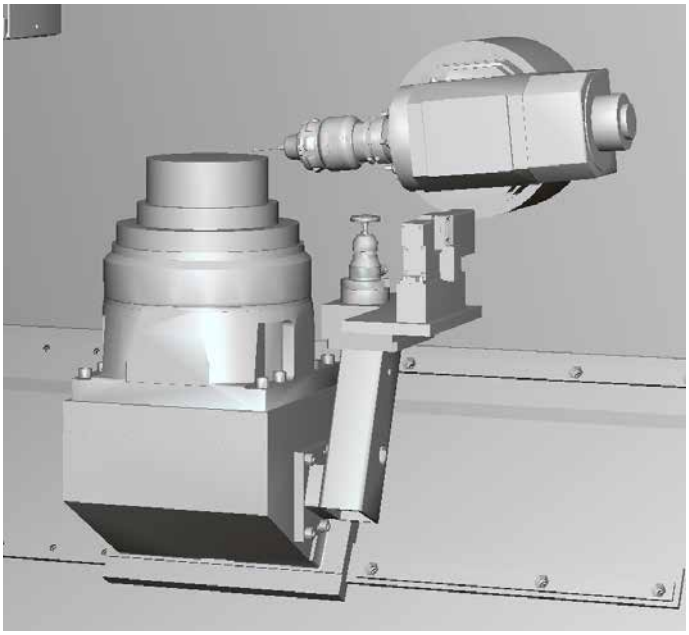
Pleased with the new SORALUCE F-MT 4000 and HEIDENHAIN TNC 640: power user Peter Lüttich, CEO Helmut-Christian Dettenweitz and TNC user Matthias Puregger.

Detailed imaging of machine components and tool carriers

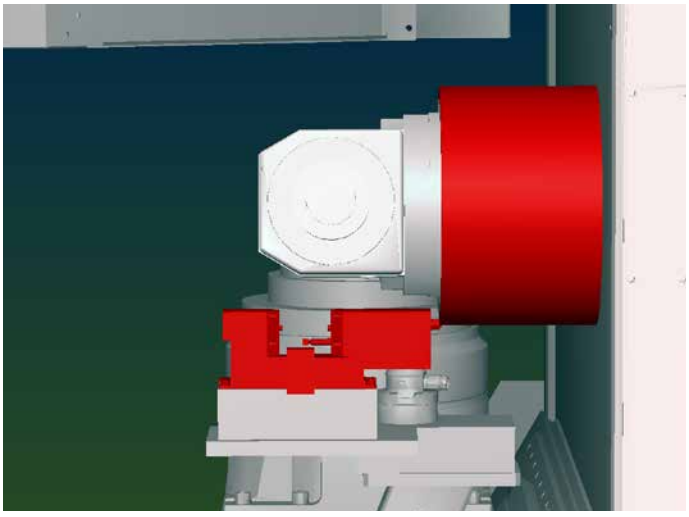
M3D – on the TNC 640, this new data format for DCM improves utilization of the machine's work envelope

Whenever a collision is imminent, the dynamic collision monitoring (DCM) stops machining and thus increases safety for the operator and the machine. In this case the TNC 640 graphically shows the machine operator which machine components are endangered. It also issues a corresponding message. This helps to prevent machine damage, which can result in costly downtimes.

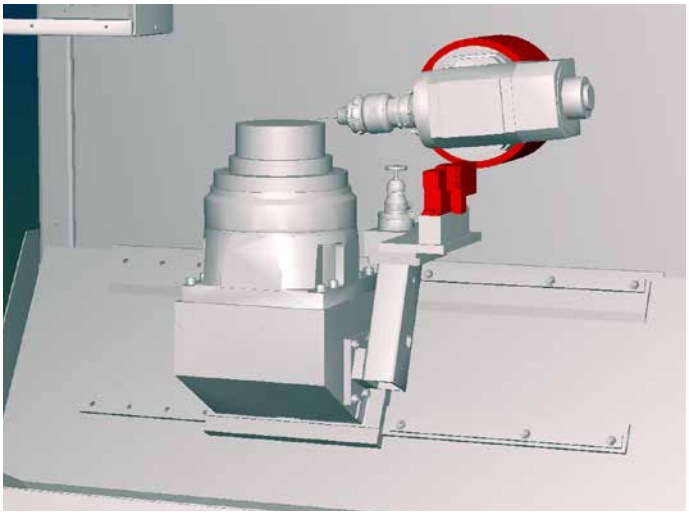
The new M3D format for imaging the collision objects makes the DCM even more effective. Now, high-detail 3D models can be used for providing a better view of potential collision objects. Machine manufacturers are thus given the option of using the PC tool M3D Converter to convert collision objects from their standard CAD models into the reliable M3D format and incorporate them in the TNC 640. The result is detailed imaging even of complex machine components, which means that use of the machine's working space can be greatly improved. DCM with M3D thus provides optimum safety and flexibility.



Probing a workpiece with loaded tool spindle.



DCM with M3D monitors even the tiniest of corners and edges for possible collisions.

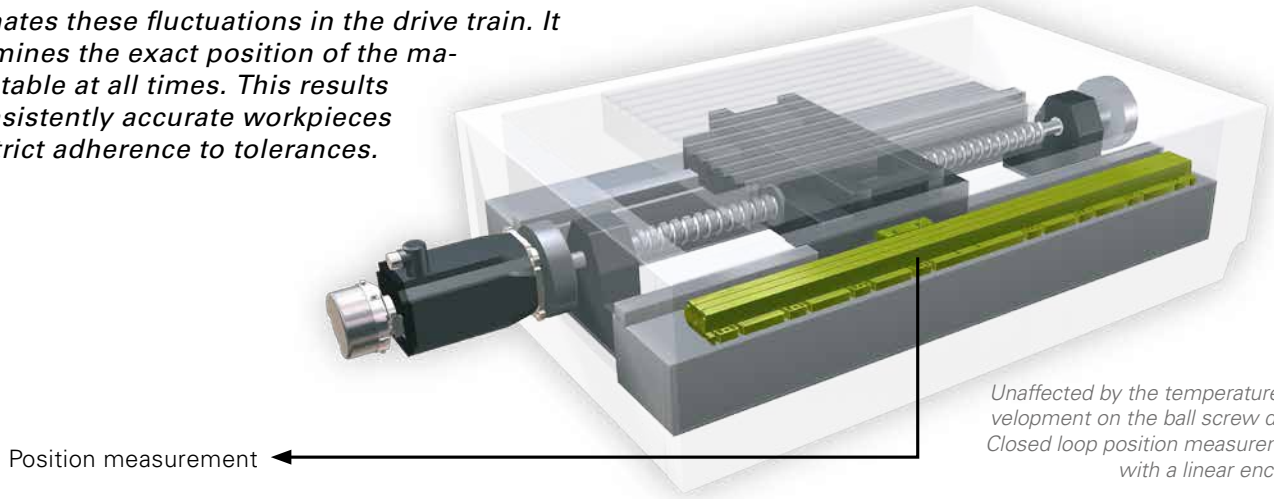


The hidden view prevents the operator from recognizing the imminent collision.

Manufacturing accuracy regardless of circumstances

Closed loop position measurement provides high accuracy in any situation with small series

Accuracy often suffers in small series production with constantly changing tasks and processing procedures. In many cases the reason for this are the permanently fluctuating and unforeseeable temperature changes in the machines and drives, which lead to the thermal expansion of the ball screw drives. Closed loop position measurement with HEIDENHAIN linear encoders eliminates these fluctuations in the drive train. It determines the exact position of the machine table at all times. This results in consistently accurate workpieces and strict adherence to tolerances.



Unaffected by the temperature development on the ball screw drive: Closed loop position measurement with a linear encoder

Flexible small series continue to demand a lot of even the most up-to-date enterprises if they are to run economically and accurately. The organization and logistics, in particular, devour time and personnel. After all, the preparations as well as the production and further processing steps all have to be synchronized with the greatest of accuracy. If the actual machining is much faster than the setting up of the machines and plant, then delays have serious consequences. The calculation is torpedoed just as much as the time-consuming and intricate planning of subsequent machine occupation.

No wonder that with all this organization and fine-toothed planning, the topic of accuracy is prominent in flexible small series production. In fact, modern machines usually do have an acceptable intrinsic accuracy. However, the devil is often in the details and in this case he is thermal expansion due to internal heat sources in the machine and therefore from the machining itself.

Thermal expansion has surprising effects

We all know that materials expand when heated. In the case of the linear axes it is mainly the ball screw drive which is affected. Due to the initial stress and associated friction between the ball screw and the nut, it heats up each time the machine table traverses during machining. The so-called fixed/floating bearings of the ball screw drive allow for the associated expansion so as to prevent damage to the bearing.

The expansion for a steel ball screw drive can be easily calculated taking the thermal expansion coefficient of steel of 10 µm per meter length and degree of temperature difference. In the case of a ball screw drive 1 m long, a rise in temperature of 1 °C causes a deviation of 10 µm. Since temperatures of 45 °C are quite common on the ball screw drive—an increase in temperature of 25 °C above the ideal temperature of 20 °C—it is easy to imagine the actual dimensions of the deviation.

Scrap due to overheating

On Monday morning the machine is at its ideal temperature of 20 °C after a weekend of standing idle. Now setup and preparation begin for a small series production run of 40 parts. It in-

Clearly visible after the second machining: The deviation of 70 µm due to the thermal expansion of the ball screw drive

Invisible second drilling with closed loop control: A twice machined part with no corners and edges

volves machining of average difficulty without any particularly high traversing speeds for the machine table. The maximum feed is 3.5 m/min. Two holes 350 mm apart are to be drilled in the parts and the contour milled. The machining takes five and a half minutes, the tolerance for the distance between the holes is ±0.02 mm.

The subsequent quality control shows that of the 40 parts to be produced only the first 25 are within the specified tolerance. About 40 percent of the production is scrap—what a catastrophic result! What happened?

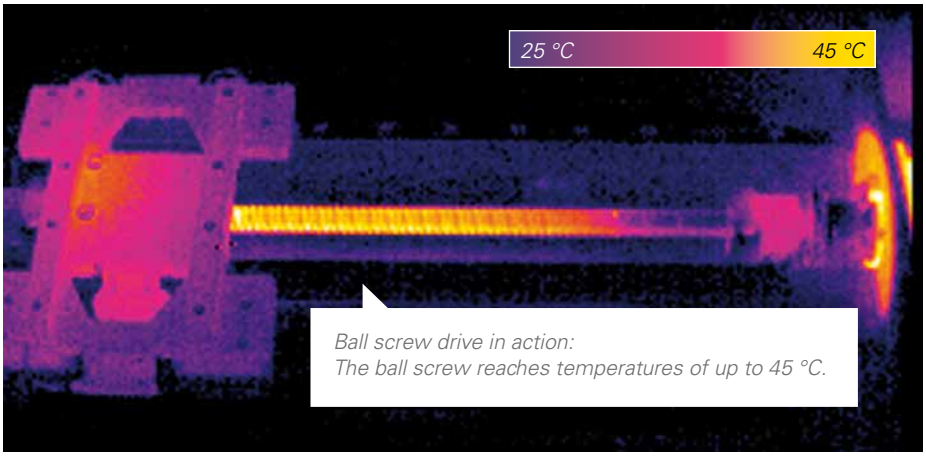
The ball screw drive heated up continuously during machining. After the 25th part the heat increase had reached the critical point when the thermal expansion of the ball screw drive causes the tolerance of ±0.02 mm to be exceeded. The deviation on the last part was even 70 µm.

You can clearly demonstrate this deviation with a simple trick: After machining of the 40th part, the first part is put back on the machine and the feed setting in Z direction is halved. The second holes made in this way in the finished part leave a clearly visible edge in the existing holes, likewise the second milling operation on the contour. This is the result of the 70 µm deviation due the thermal expansion of the ball screw drive.

Constant switching makes expansion unpredictable

However, the problem in small series production is not the linear expansion, which is easy enough to calculate. The problem is caused by the permanently changing requirements and conditions, which makes the temperature development unpredictable. For the first small series production on Monday morning is followed in the afternoon by a quick change of settings for the next machining run. But what are the temperature conditions in the machine now? Has everything cooled down again to 20 °C during the switchover or is there still residual heat in the ball screw drive?

Nobody knows, and with every subsequent small series production the conditions will become increasingly inestimable. There is no way that you can derive values for future machining runs. The same machining run could produce more or less rejects the next time round depending on the initial temperature of the ball screw drive at the start of machining and how the temperature develops.



Ball screw drive in action: The ball screw reaches temperatures of up to 45 °C.

Everything under control with precise position measurement

On the other hand, position measurement with a linear encoder is independent of the thermal expansion of the ball screw drive—and any other influences. This so-called closed loop control always determines the precise position of the machine table. The result is stable production with a constantly high level of workpiece quality.

A comparative machining run demonstrates the example described above. There is no scrap from a machine with closed loop control; all the parts are within the specified tolerance. A second machining run with the first part after machining of the 40th part with half the feed setting in Z direction leaves no visible edge.

In particular for companies who specialize in small series productions, the implementation of a machine with closed loop position measurement with a linear encoder is a profitable investment.

One millimeter decides

In the Volvo Ocean Race 2014/2015, HEIDENHAIN technology ensures dimensionally accurate hulls

It isn't until they encounter wind and weather that the boats really get going. (Photo: Rick Tomlinson/Volvo Ocean Race)

The Volvo Ocean Race, probably the world's toughest open ocean sailing regatta, goes once around the world. On the 38 789 nautical mile stretch (= 71 837 km) the crews taking part have to sail through the Roaring Forties, die Furious Fifties and the Screaming Sixties. These are sailors' names for the southern latitudes of 40° to 65°, which are characterized by strong west winds and place incredible demands on both the materials and the crews.

Uniformly designed boats with only one-millimeter's tolerance

For the first time, all teams in the Volvo Ocean Race 2014/2015 start with identical boats. This permits a meaningful comparison of crew performance. Furthermore, the single-design boats ensure that specific standards of safety are upheld through compliance with strict regulations. Above all, the dimensions are clearly defined. A maximum deviation of one millimeter from the specifications is tolerated—for both machine-made and hand-made parts. This also applies to the hull length of 20.37 meters. It must not deviate more than one millimeter from this specification, i.e. less than 0.005 percent.

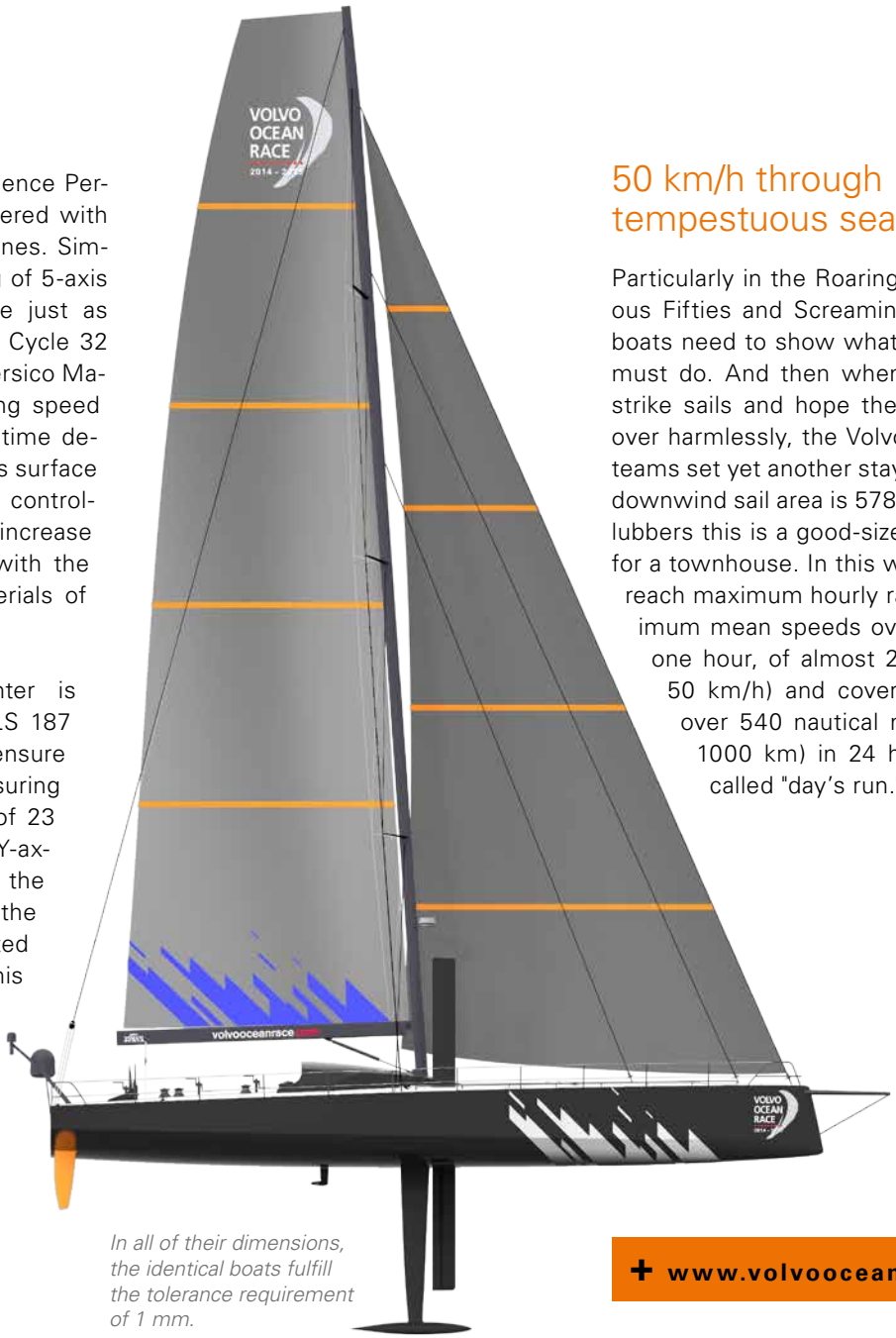
Persico Marine in Bergamo, Italy, has accepted the task of manufacturing the hull of the identical boats in a carbon-sandwich design. To do so, the mold-engineering specialists first milled a hull-shaped plug from a single block of polystyrene. This was done with a Belotti MDL 23065 5-axis machining center. Its interior dimensions of 25 m for the X-axis, 7 m for the Y-axis and 3 m for the Z-axis are large enough to handle this exacting task. On this plug, Persico then built the actual hull molds with layer upon layer of carbon fiber.

Boat builders insist on HEIDENHAIN

HEIDENHAIN technology plays a decisive role in keeping to the one-millimeter tolerance for the hull. On specific request of Persico Marine, a HEIDENHAIN iTNC 530 controls the machine. Persico Marine is convinced that this is the only way of complying with the rigorous specifications for precision on such a large machine. This trust and confi-

dence comes from the experience Persico Marine has already gathered with the iTNC 530 on other machines. Simple operation, fast processing of 5-axis programs and reliability were just as convincing arguments as the Cycle 32 TOLERANCE. This enables Persico Marine to optimize the machining speed and therefore the machining time depending on the material and its surface properties The HEIDENHAIN controller thus provides a genuine increase in efficiency when working with the ever-changing high-tech materials of modern boat building.

The Belotti machining center is equipped with LB 382 and LS 187 linear encoders. They ensure high-precision position measuring over the measuring lengths of 23 m on the X-axis, 6.5 m on the Y-axis and 3 m on the Z-axis. Here the complete feed mechanism of the Belotti MDL 23065 is integrated in the position control loop. This closed loop control compensates all influences of the feed mechanics including pitch error.



In all of their dimensions, the identical boats fulfill the tolerance requirement of 1 mm.

50 km/h through tempestuous seas

Particularly in the Roaring Forties, Furious Fifties and Screaming Sixties, the boats need to show what they can and must do. And then when other crews strike sails and hope the storm blows over harmlessly, the Volvo Ocean Race teams set yet another staysail. The total downwind sail area is 578 m²—for landlubbers this is a good-sized plot of land for a townhouse. In this way the yachts reach maximum hourly rates, i.e. maximum mean speeds over a period of one hour, of almost 28 knots (over 50 km/h) and cover distances of over 540 nautical miles (approx. 1000 km) in 24 hours, the so-called "day's run."

+ www.volvooceanrace.com

The 20.37 m long hull form with a tolerance of only 1 mm take form in the Belotti machining center.

Upon Persico Marine's express wish, the Belotti machining center is controlled by a HEIDENHAIN iTNC 530.

Innovative technology

iTNC 530 HSCI controls highly automated machining centers

Constantly taking up new threads and challenges and turning them into concrete solutions—these are the strengths of ELMANN SRLU. The Italian enterprise follows this motto to manufacture very successful molds for headlights among a host of other products. It also develops R&D and technology solutions to make its production processes simpler, safer and more productive. The aim of these developments is to achieve 24-hour production with unmanned shifts.

For ELMANN there is no question of relocating production to low-cost sites. Instead the corporate philosophy calls for the development of in-house technical solutions which turn the supposed disadvantages of a site into advantages. One example of this is the automation of the Sharav GVTD workstation from Promac, which is controlled by a HEIDENHAIN iTNC 530.

Development of effective solutions

"We are convinced that we can achieve more with less. In our case we were looking for a technology solution which is a synthesis of all the machines we need in order to maximize the production efficiency," says Almerino Canuto, owner of ELMANN, explaining the implementation of his corporate philosophy. In cooperation with Promac, a manufacturer of 5-axis machines for machining medium to large workpieces, ELMANN developed an automation system for the Promac Sharav GVTD.

The system consists of two machines with gantry portal and sliding table with five axes which are switched

Highly complex: ELMANN produces molds for headlights.

in parallel sharing a common magazine with replaceable heads and a pallet changing system. It also has an automatic machine head changing system (an extended Promac model TA with HSK-A 100 chuck), for roughing and finishing as well as drilling on the same machining center. Thanks to this configuration both machines can work independently of each other.

Flexible machining centers instead of special-purpose machines

All these options render special-purpose machines superfluous and, according to owner Almerino Canuto, give ELMANN more flexibility: "Thanks to the speed and precision of 5-axis machines, it is possible today to do without special-purpose machines. The machining centers work more competitively and the tool change is faster. The 5-axis machining center will become a mainstay for production when it acquires the necessary flexibility from relevant modules and can be adapted to various applications."

Operation is via the iTNC 530 HSCI control from HEIDENHAIN. The control ensures safe and smooth production processes, minimum downtimes and high-quality machined surfaces—fundamental requirements for molds in the automotive sector.

"Over the past few years we have observed a flow of information from the workshop to the engineering office. Today, Industry 4.0 demands a change of perspective," explains Almerino Canuto. "The focus must be on the end product: the less you get away from it, the less the additional costs and time. The creation of models for processes and products and the exchange of data are of fundamental importance, because each problem that does not have a prior virtual solution will inevitably lead to production downtime."

Fully automatic machining

The iTNC 530 guarantees high reliability of the entire system. The plant works fully automatically round the clock supported by the automatic linear pallet changing system of the two machines. The operator's tasks are reduced to a minimum: the iTNC 530 monitors the whole process from main computer

Flexible: The tilted table permits drilling and milling with five axes on five surfaces.

Adaptable: The machine head changing system enables all types of machining on one machine.

to measuring system (the machine is equipped with a linear encoder LC 183 from HEIDENHAIN) and immediately reports any problems to the central unit.

Due to the large dimensions of the plant the control is equipped with an HR 550 FS electronic handwheel with wireless transmission. This allows the operator to safely reach the working space of the machine if there is a problem and move the axes of the machining center manually with high precision. Furthermore, the TeleService 2.1 option installed on the machine permits remote access to the user interface of the iTNC 530 for monitoring and diagnostics.

With the fully automatic production of molds it is very difficult to precisely predict all the axis movements. The machine movements are extremely complex and position changes very fast. Although the CAM data are exhaustively tested and simulated prior to machining, the actual machine configuration can never be replicated one hundred percent. This is why ELMANN utilizes the iTNC 530 with the DCM Dynamic Collision Monitoring function. This prevents damage to the machine by taking into account the machine components in the working space and stopping machine movement in the case of imminent collision. This applies both for manual travel operations and the running manufacturing process.

Accommodating: The Promac machining centers take machine heads for drill holes up to 1200 mm long.

"The iTNC 530 HSCI from HEIDENHAIN ensures safe and smooth production processes, minimum downtimes and high-quality machined surfaces."

Almerino Canuto, owner ELMANN SRLU

New machining center also with iTNC 530

ELMANN also banks on HEIDENHAIN control technology with new machines. Not so long ago a third Sharav GVTD machining center with an iTNC 530 control was commissioned. This is smaller than the other plant. The liquid accumulator and the screws for chip removal are located under the walkway floor to adapt it to ELMANN's special requirements, which include a minimized footprint. The purely digital alignment of the iTNC 530 and the automation system specially developed for ELMANN ensure that the new machine can be perfectly integrated into the existing management and automation system.

Networked: The iTNC 530 is the control center for the entire automated system.

ELMANN

Founded in 1981 in Casale sul Sile in the Italian province of Treviso, ELMANN SRLU produces headlight molds for its international customers. Since the company did not want to consider relocating production to low-cost sites, it founded its subsidiary FCS SYSTEM SRLU specially for research and development. Technologies for optimizing production. Here it is important for ELMANN to work together with partners who provide top class technical solutions and implement the same corporate philosophy. Such partners are the Promac-HEIDENHAIN duo with cutting-edge, profitable solutions.

+ www.elmann.eu

Software version 06

Automatic check of clamping and workpiece

With VSC—Visual Setup Control—the TNC 640 has the current setup and machining situation in full view

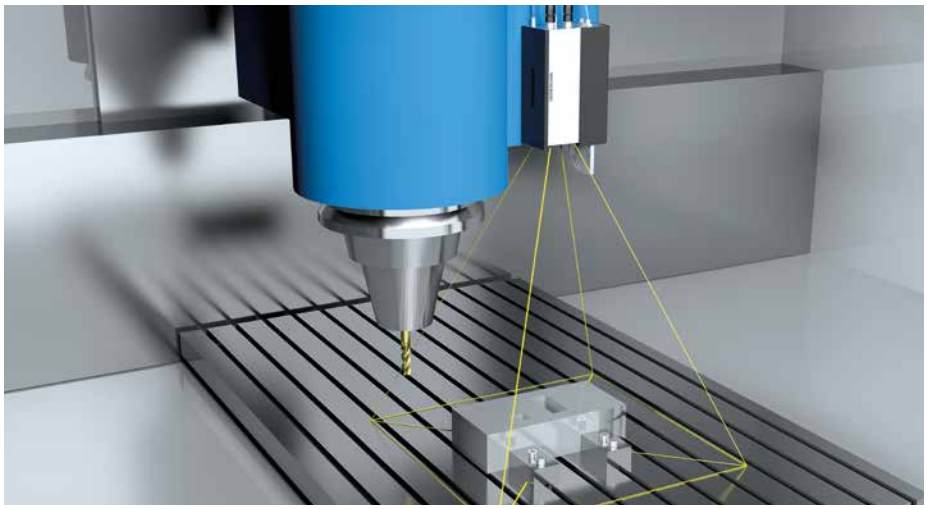
Is everything as it should be in the working area? This scrutinizing check can now be done by the TNC 640 with software version 06 and higher. With a camera installed in the working area, the new VSC option can monitor the setup and machining fully automatically. By checking the clamping situation, VSC can prevent expensive damage to tools, workpieces and machines. Checking the workpiece to be machined can show the operator if a machining operation has been missed among other things. Furthermore, the operator can document complex clamping setups with photos and use these to simply replicate the setup for a repeat job.

A HEIDENHAIN camera installed directly on the spindle first makes reference images of the first workpieces of a series; for example, images of the correct clamping before machining and of perfect workpieces after machining. During the course of the series the TNC 640 automatically monitors whether the subsequent parts correspond to the reference images. When and how often these checks are made can be defined individually by the operator implementing user-friendly cycles in the NC program. In this way VSC can recognize prior to machining whether a workpiece has been incorrectly clamped. After machining, VSC can for example display when a hole is missing, indicating that a machining operation was not performed.

The operator can define special monitoring areas in the reference images, for example areas on the workpiece with particularly critical clamping setups or machining operations. VSC can then concentrate only on those monitoring areas. The advantage of this selective checking is the reliable result. This is evident above all in the check after machining which shows whether there is swarf and coolant on the workpiece. The narrower you define the testing area, the better the results produced by VSC. VSC can also learn. The option can learn typical structures and contamination situations from multiple reference images so that swarf and coolant have less influence on the search for deviations.

The operator can also use VSC to make and store images manually for documenting a special clamping setup. By manually operating the spindle the operator can bring the camera into the desired positions and viewing angles to display important details. The image is projected in a live preview on the TNC 640 monitor.

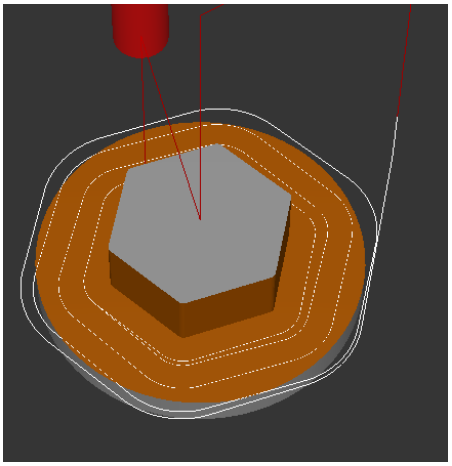
In order to prevent swarf and coolant from contaminating or even damaging the camera and its lens during machining operations, the sensitive technology is located in a protective housing. The flap in front of the lens opens only to take photos. Since VSC can be programmed with two separate cycles in the HEIDENHAIN plain-language conversational programming language, operators can very quickly benefit from the intuitive system to make their work even more reliable and safer.



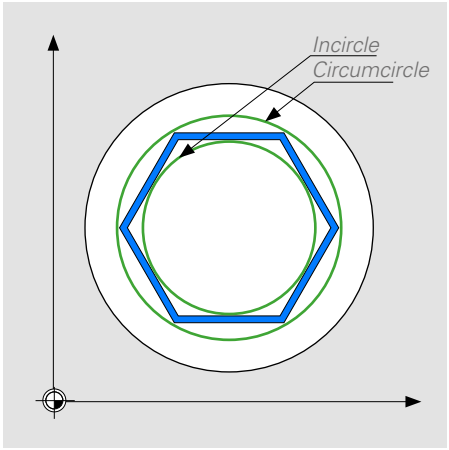
Automatic monitoring of the workpiece setup and machining: The HEIDENHAIN camera produces reference images with which the TNC 640 can automatically compare subsequent parts.

Complete milling of regular polygonal studs

In addition to the cycles for the complete machining of cylindrical studs and square studs, the TNC 640 with software version 06 and higher has the new 258 POLYGON STUD cycle for polygonal studs. With just a few parameter settings you can have regular polygonal studs milled automatically.



Polygonal stud milling: The parallel tool paths ensure even removal of material. This spares the tool and permits high feed speeds.



The operator defines the polygonal stud first via a reference circle based on the circumcircle or the incircle, i.e. the width across flats. Then follows input of the blank diameter, the number of sides and the rotary orientation. The TNC distributes the number of sides evenly on the stud. The radius/chamfer parameter determines whether the sides of the polygonal stud are rounded or have a chamfer.

The control produces the polygonal stud fully automatically on a spiral path. The start position of the cycle depends among other things on the diameter of the blank and rotary orientation of the stud. The cutter paths are oriented on the contour of the polygon and run practically parallel to each other. The even distribution of the paths means that the milling tool always remains in contact with the workpiece throughout the entire machining run. This results in an approximately constant cutting depth, which has positive effects on the tool life.

If the trochoidal milling cycle is used, this type of motion control with a correspondingly large feed in the machining plane and small lateral feed permits very high feed speeds.

Automatic turning tool compensation

In some cycles for automatically checking workpieces the TNC 640 can run an automatic tool monitoring sequence. The new software version 06 makes what was previously available only for milling tools also available for turning tools. Cycles 421, 422 and 472 permit reference to turning tools in parameter Q330.

The touch probe cycles for automatic workpiece monitoring check whether the specified tolerances have been respected during machining. Before a hole becomes too big, or a stud too small, among other things the cycles 421 (MEASURE HOLE), 422 (MEASURE CIRCUMCIRCLE) and 472 (MEASURE COORDINATES) issue a message and automatically indicate to the machine operator any discrepancies between the nominal and actual statuses. Complicated manual checking and correcting with corresponding downtimes are now a thing of the past.

The requirement for automatic tool monitoring is an active tool table. Using parameter Q330 the operator defines that the TNC 640 is to run tool monitoring for both milling and turning tools. The values in columns DZL and DXL are corrected for turning tools.

Interpolation turning makes machining centers even more flexible

Interpolation turning is one of the interesting special applications of the TNC 640. It opens up many flexible machining options which even turning machines can only achieve with difficulty.

One possible application case is the housing of a USB hub produced by interpolation turning in part with a tilted working plane. The housing demands multiple machining operations in which interpolation turning can really show its strengths: the production of an annular slot and a radius at the edge of the slanted section. In addition, the machining includes milling operations in between the interpolation turning, which results in the following sequence:

- Rough-cutting of the shell with cycle 292 (milling tool)
- Cutting of the inside pocket (milling tool with 25° setting angle)
- Interpolation turning of the annular slot with cycle 291 (turning tool at 25° setting angle)
- Finish-cutting of the inside pocket (milling tool with 25° setting angle)
- Interpolation turning of the shell with cycle 292 (turning tool)
- Interpolation turning of the radius with cycle 292 (turning tool at 25° setting angle)

The pre-machining is done quickly and efficiently with a milling tool with a high volume of material removal. The annular slot and radius at the radius at the edge of the slanted section are produced by interpolation turning, which—unlike conventional turning—can be implemented in any position with a tilted working plane. Cycles 291 COUPLING TURNING INTERPOLATION and 292 CONTOUR TURNING INTERPOLATION are available for this, which we presented in the last edition of Klartext.

```
15 CYCL DEF 292 CONTOUR.TURNG.INTRP.
    Q560=1     SPINDLE COUPLING
    Q336=+0    ;ANGLE OF SPINDLE
    Q546=+3    ;CHANGE TOOL DIRECTN.
    Q529=+0    ;MACHINING OPERATION
    Q221=+0    ;SURFACE OVERSIZE
    Q441=+1    ;INFEED
    Q449=+15000 ;FEED RATE
    Q491=+50   ;CONTOUR START RADIUS
    Q357=+2    ;CLEARANCE TO SIDE
    Q445=+50   ;CLEARANCE HEIGHT
```

Interpolation turning: The TNC 640 enables simple and flexible machining with cycles 291 and 292—even with a tilted working plane.

The operator can use both cycles after enabling option 96. They turn a conventional milling machine into a "milling machine plus." This is thanks to the ability of the milling machine to produce the turning contour at any point and in any position. In particular in Cycle 292, the TNC 640 also handles all the necessary calculations for the complex sequence of motions to produce the required turning contour. Cycle 292 is programmed in the usual conversational programming language, which makes it very user-friendly. You can implement interpolation turning for producing sealing and lubrication grooves. Of course, grooves in the axial and radial directions are also possible.

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