Shaft cooling system optimises motorised spindles

>> The spindle can often make all the difference in the world of machinery. The highest demands are required from them in terms of thermal performance. Here, the spindle manufacturer FISCHER AG Präzisionsspindeln introduces their CSC spindle. What is ingenious is for example the tool change, carried out by a clamping cylinder, which is integrated directly into the shaft.

The innovative advancement of machine tools has opened new doors in the last few years in precision processing. Linear motors and hydrostatic guideways are used for a high degree of accuracy. Cooled axes and mechanical components guarantee stable thermal properties of the system and optimised structures in construction mean the best damping properties. This as well as other new technologies are used today in HSC machines in order to achieve the highest possible precision, dynamics and surface quality when processing high-precision components. In the machine tool industry, the spindle is becoming increasingly important.

High thermal stability required

In particular in mould and tool making and nano-precision processing, the requirements are increasing for the motorised spindle in terms of these concepts. The best specifications in balance quality are no longer a guarantee here for constant processes and excellent processing results. As a key element within the machine concept, the highest demands are required in terms of thermal performance and stability. This is where traditional spindle concepts are pushed to their limits.

Top spot in technology thanks to the patented shaft cooling system

With the shaft cooling, introduced onto the market four years ago, Fischer took the demands upon themselves and secured the top spot in technology. Over 1000 spindles based on the patented Fischer shaft cooling are used daily in mould making and precision processing and prove their reliability in these areas. For example, manufacturing visually demanding and technically high-quality casing for smart phone sector is mentioned. Thanks to the stable and established system, engine power can be increased, shaft growth reduced, the length of time that the spindle can be used can be increased and the running-in time shortened.

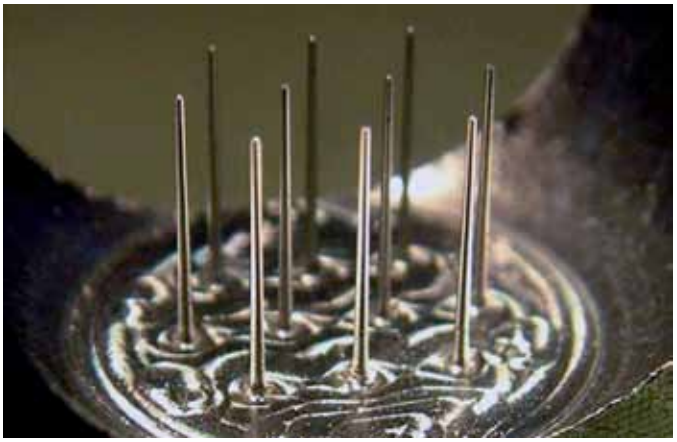

Image: Quick Jet Machine

Image 1: High-end micro processing in perfection (reproduced with kind permission of Quick Jet Machine Co., Ltd., Taiwan).

The replaced tool remains cooler

Even with maximum rotations and the largest load, the spindle shaft guarantees a thermally stable basis for the tool holder. The replaced cold tool thereby remains cool and the investment in intelligent and elaborate systems to compensate for the axial expansion as a result of thermal changes can be minimised. By the stable milling processes, surface quality could be achieved with reflective quality which eliminates downstream polishing processes and delivers a lasting reduction in all production costs. Image 1 shows an application example of a spindle with a Fischer shaft cooling system. The conical pins were made of solid material which are 0.1mm in diameter, 5mm in height and a gradient of 1°.

Innovation: Compact Shaft Cooling

In order to further develop the product in terms of stability, performance, compactness and user-friendliness, Fischer presents a completely new generation of shaft cooling spindles. In addition to the established shaft cooling system, the new integral CSC system (Compact Shaft Cooling) is com-

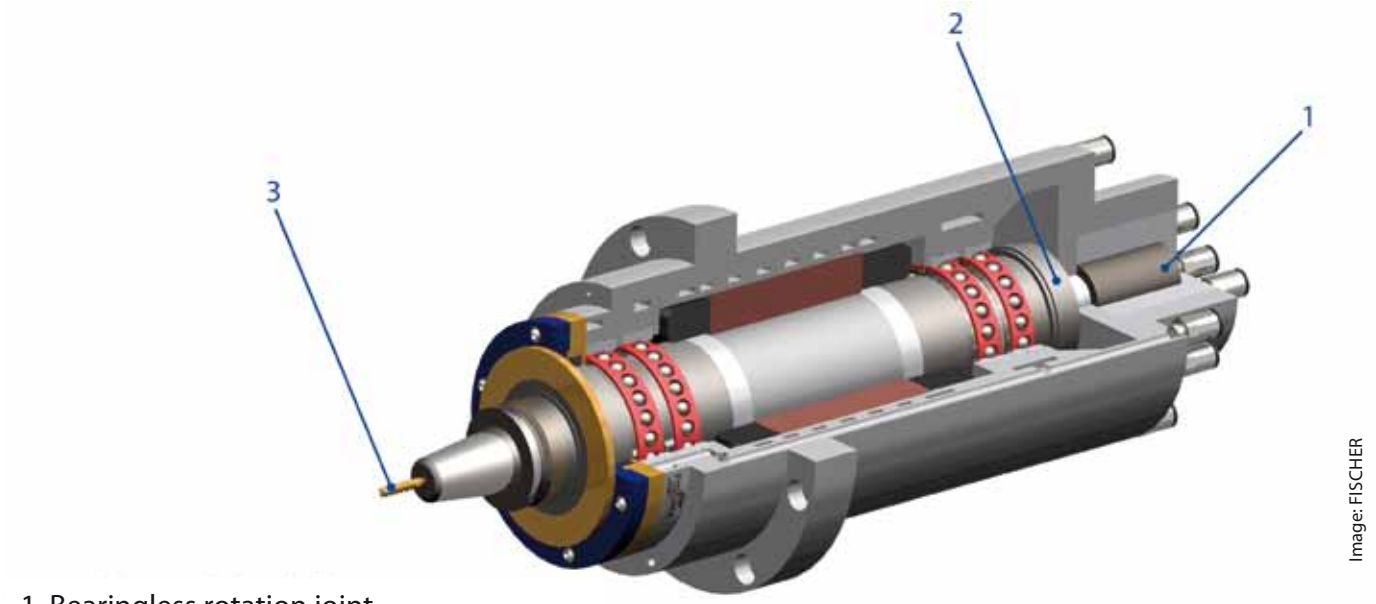

Image: FISCHER

1. Bearingless rotation joint
2. Clamping cylinder integrated in the spindle shaft
3. Process cooling

Image 2: Schematic representation of the new generation CSC spindles

Image: FISCHER

Image 3: MFW-1220/45 CSC VC HSK-E40

prised of the following three components (image 2):

1. Bearlingless rotation joint
2. Clamping cylinder integrated in the spindle shaft
3. Process cooling

High-tech unit: Bearlingless rotation joints

Compared to the last generation of bearingless rotation joints, the newly developed rotation joint for shaft cooling is built extremely compactly and is easy to replace when it needs repaired. The technology is based on the patented Fischer solution and sets a new standard for rotation joints for fast-turning spindles. The central element is a «high-tech unit» which takes the cooling medium to the shaft, adopts the precise control of the clamping cylinder and also introduces the process cooling in the spindle system.

New: Clamping cylinder integrated in the shaft

The pneumatic tool change is carried out by dynamics of the machine. Thanks to the integrated cylinder, the flux flows completely into the shaft when the tool is being changed, a special release of the spindle bearings is not necessary and saves costs. The clamping system also works with the same medium which is used in the shaft cooling, an additional circuit is not necessary. When choosing the cooling medium, the machine manufacturer can chose between oil or coolant emulsion. It is a closed system with combined clamping hydraulics and shaft cooling. The system can do without an additional hydraulic unit and works pneumatically using a pressure of 6 bars.

Process cooling: Anything is possible

The user receives a new freedom when choosing process cooling. Dry processing, minimum lubrication, cooling lubricant emulsions or oil.Anything is possible right up to the maximum rotation speed. Just by using air or minimum amounts of lubrication, new doors are opened in terms of process strategies. The special solution from Fischer guarantees safe and low-wear operation with support of sealing air up to the maximum rotation speed. At the same time, the process cooling is not to be understood as an additional option, every spindle of the CSC generation is equipped with this feature. The challenge to find an optimal concept for the new spindle generation is not only concentrated on the development. The innovative idea of the CSC concept requires high-precision components. These complex

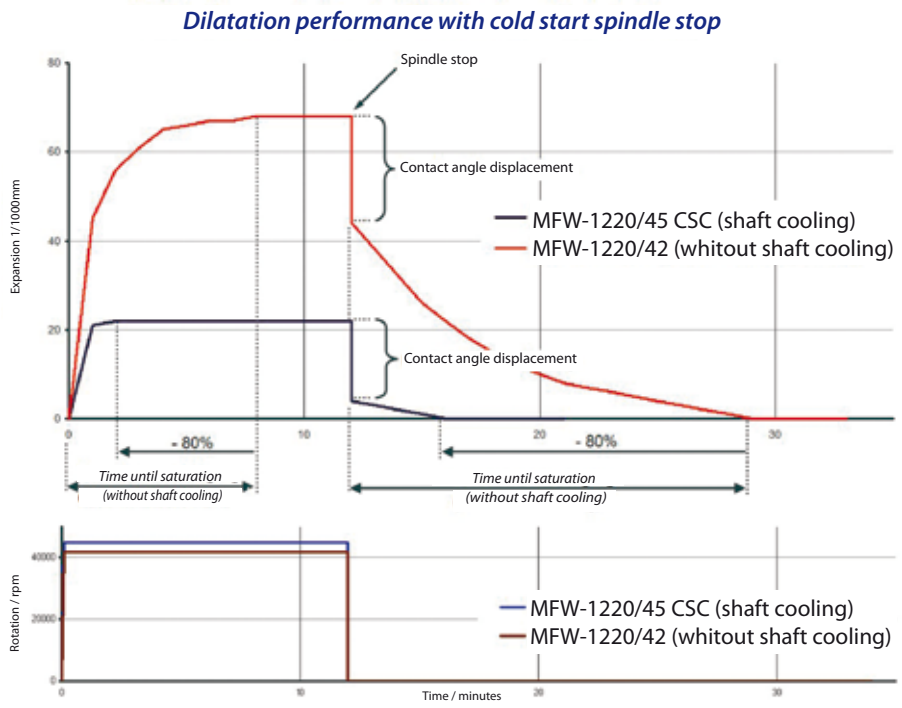

Image: FISCHER

Image 4: Excellent dilatation performance at the tool interface.

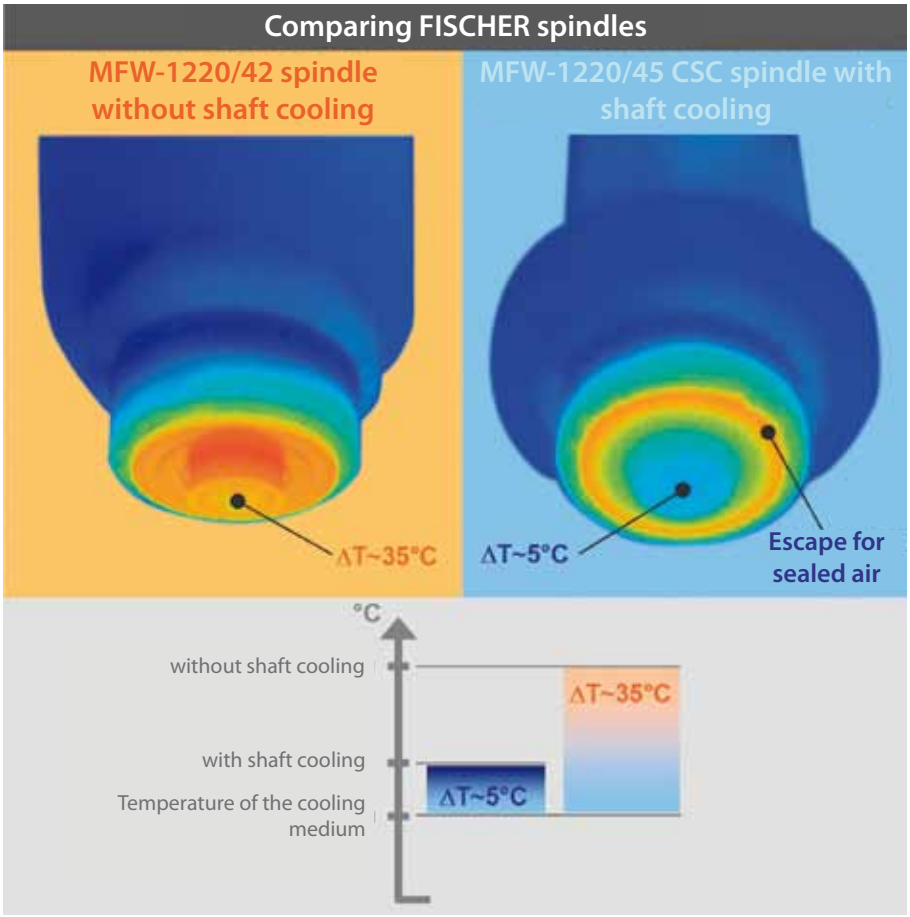

Image: FISCHER

Image 5: Comparison of the temperatures at the spindle nose and shaft, data for experimental setup: 1. Comparative measurement for maximum rotation and temperature saturation, 2. Cooling medium Cool-x (Motorex), 3. Flow rate 1.5l/min through the spindle shaft 10l/min through stator and bearings.

core components are manufactured directly by FISCHER AG Präzisionsspindeln thanks to their great production depth. With newly introduced processes, it is also ensured that precision can be guaranteed for years.

Thermal performance

I Image 5 shows the measured temperatures of two spindles. If the shaft cooling is missing (left side) it is noticeable that the shaft is the warmest element. A difference in the temperature of 30° to a cooling water temperature in the shaft is often a reality. The heat which occurs from rolling friction and the motor is not dissipated and allows the temperature of the shaft to increase to over 50°C. Traditional concepts with bearing and stator cooling are ideal for reaching a thermally stable interface to the machine (cool spindle housing). However we are still a long way from a thermally stable interface to the tool. This is not the case with the shaft cooling. The extremely efficient cooling of the spindle shaft distinguishes itself by the fact that the shaft is only 5°C more than the respective input temperature of the cooling medium. The warmest area of the spindle with a shaft that has been cooled is annularly outside of the shaft. It involves the area where the sealed air which has been heated escapes due to turbulence.

Considerable time savings possible

In image 4, the dilatation performance at the tool interface is analysed. After a cold start to the maximum speed, the CSC spindle reached saturation after approx. 2 mins. This means approx. 80% of time is saved for the user in comparison to a spindle without a shaft cooling system. After the spindle stopped, the zero position was achieved after approx. 4 mins which means approx. 80% of time saved again in comparison to a spindle without a shaft cooling system. With a contact angle displacement dependant on the number of rotations, the roller bearing also has a significant impact on the dilatation performance. The contact angle displacement results in track changes to the rolling elements (balls). With high speeds, they are pressed outwards by the centrifugal force. In image 4 this is evident by a preliminary rapid decrease in expansion directly after the spindle stops.

Position stabilised quickly

The end users can use these advantages immediately in which, for example, they

Image: FISCHER

Image 6: Use of the spindle MFW-2104/24 of the CSC series in a DMG GMX 400 LINEAR turning/milling centre

MFW-1220/45 CSC	MFW-1412/36 CSC	MFW-2104/24 CSC
HSK-40	HSK-50	HSK-63
45‘000 rpm	36‘000 rpm	24‘000 rpm
11 kW (asynchronous, S1)	15.2 kW (asynchronous, S1)	29 kW (asynchronous, S1)
5.5 Nm (S1)	12.1 Nm (S1)	69.2 Nm (S1)
Size ø120 mm	Size ø140 mm	Size ø210 mm

Image 7: The different performance classes of the spindles with induction motors

CONCLUSION !

Highest precision results guaranteed

The new CSC generation represents the demand for highly compact and thermally stable spindle systems. The coolest tool interface and minimal axial displacement of the spindle shaft guarantee the highest precision results. Process cooling is standard with every spindle, without restrictions in the media to be used.
Through constant innovation, a product was created from the established Fischer shaft cooling which sets standards in terms of precision, efficiency and technological advantages. The spindle concept has already proven its performance in large numbers in the industrial environment and has shown itself to be a reliable product in the production of precision parts on the international market.

insert a 3D sensor directly after the manufacturing process and a highly accurate measurement of the workpieces can be taken. Quick stabilisation of the position also allows significant amounts of time to be saved in the machining cycle.

Performance from 5.5 to 29kW

With he introduction of the CSC series, Fischer presents a variety of spindles at the highest degree of innovation. In addition to the advantages such as maximum precision and time saving in the process, the spindles are also easy to maintain. All of the sensors to monitor the tool clamping are freely accessible from the outside. The current portfolio includes spindles in the performance category 5.5kW to 29kW with induction motors and speeds of up to 45 000 rpm (image 7). <<

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