Spindle types - Overview

Design and features of HC/HCS style

Shaft output power
Integral encoders for closed loop control

Advantages of hybrid ceramic bearings

Adjustable bearing preload
Vibration sensor

Tool interface
Taper cleaning

Clamping system
Position sensors

Air purge

Coolant through shaft
Coolant through spindle housing

Internal minimized coolant supply - Single-channel system

Internal minimized coolant supply - Two-channel system

A method for controlling axial shaft growth
Measurement of the axial shaft growth by sensor

Pick-up spindle / Multi couplings

Spindle testing stand

Dimensions and characteristics of the spindle types
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<td>8000</td>
<td>40</td>
<td>1050</td>
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</table>

Max. power St [kW]
Max. speed [rpm]
Housing diameter [mm]
Spindle type
HC = for open-loop drive
HCS = for closed-loop drive

W1 = Bore diameter of front bearings
OL = Oil/air lubrication
g = Permanent grease lubrication
SK = ISO taper
HSK = Hollow tapered shank

Preference type

Please ask if spindle drawing is required. We send it as dxf file.
Chip removal rates are defined by the material's specific cutting speeds. Generally small tool diameters require high speeds and larger tools are operated at lower speeds. Large tools require high torque while small tools require less torque, but higher speeds. Integral motors utilized in the HC/HCS style spindle meet these requirements. The "field weakening" characteristics provide the high torque at lower speed.

The spindles can be operated in the following modes:

- **S1**
  - Continuous power
- **S6**
  - Continuous duty with intermittent loading, a duty factor of 60% (S6-60%) for a cycle time of 2 minutes.

Depending on the application requirements, the motor characteristics curve of power / torque relative to speed can be met.

Rigidity is a prerequisite for the volume of metal to be removed and the surface finish required. This requires large shaft diameters, and accordingly large spindles, whereby large motors can be utilized.

Due to the advances in motor development, the power density has been increased to such an extent that in many cases the output power far exceeds the application requirements. Oversized systems are costly, due to the size of the frequency inverter's required to operate them. Therefore operating the spindles at the required power level, the capacity of the inverter determines the power profile.

Incorporating high resolution encoders into spindles, provides feedback and control of the actual shaft speed, and angular position of the shaft, at all times.

The advantages are as follows:

- Smooth precise rotation and control at low speed
- "C"-axis operation e.g. thread cutting
- Shaft positioning within 0.001 degree
- The drives high dynamic performance at full capacity, combined with the quick acceleration and deceleration times, allows the systems full power capacity to be utilized.

GMN can interface the encoders to meet the selected drive systems requirements.

The encoder system consists of a precision gear mounted to the rotating spindle shaft and a stationary sensor in the spindle housing readily accessible, for ease of service.

GMN will optimize the performance of the complete spindle and drive package before shipment, and provide all the necessary parameters.
Advantages Of Hybrid Ceramic Bearings

GMN "HC/HCS" series high frequency spindles utilize hybrid ceramic ball bearings. These bearings have standard steel bearing races and are matched with silicon nitride balls. Advantages of Hybrid bearings compared with normal spindle bearings are:

Reduced wear
The high degree of hardness of the balls, and the nonaging effect of the silicon nitride against metallic material lessens the wear. This is especially important in cases of minimal lubrication. In addition, wear particles will not embed themselves into the balls to further damage of the races.

Rigidity
Modulus of elasticity is bigger than steel, which increases the static and dynamic stiffness. The increase in dynamic rigidity depends on the ratio of bearing preload to the centrifugal force on the balls.

Friction
Because of the reduced spin rolls ratios and lower Hertzian stresses, friction and respectively operating temperatures are reduced.

Axial shaft movement
As a result of the lightweight ceramic balls, centrifugal forces are reduced with a corresponding reduction in dynamic movement of bearing races. In addition, movements due to less friction and the lower coefficient of expansion of ceramics are reduced.

Reliability of operation
The low thermal coefficient of expansion of the ceramic balls lessens the reduction of the radial running fits in the bearings. These fits are less variable at higher temperature differences between races.

Vibrations
Radial forces and the moments acting on the bearings produce displacement between the balls and the retainer. Hybrid bearings reduce this effect and produce a positive influence on cage vibrations and stresses.

Fatigue life
The fatigue life is comparable when the Hertzian stress on the contact surfaces between rings and balls is similar. As a result of the minor weight of the ceramic balls the Hertzian stress is lower. Therefore hybrid bearings achieve longer life time.

Accuracy
Spindles of HC family are fitted with bearings produced according to GMN standard grade UP. They are distinguished from international standards due to excellent running accuracy.

Radial runout of assembled bearing inner ring
Limits in micron

<table>
<thead>
<tr>
<th>Bearing bore diameter [mm]</th>
<th>Tolerance class P4/ABEC 7</th>
<th>Tolerance class P2/ABEC 9</th>
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<td>&gt; 10...18</td>
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<td>&gt; 50...80</td>
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<td>2.5</td>
<td>2.0</td>
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Assembled bearing outer ring face runout with raceway
axial runout - Limits in micron

<table>
<thead>
<tr>
<th>Bearing outside diameter [mm]</th>
<th>Tolerance class P4/ABEC 7</th>
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</tr>
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<td>&gt; 80...120</td>
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<td>5.0</td>
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Adjustable Bearing Preload

Bearing arrangement and preload determine the rigidity, and influence the life time of the spindle system.

For small speed ranges, and low speed operation the different versions of a solid preload arrangement are suitable. Large speed range variances, and high speed spindles, require a systems that will not allow the bearing preload to be influenced by either temperature or speed. These applications require spring preloading of the bearings. The above mentioned arrangements cannot be adjusted or changed, without disassembling the spindle.

With the "Adjustable bearing preload" system the bearing preload can be optimized to the application, and prolong the lifetime of the spindle.

The base preload of the bearings is determined by the highest speed requirements, and is set by spring preloading. The optimized settings over the speed range is varied through an internal piston which is actuated via either hydraulic or pneumatic pressure.

As further advantage of the adjustable preload system is reduction of vibration.

Vibration Sensor

Unmonitored vibration can cause major damage to the spindle, machine tool and component being machined. GMN can provide sensors close to the front bearing set, which will quickly recognize any unbalance or high resonance which can cause catastrophic damage and shut-down the machine, or can plot out the curve on a display unit for analysis and correction of the process or problem.

The illustration shows a spike in the vibration spectrum at 1000 Hertz at a 10 mm depth of cut. This vibration could be from extreme cutting loads, unbalanced tooling, or damaged spindle bearings.
GMN can provide high frequency spindles to accept common tooling interface configurations.

The preferred HSK style offers the following advantages versus the ISO taper:

- High static and dynamic rigidity
- High tool change accuracy and repeatability
- Low axial movement during speed variations
- Increased pull-in force as the speed increases
- High torque transmission
- Increase in personal safety due to the internal drive dogs (Form A/C)

"Hollow tapered shanks with flat contact surfaces" are standard per DIN 69893. The different "FORMS" of a particular size are based on a similar shank size dimension. The tool flange is dictated by the mode of tool change.

HC/HCS style spindles allow the use of tools with hollow shanks, type A, E or F according to interface design.

Form E was developed for high speed without drive dogs. The torque transmission is actuated by adherence.

Form A can also be used with manual tool change system provided in the HSP style spindles. This reduces the need for additional tool holders.

Tools according to Form B/D cannot be used in the HC/HCS spindle, they are designed for different applications.
Clamping System

Both the ISO taper style and the "HSK" hollow shank tool holders are clamped via a set of gripper fingers. The clamping forces are generated through a spring washer pack, included in the power drawbar.

The centrifugal forces exerted by the balls in the pressure intensifier, multiplies the pull in force on an ISO taper style system. It is also speed dependent.

Increases in the pull in force for the HSK style tool clamping system is by the centrifugal forces on the internal gripping mechanism.

Tool unclamping on either system is accomplished by pressure. An internal cylinder mounted at the rear of a spindle, along with a gripping mechanism supports the shaft during unclamping, to prevent the pressure exerted through the shaft from damaging the spindle bearings. During operation the gripping mechanism is disconnected.

These designs provide low vibration and a high safety factor for high speed quick change tool clamping systems.

Position Sensors

The GMN spindles are equipped with proximity sensors to allow for proper, trouble free operation during tool changing.

- **Tool change**
  Depending on the size and nominal speed of the spindle, a variety of sensor arrangements can be applied for feed back to the machine control, about the tool changing cycle.

  **Variation A**
  Depending on the internal space constraints the drawbar can be monitored for "tool clamped", "unclamped", "clamped no tool", with one analog sensor or three inductive proximity switches.

  **Variation B**
  A two sensor arrangement for monitor the position of the piston, either "forward" or "back".

- **Rotation of shaft**
  If the spindle size and speed restrict the use of an encoder, GMN can provide alternative sensors for actual shaft speed, and also "zero speed".
Air Purge

Pressurized air is used to prevent the ingress of contamination into the bearing system. A continuous flow of clean dry air fills the closely machined gaps between the stationary and rotating members of the spindle. The air stream also stops the spent oil lubrication from existing at the front of the spindle and away from the work piece.
The internal coolant supply provides cooling directly to the cutting edge also at difficult form of workpieces. In accordance to the interface size and dependent on the maximum operating speed different systems can be used:
- Only air
- Air or coolant in one line
- Air and coolant in separate lines

For cooling of tool and workpiece the medium is supplied through spindle housings and nozzles to the cutting surfaces.
Compressed air, cooling lubricant/air mixture or cooling lubricant can be used.
The representation below is with cooling lubricant as medium.
Internal Minimized Coolant Supply
Single-Channel System

Characteristics of single-channel minimized coolant supply:

- Superfine oil mist (aerosol)
- Speed limitation due to aerosol decomposition
- For standard rotary unions
- For tools with coolant bore diameter > 1 mm
- In comparison with two-channel system longer reaction times at quantity changings
- For machines with less tool changes
Internal Minimized Coolant Supply
Two-Channel System

Characteristics of two-channel minimized coolant supply:
- No oil mist
- Oil and air mixable in almost any quantities or only air supply
- In comparison with single-channel system higher speeds possible
- For tools with high lubricant consumption
- For machines with more tool changes
Precision machining requires the position of the cutting edge of the tool to be maintained. Temperature variations and centrifugal forces at the balls and bearing races, can cause axial movement of the tool mounting face of the shaft.

Axial shaft growth which is caused by fluctuations in temperature, can produce process errors in milling applications. GMN can incorporate a sensor at the front of the spindle to record the exact growth and the CNC machine control can compensate for the movement. The measuring system which consists of an electronic controller which conditions the signal provided by the sensor has data storage capacity which provides immediate response after spindle exchange.

The "centrifugal forces" factor can be calculated and the speed dependent shaft movement can be compensated by through the machine tool control.

Measuring the shaft temperature at the bearing during operation is difficult. Experience has shown that by measuring the temperature at outer diameter of the bearings, approximate temperature variations can be established and the axial movement compensated for.

The diagram illustrates the axial shaft growth of a spindle operating at 25000 rpm.
GMN spindles can be supplied with multi-couplings for energy and fuel supply. This reduces the unproductive spindle replacement times, or - depending on the design - can even make possible the automatic replacement of spindles, thus increasing the flexibility of the machine.
Before GMN machine spindles for high speed machining (HSC) are delivered, they are tested on a test stand specially developed for GMN.

One reason for this is that motor spindles become more and more complex and on the other hand their reliability is guaranteed by this.

The test in which the setpoints as well as cycle and switching times are specified runs automatically. Finally a test certificate is produced in which all measured values are documented.

2 motor spindles with different parameters can be tested simultaneously. Here it was proven that 180 cycles are sufficient to guarantee the highest possible reliability. In every cycle the spindle is turned to maximum speed in a specified time within seconds, the shaft encoder signals are checked, the spindle is braked under defined conditions after a certain time, the tool change is performed and the signals of the position sensors are measured. The position of the tool clamping system can be determined optionally analogously or through individual switches.

Furthermore the following are acquired: motor current, voltage in the windings, temperature of the winding and of the foremost bearing and, depending upon spindle equipment, functioning of coolant supply through the shaft and the adjustable bearing preload.
**HC 80cg - 40000/3**

**Synchronous motor**
- Power P (S1): 3 kW at 30,000 rpm
- Torque M (S1): 0.96 Nm
- Speed n max: 40,000 rpm
- Drive: open-loop

**Hybrid ball bearings**
- Bore diameter of front bearings: 30 mm
- Lubrication: Grease
- Interface: HSK-E 25

**Tool interface**
- Monitoring: "clamped", "unclamped"
- Taper cleaning
- Static tool pull-in force
- Tool release: Analog sensor, Air, 2.8 kN, Hydraulic or pneumatic, Air purge

**Seal**
- Radial: 41 N/μm
- Axial: 50 N/μm

Also available for oil/air lubrication. This lubrication possibly leads to increase of speed.
**Synchronous motor**
- Power P (S1): 5 kW at 60,000 rpm
- Torque M (S1): 0.8 Nm
- Speed n_max: 60,000 rpm
- Drive: open-loop

**High precision hybrid ball bearings**
- Bore diameter of front bearings: 35 mm
- Lubrication: Oil/air

**Tool interface**
- Interface: HSK-E 32
- Monitoring: "clamped", "unclamped"
- Static tool pull-in force: Analog sensor 4 KN

**Seal**
- Radial: Air purge
- Axial: 96 N/μm
- 35 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Synchronous motor
- Power P (S1): 15 kW at 24,000 rpm
- Torque M (S1): 6 Nm
- Speed n max: 45,000 rpm
- Drive: closed-loop

Hybrid ball bearings
- Bore diameter of front bearings: 45 mm
- Lubrication: Oil/air, HSK-E 40

Tool interface
- Monitoring: "clamped", "unclamped", "clamped without tool"
- Taper cleaning
- Static tool pull-in force
- Proximity switches Air
- 6.8 kN

Seal
- Coolant through shaft: Air purge
- 80 bar

Shaft movement
- Compensating - Axial: Temperature sensor

Rigidity
- Radial: 125 N/μm
- Axial: 91 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Asynchronous motor
Power P (S1) 10.5 kW at 51,000 rpm
Torque M (S1) 2 Nm
Speed n_max 60,000 rpm
Drive closed-loop

Hybrid ball bearings
Bore diameter 30 mm
of front bearings Oil/air
Lubrication HSK-E 25

Tool interface
Monitoring "clamped", "unclamped",
"clamped without tool"
Taper cleaning Analog sensor
Static tool pull-in force Air

Seal
Coolant through shaft 2.8 kN
Air purge

Rigidity
Radial 80 bar
Axial 110 N/μm
70 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
GMN
High frequency spindle for automatic tool change

HCS 120 - 75000/10

Synchronous motor
- Power P (S1): 10 kW at 75,000 rpm
- Torque M (S1): 1.3 Nm
- Speed n<sub>max</sub>: 75,000 rpm
- Drive: closed-loop

Hybrid ball bearings
- Bore diameter of front bearings: 30 mm
- Lubrication: Oil/air

Tool interface
- Monitoring: Analog sensor
- "clamped", "unclamped", "clamped without tool"
- Taper cleaning: Air
- Static tool pull-in force: 2.8 kN

Seal
- Coolant: Air purge
  - through shaft: 80 bar

Shaft movement
- Compensating - Axial temperature sensor

Rigidity
- Radial: 110 N/μm
- Axial: 69 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Synchronous motor
- Power P (S1): 4 kW at 90,000 rpm
- Torque M (S1): 0.43 Nm
- Speed n_max: 90,000 rpm
- Drive: closed-loop

Hybrid ball bearings
- Bore diameter: 25 mm
- Oil/air

Tool interface
- Monitoring: Analog sensor
- "clamped", "unclamped", "clamped without tool"
- Taper cleaning: Air
- Static tool pull-in force: 1.8 kN

Seal
- Air purge

Rigidity
- Radial: 89 N/μm
- Axial: 56 N/μm

Option
- Vibration sensor
- Coolant through the shaft: 80 bar

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
**Synchronous motor**
- Power P (S1): 15 kW at 24,000 rpm
- Torque M (S1): 6 Nm
- Speed n\(\text{max}\): 42,000 rpm
- Drive: closed-loop

**Hybrid ball bearings**
- Bore diameter: 35 mm
- of front bearings
- Lubrication: Oil/air
- HSK-E 32

**Tool interface**
- Monitoring: Analog sensor
- “clamped”, “unclamped”, “clamped without tool”
- Taper cleaning: Air
- Static tool pull-in force: 5 kN
- Seal: Air purge

**Shaft movement**
- Measuring - Axial: Displacement sensor

**Rigidity**
- Radial: 146 N/μm
- Axial: 84 N/μm

**Option**
- Coolant through the shaft: 80 bar

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
**Synchronous motor**
- Power P (S1)
- Torque M (S1)
- Speed nmax
- Drive

**Hybrid ball bearings**
- Bore diameter
- of front bearings
- Lubrication
- Bearing preload

**Tool interface**
- Monitoring
- "clamped", "unclamped",
- "clamped without tool"
- Taper cleaning
- Static tool pull-in force
- Analog sensor
- Air

**Seal**
- Air purge

**Shaft movement**
- Compensating - Axial
- Measuring - Axial
- Measuring - Radial
- Temperature sensor
- Displacement sensor
- 2 Displacement sensors

**Rigidity**
- Radial
- Axial

**Option**
- Coolant through the shaft

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Synchronous motor
- Power P (S1)
- Torque M (S1)
- Speed n_{max}
- Drive

Hybrid ball bearings
- Bore diameter
- of front bearings
- Lubrication

Tool interface
- Monitoring
  - “clamped”, “unclamped”,
  - “clamped without tool”
- Taper cleaning
- Static tool pull-in force

Seal
- Air purge

Coolant
- through shaft

Rigidity
- Radial
- Axial

Also available with permanent grease lubrication.
This lubrication leads to speed reduction.
Synchronous motor
- Power P (S1) 42.8 kW at 14,000 rpm
- Torque M (S1) 29.2 Nm
- Speed n_{max} 28,000 rpm
- Drive closed-loop

Hybrid ball bearings
- Bore diameter 70 mm
- of front bearings Oil/air
- Lubrication HSK-A 63

Tool interface
- Monitoring Analog sensor
- "clamped", "unclamped", Air
- "clamped without tool" 18 kN
- Taper cleaning Air purge
- Static tool pull-in force

Seal
- Coolant Air
- through shaft 40 bar

Rigidity
- Radial 460 N/μm
- Axial 180 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
**Synchronous motor**
- Power P (S1)
- Torque M (S1)
- Speed n\text{max}
- Drive

**Hybrid ball bearings**
- Bore diameter
- of front bearings
- Lubrication

**Tool interface**
- Monitoring
  - “clamped”, “unclamped”, “clamped without tool”
- Taper cleaning
- Static tool pull-in force

**Seal**
- Coolant
  - through shaft
  - through spindle housing
- Rigidly
  - Radial
  - Axial

40 kW at 7,000 rpm
55 Nm
30,000 rpm
closed-loop
70 mm
Oil/air
HSK-A 63

**Analog sensor**
- Air
- 71 kN
- Air purge
- 80 bar
- 10 bar
- 470 N/µm
- 135 N/µm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Asynchronous motor
- Power P (S1): 39 kW at 18,000 rpm
- Torque M (S1): 20.7 Nm
- Speed n_max: 40,000 rpm
- Drive: closed-loop

Hybrid ball bearings
- Bore diameter: 55 mm
- Oil/air lubrication

Tool interface
- Interface: HSK-E 50
- Monitoring: Proximity switches
- Taper cleaning: Air
- Static tool pull-in force: 10 kN

Seal
- Air purge

Coolant
- through shaft: 80 bar

Shaft movement
- Compensating - Axial
- Measuring - Axial
- Temperature sensor
- Displacement sensor

Rigidity
- Radial: 307 N/μm
- Axial: 102 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Asynchronous motor
- Power $P$ (S1): 10 kW at 15,000 rpm
- Torque $M$ (S1): 6.4 Nm
- Speed $n_{max}$: 42,000 rpm
- Drive: closed-loop

Hybrid ball bearings
- Bore diameter: 55 mm
- of front bearings: Oil/air
- Lubrication: HSK-A 50 / HSK-E 50

Tool interface
- Monitoring: Analog sensor
- "clamped", "unclamped", "clamped without tool"
- Taper cleaning: Air
- Static tool pull-in force: 10 kN

Seal
- Coolant through shaft: Air purge
- 40 bar

Shaft movement
- Compensating - Axial: Temperature sensor
- Rigidity
  - Radial: 270 N/μm
  - Axial: 140 N/μm

Option
- Acceleration sensor
- Shaft movement sensor

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Synchronous motor
- Power P (S1) 30 kW at 1,600 rpm
- Torque M (S1) 179.3 Nm
- Speed n_max 12,000 rpm
- Drive closed-loop

Hybrid ball bearings
- Bore diameter 110 mm
- of front bearings oil/air
- Lubrication HSK-A 100

Tool interface
- Monitoring analog sensor
- "clamped", "unclamped"
- "clamped without tool"
- Taper cleaning air
- Static tool pull-in force 45 kN

Seal
- Coolant Air purge
- through shaft 50 bar
- through spindle housing 3 bar

Rigidity
- Radial 800 N/μm
- Axial 320 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Synchronous motor
- Power P (S1) 120 kW at 13,800 rpm
- Torque M (S1) 83 Nm
- Speed n_{\text{max}} 24,000 rpm
- Drive closed-loop

Hybrid ball bearings
- Bore diameter 90 mm
- of front bearings Oil/air
- Lubrication HSK-A 80

Tool interface
- Monitoring Proximity switches
- “clamped”, “unclamped”, Air
- “clamped without tool” 32 kN
- Taper cleaning Air purge
- Static tool pull-in force 50 bar

Seal
- Coolant
- through shaft Air

Shaft movement
- Compensating - Axial Temperature sensor
- Measuring - Axial Displacement sensor
- Measuring - Radial 2 Displacement sensors
- Vibration recognition Sensor

Rigidity
- Radial 496 N/\mu m
- Axial 160 N/\mu m

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
**Synchronous motor**
- Power P (St)
- Torque M (St)
- Speed n_{max}
- Drive

**Hybrid ball bearings**
- Bore diameter
- of front bearings
- Lubrication

**Tool interface**
- Monitoring
  - "clamped", "unclamped"
  - "clamped without tool"
- Taper cleaning
- Static tool pull-in force

**Seal**
- Coolant
  - through shaft
  - through spindle housing
- Air
  - 20 kN
  - Air purge

**Shaft movement**
- Compensating - Axial
  - Temperature sensor

**Rigidity**
- Radial
- Axial
  - 380 N/μm
  - 145 N/μm

**Option**
- Vibration sensor
- Shaft movement sensor

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
**Asynchronous motor**
- Power P (S1) 40 kW at 4,500 rpm
- Torque M (S1) 85 Nm
- Speed nmax 16,000 rpm
- Drive closed-loop

**Hybrid ball bearings**
- Bore diameter 70 mm
- of front bearings Oil/air
- Lubrication HSK-A 63

**Tool interface**
- Monitoring Analog sensor
- "clamped", "unclamped", Air
- "clamped without tool" 20 kN
- Taper cleaning Air purge
- Static tool pull-in force

**Seal**
- Coolant 80 bar
- through shaft 10 bar
- through spindle housing

**Shaft movement**
- Compensating - Axial Temperature sensor

**Rigidity**
- Radial 647 N/μm
- Axial 282 N/μm

**Option**
- Shaft displacement sensor
- Vibration sensor

Also available for oil/air lubrication. This lubrication possibly leads to increase of speed.
Asynchronous motor
- Power $P$ (S1)
- Torque $M$ (S1)
- Speed $n_{\text{max}}$
- Drive

Hybrid ball bearings
- Bore diameter
- of front bearings
- Lubrication

Tool interface
- Monitoring
  - "clamped", "unclamped"
  - "clamped without tool"
- Taper cleaning
- Static tool pull-in force

Seal
- Coolant
  - through shaft
  - through spindle housing

Shaft movement
- Compensating - Axial

Rigidity
- Radial
- Axial

Option
- Shaft displacement sensor
- Vibration sensor

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Synchronous motor
- Power P (S1)
- Torque M (S1)
- Speed n_max
- Drive

Hybrid ball bearings
- Bore diameter
- of front bearings
- Lubrication

Tool interface
- Monitoring
  "clamped", "unclamped",
  "clamped without tool"
- Taper cleaning
- Static tool pull-in force

Seal
- Air purge

Coolant
- through shaft

Rigidity
- Radial
- Axial

Option
- Closed housing with internal motor cooling

96 kW at 1,500 rpm
611 Nm
8,000 rpm
closed-loop
120 mm
Oil/air
BBT 50
Proximity switches
Air
25 kN
Air purge
80 bar
935 N/μm
540 N/μm
Ø D_{min} = 285 mm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
**Synchronous motor**
- Power $P$ (S1): 94 kW at 2,000 rpm
- Torque $M$ (S1): 450 Nm
- Speed $n_{\text{max}}$: 10,000 rpm
- Drive: closed-loop

**Hybrid ball bearings**
- Bore diameter: 110 mm
- of front bearings: Grease
- Lubrication: HSK-A 100 / SK 50

**Tool interface**
- Monitoring: Analog sensor
- "clamped", "unclamped", "clamped without tool":
- Taper cleaning:
- Static tool pull-in force: Air
- 45 kN

**Seal**
- Coolant: Air purge
- through shaft: 80 bar

**Shaft movement**
- Compensating - Axial: Temperature sensor

**Rigidity**
- Radial: 920 N/μm
- Axial: 610 N/μm

**Option**
- Closed housing with internal motor cooling: $\phi$ Dmin = 285 mm

Also available for oil/air lubrication. This lubrication possibly leads to increase of speed.
**Asynchronous motor**
- Power $P$ ($S_1$): 60 kW at 3,300 rpm
- Torque $M$ ($S_1$): 174 Nm
- Speed $n_{\text{max}}$: 18,000 rpm
- Drive: closed-loop

**Hybrid ball bearings**
- Bore diameter of front bearings: 110 mm
- Lubrication: Oil/air

**Tool interface**
- Monitoring: "clamped", "unclamped", "clamped without tool"
- Taper cleaning
- Static tool pull-in force: Analog sensor
- Air
- 45 kN

**Seal**
- Coolant: through shaft
- 80 bar
- through spindle housing: 10 bar

**Shaft movement**
- Compensating: Axial
- Temperature sensor

**Rigidity**
- Radial: 890 N/μm
- Axial: 310 N/μm

**Option**
- Shaft displacement sensor
- Vibration sensor
- Closed housing with internal motor cooling: $\varnothing D_{\text{min}} = 300$ mm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
**HCS 280g - 6000/31**

**Synchronous motor**
- Power P (S1): 31 kW at 350 rpm
- Torque M (S1): 850 Nm
- Speed $n_{\text{max}}$: 6,000 rpm
- Drive: closed-loop

**Hybrid ball bearings**
- Bore diameter of front bearings: 110 mm
- Lubrication: Grease
- Tool interface: HSK-A 100

**Monitoring**
- “clamped”, “unclamped”, “clamped without tool”
- Taper cleaning
- Static tool pull-in force
- Analog sensor
- Air
- 65 kN

**Seal**
- Air purge

**Coolant**
- through shaft
- through spindle housing
- 80 bar
- 5 bar

**Shaft movement**
- Compensating - Axial
- Temperature sensor

**Rigidity**
- Radial
- 597 N/μm
- Axial
- 734 N/μm

**Option**
- Vibration sensor

Also available for oil/air lubrication. This lubrication possibly leads to increase of speed.
Asynchronous motor
Power P (S1) 40 kW at 1,680 rpm
Torque M (S1) 227.5 Nm
Speed n max 12,000 rpm
Drive closed-loop

Hybrid ball bearings
Bore diameter 110 mm
of front bearings
Lubrication Oil/air

Tool interface
Monitoring HSK-A 100
"clamped", "unclamped",
"clamped without tool"
Taper cleaning
Static tool pull-in force

Seal
Coolant
through shaft
through spindle housing

Shaft movement
Compensating - Axial

Rigidity
Radial 760 N/μm
Axial 350 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Asynchronous motor
- Power P (S1): 30 kW at 1,000 rpm
- Torque M (S1): 270 Nm
- Speed n_max: 12,000 rpm
- Drive: closed-loop

Hybrid ball bearings
- Bore diameter: 110 mm
- of front bearings
- Lubrication: Oil/air

Tool interface
- Monitoring: "clamped", "unclamped", "clamped without tool"
- Taper cleaning
- Static tool pull-in force: Analog sensor
- Air
- 45 kN
- Seal
- Coolant: Air purge
- through shaft: 50 bar

Rigidity
- Radial: 955 N/μm
- Axial: 607 N/μm

Also available with permanent grease lubrication.
This lubrication leads to speed reduction.
Asynchronous motor
Power $P$ ($S_1$)
Torque $M$ ($S_1$)
Speed $n_{\text{max}}$
Drive

Hybrid ball bearings
Bore diameter
of front bearings
Lubrication

Tool interface
Monitoring
“clamped”, “unclamped”,
“clamped without tool”
Taper cleaning
Static tool pull-in force

Seal
Coolant
through shaft
through spindle housing

Shaft movement
Compensating - Axial

Rigidity
Radial
Axial

Option
Shaft movement sensor
Vibration sensor

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Asynchronous motor
- Power P (S1): 40 kW at 1,050 rpm
- Torque M (S1): 380 Nm
- Speed n_max: 8,000 rpm
- Drive: closed-loop

Hybrid ball bearings
- Bore diameter: 110 mm
- of front bearings: Oil/air
- Lubrication: SK 50

Tool interface
- Monitoring: "clamped", "unclamped", "clamped without tool"
- Taper cleaning
- Static tool pull-in force: Analog sensor
- Air: 25 kN
- Air purging

Seal
- Coolant: through shaft
- through spindle housing: 80 bar
- 3 bar

Rigidity
- Radial: 760 N/μm
- Axial: 350 N/μm

Also available with permanent grease lubrication. This lubrication leads to speed reduction.
Internet
At our internet site www.gmn.de we provide comprehensive product information that can be downloaded.

GMN
GMN Paul Müller Industrie GmbH & Co. KG manufactures high precision ball bearings, machine spindles, freewheel clutches and seals for a broad spectrum of applications at its Nuremberg, Germany plant.

On the basis of long experience in the development and production of machine components, GMN has specialized in the manufacture of high quality products in the field of high precision ball bearings and, beyond a comprehensive standard product line, also offers customer-oriented special solutions.

A global GMN service network offers competent customer consultation and individualized solutions.

GMN Quality management - tested and certified.
GMN guarantees utmost quality for its products and services that is based on long term reliability. Highly modern development and production methods ensure products that always represent state-of-the-art technology. All GMN corporate divisions are structured for transparency and clear organisational workflows to ensure customer-oriented services and economic security.

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For GMN, progress means the best possible customer support combined with performance-oriented optimization of its technical products. This claim is realized at GMN under especially strict observance of national and international environmental standards with regard to efficient, responsible utilization of ecological resources.