



Mastering high precision in large series manufacturing
Highly productive manufacturing of tungsten carbide milling cutters with diameters of up to 20 mm

Many industrial sectors are noting a rising demand for especially precise milling cutters and drills with larger diameters. In view of the enormous quantities that have to be manufactured and the comparatively long production cycle times, the productivity of the grinder plays an increasingly important role. We interviewed the Product manager of a technology and market leader for the manufacture of such machines, turning a particular spotlight on the features that nowadays ensure the mastering of the production of such cutters in large series in fully automatic, unstaffed operation mode.

“Tungsten carbide milling cutters are high-precision products. Nowadays, they are often manufactured in large batches, which moves the focus of machine operators onto cost aspects,” reveals Jean-Charles Marty, Head of Technology and Process Development of Rollomatic SA in Le Landeron (Switzerland). The company, which is located in the heartland of Switzerland’s high-precision and watchmaking industry activities, had initially developed its own grinding centers for the

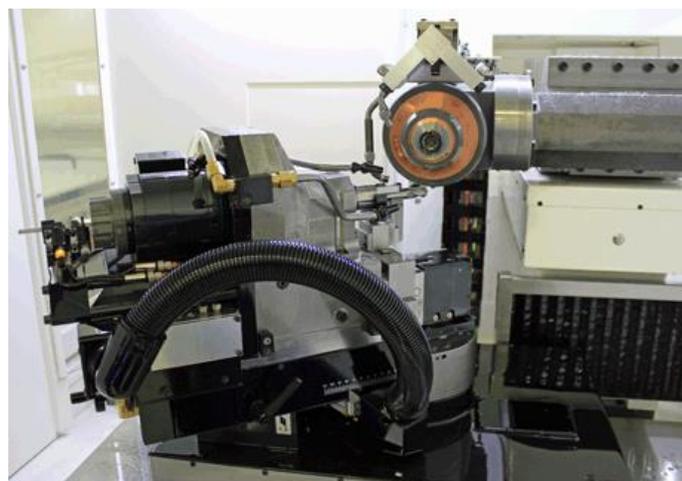


manufacture of milling cutters. After discovering they could sell such tool and cutter grinders to other tool manufacturers, they perfected their technology to such a degree that they have become technology and world market leader in the field. At the same time, the initial specialization on the watchmaking and electronic equipment manufacturing sector has been replaced by a broader viewpoint. Nowadays, the company manufactures precision CNC grinding machines for the production of drilling and milling cutters with diameters of up to 20 mm, which are used in virtually all industrial sectors such as aerospace, automotive, machine-building, tool-making or medical technology. These sectors often need quite large quantities. As a result, customers increasingly focus not only on the highest quality but also on the production costs of such tools. In order to cater for this market trend, Rollomatic endeavored to equip its grinding centers for manufacturing large diameter milling tools with cutting edge features enabling them to master the fully automatic

production of such workpieces in large batches. As an extra bonus, this also results in extremely high flexibility with respect to switching quickly between different product types.

Grinding milling cutters using 5 or 6 axes

“Basically, our two “GrindSmart“-centers for large diameter cutters differ by virtue of a sixth axis for the model 629XW,” adds J.-C. Marty. Both centers are characterized by four numerically controlled axes located on the support of the collet chuck. The fifth axis is located in the support of the grinding wheel and conducts the grinding wheel horizontally across the workpiece. The model 529XW featuring these characteristics is designed for processing cutting tools in the diameter range between 1 and 20 mm. With the model 629XW, the grinding wheel assembly can additionally perform a vertical swiveling movement facilitating the manufacture of certain tool geometries. Furthermore, the 629XW is also suited for grinding smaller tools with diameters down to 0.1 mm. With both machines all axes are synchronized with the highest accuracy in order to ensure the required precision of the workpiece.



An additional factor, and possibly even more important than the doubled power rating of the new grinding spindle featured by both the GrindSmart 529XW and the GrindSmart 629XW, is its driving technology. A very high and constant torque, especially in the lower speed range, is a key asset in ensuring an enhanced performance, “giving the

machine the ability to achieve sizeable material removal rates when grinding large diameter cutting tools,” states Jean-Charles Marty.



Automation for highest flexibility and productivity

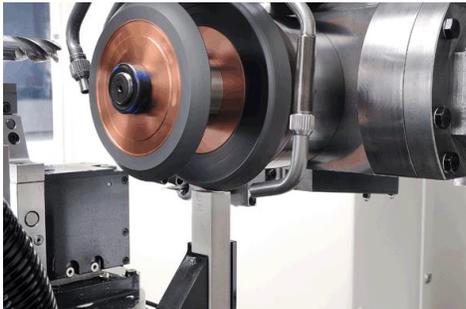
“One prerequisite for achieving unmanned automatic production comprises handling systems for the exchange of workpieces as well as grinding wheels,” explains J.-C. Marty. The exchange of workpieces is performed by a robot equipped to hold ready up to 1,000 blanks. An equally important aspect is the possibility of exchanging the wheel packs, since especially in the case of more complex milling cutter geometries, quite a number of different grinding wheels might be put to use. To this end, both grinding machines are equipped with an automatic wheel changer system for individually configured grinding wheel sets. Such a set may comprise up to four different wheels on a common shaft. It is

coupled with the spindle via a standardized HSK 50 interface. The machine can thus hold up to 24 different grinding wheels at the disposal of the control system, which can put them to use in line with current machining priorities. This gives the operator a high degree of flexibility with respect to the task to be performed. He can either equip the wheel changer with a number of identical replacement sister packs in order to process especially large batches or alternatively use a given grinding wheel to perform varying operations on different types of workpieces in order to maximize flexibility of use without having to interrupt the job sequence.

Another vital aspect in all grinding operations is an enhanced supply of cooling lubricant to the workpiece and grinding wheel. In order to secure an optimized coolant supply every assembly of grinding wheels is fitted with its individually adjusted set of nozzles. Both assemblies are stocked together in the wheel changer and handled simultaneously.

Reconditioning of grinding wheels

“Another important point if you want to achieve uninterrupted operation is a periodic reconditioning of the grinding wheels,” explains J.-C. Marty. In order to maintain its abrasiveness, a grinding wheel has to be dressed after performing a certain quantity of operations by passing it against a special dressing stone. In the course of a prolonged uninterrupted job sequence, such an operation may have to be repeated several times in fully automatic mode. The dressing stone is located in a dedicated extendable holder on the workpiece support carriage and is periodically



brought to use in intervals specified by the control system. This procedure ensures that the abrasive properties of the grinding wheel and hence one of the key parameters for the secure mastering of the grinding process is maintained within a narrow bandwidth around its optimum. The reduction of the wheel diameter caused by the dressing operation is monitored by the control system and taken into account when computing the movements of the grinding wheel

Direct quality control

“A further noticeable feature of our new generation of grinding centers is their considerably extended software for the measuring process with

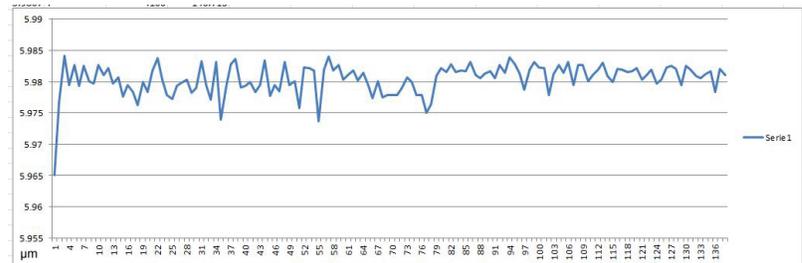
a 3D touch probe located underneath the grinding spindle” says J.-C. Marty. Prior to starting a processing cycle, the device is used to detect the exact position of the workpiece, which is then registered in the control system and serves as a reference. Upon completion of the grinding process, the device is used to control key dimensions without having to unclamp the workpiece. This immediate control of vital geometrical characteristics of the workpiece is essential for assuring quality at a very high level. Drifting of machine parameters is immediately recognizable and can – at least in the case of oversize – still be corrected. Furthermore, dimensional control directly in the collet chuck that has been used during machining eliminates possible clamping errors that can impact on measurements performed on external measuring systems. Another major advantage of this direct feedback of possible divergences is the elimination of defect pileups through the accumulation of rejects in the quality control pipeline due to the time lag between the occurrence of a systematic deviation and its recognition.



Success with customers in Europe...

“In the meantime, we have already been able to deliver a number of these grinding centers to customers, where they have performed very well,” says a pleased J.-C. Marty. One of these customers is a manufacturer of milling cutters serving a wide range of highly demanding markets such as the aerospace, automotive, medical technology or mechanical engineering industries. These customers won’t accept anything but top quality and attach considerable importance to highly competitive prices. Accordingly, by mid-2014 this manufacturer ordered a new 629XW plant that is mainly used to produce milling cutters with a diameter of 6 mm. Particular attention was paid to the capability to perform an immediate dimensional control of the workpieces in the machine while they are still chucked since this facilitates the on-the-spot identification and compensation of any drifting of key dimensions. The scatter of workpiece characteristics could thus be contained within a very narrow bandwidth.

Furthermore, the fact that it was possible to maintain a quite even distribution of the residual scatter around the center line of the tolerance bandwidth was deemed to be of comparable importance since this perfectly fits the 6-sigma philosophy of the end users. Part of the machine acceptance tests was a fully automatic production run lasting for more than two days, which yielded a batch of about 600 milling cutters. The chart of the outer diameter values recorded for every fourth workpiece proves how narrow the scatter band is and that virtually no drift occurred.



... and in the United States

“The second customer we can report about is the US branch of a big international group,” says J.-C. Marty. Here too, the end users come predominantly from high-tech industry sectors with sometimes very high throughput quantities, resulting in related prerequisites with respect to tool quality and precision. And it goes without saying that the US market traditionally reacts with extreme sensitivity to price differences. This customer opted for the 529XW type plant which he uses for the production of 12.7 mm (1/2“) tungsten carbide tools. Due to the fact that the company also operates a machine made by a competitor featuring significantly higher nominal performance characteristics, both machines were subjected to comparison tests with identical workpieces in large batches. During such a campaign, the GrindSmart 529XW grinding center took 120 hours to produce

800 workpieces of the same type in uninterrupted fully automatic mode. After this comparison test, the user highlighted the following differences:

- The Rollomatic 529XW achieved a production cycle time of 9’12” while the competitor needed 11’35” to deliver the same result. The productivity advantage of the 529XW was thus 20 %.
- While the reject rate of the workpieces produced with the Rollomatic grinding center was in the order of magnitude of per mil, the competing machine had an average reject rate in the mid-single-digit percentage range.
- The floor shop footprint of the 529XW is some 35 % smaller than that of the other grinder.

“With both customers, our GrindSmart plants have wholly fulfilled the high expectations placed on them by securing the unmanned, fully automatic large series production of large diameter milling tools at the highest quality level,” Jean-Charles Marty said in summing up.

Klaus Vollrath

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Captions



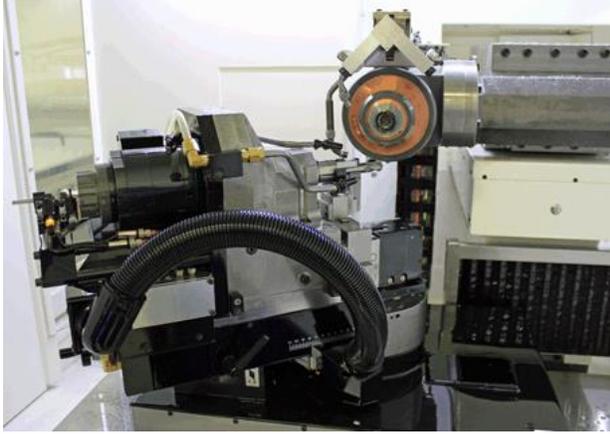
The five-axis model 529XW is suitable for producing precision cutting tools with diameters between 1 and 20 mm. The automatic system for the exchange of grinding wheel sets is docked at the right-hand side (Photo: Klaus Vollrath)



“Our GrindSmart precision tool and cutter grinder are suitable for the unmanned fully automatic production of large diameter milling tools at the highest quality level” Jean-Charles Marty (Photo: Rollomatic)



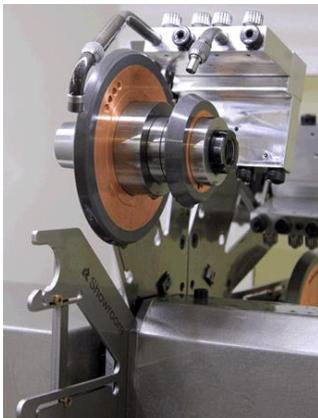
The production of this cylindrical milling tool from a blank with a diameter of 20 mm takes only about a quarter of an hour (Photo: Rollomatic)



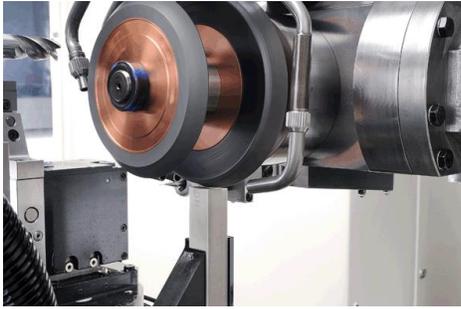
The complete support assembly can be swiveled horizontally around a vertical axis located underneath. In addition there is a horizontal axis oriented in the direction of the axis of rotation of the workpiece and a vertical axis as well as the rotational axis of the collet chuck. The grinding wheel set can be shifted in the direction of its rotational axis (Photo: Klaus Vollrath)



The oil used to cool and lubricate the workpiece and grinding wheel is very carefully filtered and tempered (Photo: Klaus Vollrath)



In order to secure an optimized supply with cooling lubricant, the transfer plate holds a specific nozzle set for each grinding wheel assembly. Both are exchanged simultaneously (Photo: Klaus Vollrath)



Reconditioning of grinding wheel is performed by periodically passing the wheel against a special dressing tool (Photo: Rollomatic)



Prior to starting the grinding process, the exact position of the workpiece is determined using a 3D touch probe. Upon completion of the treatment, the device is also used to control vital geometrical characteristics of the workpiece (Photo: Klaus Vollrath)

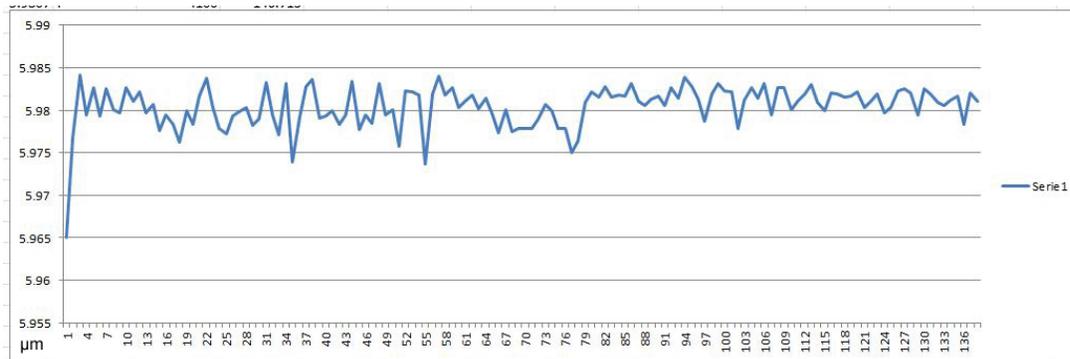


Chart of the outer diameter values recorded for every fourth workpiece during an automatic production run of about 600 milling cutters of the same type, proving how narrow the scatter band is and that virtually no drift occurred (Graphics: Rollomatic)



The control system can be easily and quickly programmed using a tracer pin (Photo: Klaus Vollrath)