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# THE NEW PRINCIPAL ACTION TO THE HORIZONTAL MACHINING CENTRE: CPH 800

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## Abstract

**Keyword**: high spindle speed for HSK

The paper work is presenting the principal action of CPH 800 (horizontal machine centre), with a power oh 22KW, a high spindle speed of 8,000 rpm, with the axis drive system: X=800, Y=800, Z=1250, an APC 2x800, ATC 40. (See fig. 4)

## Introduction

The objective necessity to produce faster with a bigger productivity; drive to a vertiginous evolution of the actual conception of structural realization of the machine work centre. Because of this the productivity gains through high-speed machining, has become a major focus of the metal working industry. To, day the majority of the components of the machine centres are standardized, that make more easy the design and the construction of the machine, reducing a lot of time.

## Contents

One of the most modern systems of tool fix on the work machine centres is the HSK system. Even it started to be used of more companies, this solution of fix is not sow know.

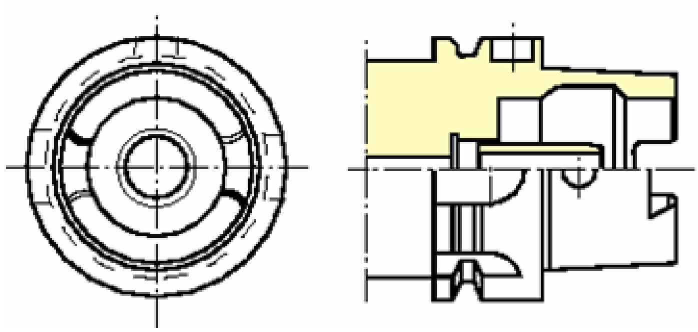

**fig. 1 - Hollow shaft tapers DIN 69893; Form A, [5]**

The HSK comes from Hollow Short Kegel (German language) and means hollow shaft taper. This system started to be used since 1980 in Germany for obtain a more good work and a more high speed on the machine work centres. The hollow shaft taper, was designed by a students group from Aachen University. They took in discussion all the disadvantages of the classic system of tool fix and they tried to create a new system of tool fix that eliminate all the disadvantages and can work at a more high speed.

The students from Aachen tried to eliminate the following four disadvantages of the traditional hollow shaft taper:

-dynamic instability when the forces of chip removal, acts radial and the speeds of chip removal are big

-the elongation and the deformations of the hollow shaft taper because of forces action

-the blockage of the hollow shaft taper in the boring spindle

-the incompatibility methods of clamp of the hollow shaft taper at various machines

The new system HSK was projected an achieved by taken in consideration the next chip removal characteristics: the static and dynamic comportment,
the forces and the moments that appear in the time working, the vibrations, the high speed chip removal, the mass of the tools, the high precision, the thermic behaviour of the whole assemble, the cooling tool system.

Chuck (tool-holder) design is also an important consideration in high-speed machining. Tool-holders for tool changer type machines (which are commonly used in HSM) interface with both the spindle as well as the tool shank. The spindle interface is typically via a taper held in place by a spring loaded retention system which is mounted inside the spindle shaft. The most popular taper for HSM is becoming the HSK (hollow shank taper) design, which combines the accuracy of a taper with the rigidity of a flange mount. The HSK tool-holder - spindle interface actually improves at high-speed due to “centrifugal clamping”. There are several tool holding systems that are used in HSM for holding the tool shank in the tool-holder. These include the traditional collet-nut system, hydraulic systems, hydro-mechanical systems and heat shrink systems. The traditional collet nut system relies on contraction of a collet, and is limited in torque capacity and accuracy.

The latest technique of using minimum volumes of coolant for dry operations has become a focal point in the manufacturing industry. We have two variations for all HSK-clamping units:

-External minimum volume lubrication

Using external MMKS, the aerosol is produced in a special mixing device outside the spindle. Like coolant, the mixture is fed through a rotary union. And we have two variations offers three variations of rotary unions to be used for external minimum volume lubrication for HSK-clamping units:

• Dual-passage rotary union (max. 10.000 RPM – mixed externally $p_{max}$ = 5bar)

• Single-passage rotary union GDR for unclamp units (max. 16.000 RPM – mixed externally $p_{max}$ = 5 bar)

• Single-passage rotary union GD for unclamp units (max. 36.000 RPM – mixed externally $p_{max}$ = 5 bar)

-Internal minimum volume lubrication

Using internal MMKS, the air-lubrication mixture is produced inside the spindle.

Air and minimum amounts of lubrication are fed separately into the spindle through the HSK-clamping unit. They are mixed directly in front of the tool interface. Changing the mixture ratio, allows for a quick adjustment of the aerosol doses.

Both, systems can be integrated as modules in to existing as well as new HSK-clamping units.

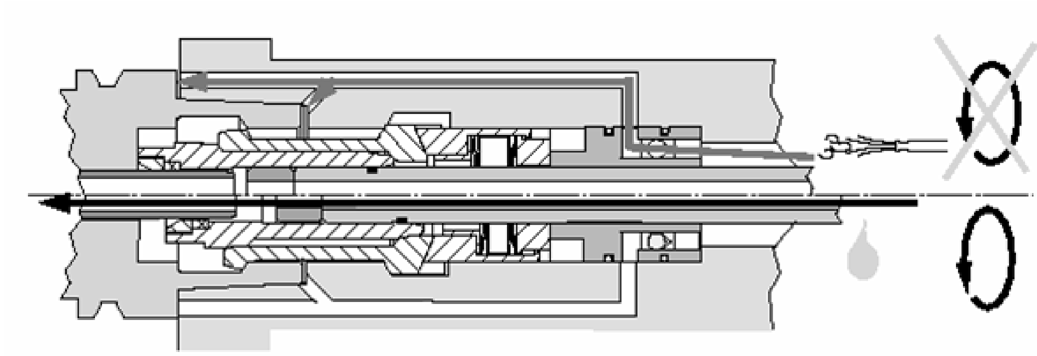

**fig.2 - An example of medium transfer for HSK-clamping unit with the follow characteristics: axial transfer; air transfer through spring location, [5]**

Accelerated machining in the machine tool and mould making industry and in the cutting industry through High-Speed-Cutting (HSC) requires solutions for faster tool change.

A shorter tool changing time represents a constant challenge, which even increased with HSC-manufacturing. Fast working automatic clamping systems are necessary which have to be more accurate, rigid and universal than conventional systems.

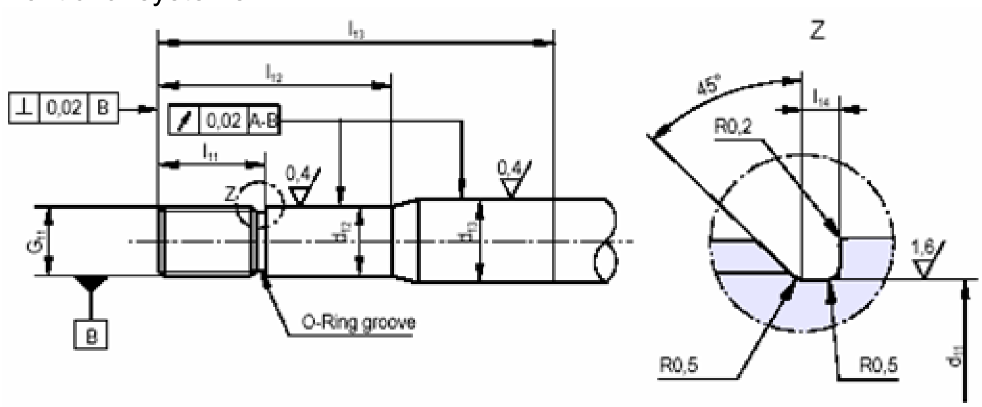


**fig.3 - Draw bar HSK form A, [5]**

In the area of Steep Tapers, was developed a SK-50 Power Drawbar with a sensational short spindle of 298 mm length. Because of these new dimensions, new manufacturing methods became feasible of which machine tool designers in the past could only dream. This short spindle length of 298 mm allows for optimum flexibility and space saving. Five-axis heads, as well as threaded head, can now be built more compact. As spindle speed of 8,000 RPM and a pull force of 15,000 N are features which can be advantageously utilized for extreme applications. Secure tool retention at extreme cutting conditions at any angle position can be realized.

The coolant/air supply is possible through single or double passage rotary unions. The assembly of the power drawbars can be done easily and quickly by average personnel.

The spindle is the key to high-speed machining applications and bearings are the most critical part of a high-speed spindle. The design of a high-speed spindle must result in a high rotational speed, sufficient power and torque, and reasonable load capacity and life. High-speed spindle bearing design options include roller bearings, ball bearings, hydrostatic bearings, and magnetic bearings. The most popular bearing type for high rotational speeds (above 30,000 rpm) is the angular contact ball bearing system.

The primary factors influencing power consumption for metal machining operations, include width of cut, depth of cut, spindle rotational speed (rpm), number of flutes on the cutter, work-piece feed speed, and details of the milling process (conventional or climb cutting). Other factors which influence power consumption include cutter diameter, tool edge condition, tool rake angle and type of cutting tool.

Motion of the X, Y, and Z axes of CNC is traditionally provided by ball screws and servo motors.

Control systems and control system software must be compatible with high-speed operation. An important factor is servo cycle time; the time required for a system to detect location it is and issue a command for the next move. The cycle time is critical in the operation of high-speed systems, since between cycles, the machine is essentially out of control.

One of the key components of a high-speed machining centre is the spindle assembly, which rotates the tool. Due to space and speed capability considerations, most high-speed spindles of the type used on modern CNC routers are motorized units, in which the spindle shaft and motor are integrated into a single package. Many machine spindles are not properly designed for high-speed operation and exhibit high bearing failure rates resulting from high loads, plunge cutting, dust contamination, excessive heat, and excessive vibration. High-speed spindles (over 8,000 rpm) require high precision manufacturing tolerances, special bearings and bearing lubrication, and effective bearing - rotor cooling provisions. For high-speed operation, the spindle rotor - bearing system must be dynamically stable (no critical speed or resonant behaviour in the operational rpm range) and be balanced to high precision. Dust contamination and heat problems must also be addressed in the spindle design process by using appropriate seals, air purge systems, and proper lubrication and cooling techniques.

Bearing loading considerations, including requirements relating to heat expansion and plunge routing, are also an important part of the spindle design process.

Computer programs are useful in helping avoiding critical (resonant) speeds, selecting bearings, determining resulting bearing loading, and establishing required manufacturing tolerances. At very high rpm (30,000 and above) spindle cooling becomes critical for motorized spindle designs and provision for thermal growth of the shaft must be carefully designed into the spindle bearing housing to prevent excessive axial loading of the bearings at elevated temperature.

The technology has progressed significantly in recent years and some machines are now capable of extremely high feed rates as well as high-speed loading and unloading of sheet material. These machine employ high-speed, high-power cutter spindles, high-speed drive systems (linear motors, motorized ball screw nut, etc.), low weight-high rigidity tables, advanced controllers capable of “look ahead” cornering, and often employ software programs which optimize the nesting of components for improved material usage and machining efficiency. HSM can result in fewer machines, fewer operators, and much more efficient operation. High-speed, high- power machines are typically more expensive to purchase than conventional machines and the justification of these machines requires a detailed understanding of the machine capability and how the machine will be used. This understanding requires a knowledge of the feed rates and rapid travel rates which can be achieved by the machine, the number of sheets of material that can be processed simultaneously, and the time required for loading and unloading sheet material. In addition to assessing machine capabilities, it is important to make an accurate assessment of the volume of parts that will be required. The higher expense of a machine capable of HSM may not be warranted unless the machine is utilized to the extent anticipated.

In order to pursue HSM, a number of machine performance factors must be addressed simultaneously; including spindle motor power and torque, feed drive system capabilities, and controller capabilities. One of the more difficult machine features to assess is the capability of the machine spindle, which holds and rotates the cutting tool. As feed speeds and number of sheets cut simultaneously increase, the power and torque requirements placed on the spindle rise dramatically.

Once the production capabilities of a high-speed, high-power machine is established, economic decisions can be made based on machine cost, machine utilization, labour and maintenance costs, and a knowledge of the outsourcing part pricing. In order to facilitate these comparisons, a computer program was developed in this study which provides assistance in making a meaningful comparison of operating high-speed equipment to (a) operating low speed equipment, and (b) outsourcing parts.

## Conclusion

All of the elements of the CNC router must be matched to provide optimum conditions for high-speed machining. It is of no value to place an 8,000 rpm spindle on a machine that cannot provide a controlled feed rate sufficient to maintain constant tooth loading. Significant gains in productivity are possible for many applications through the use of high-speed CNC routers; however, nearly every key component of a conventional CNC router must be redesigned to achieve satisfactory high-speed performance.

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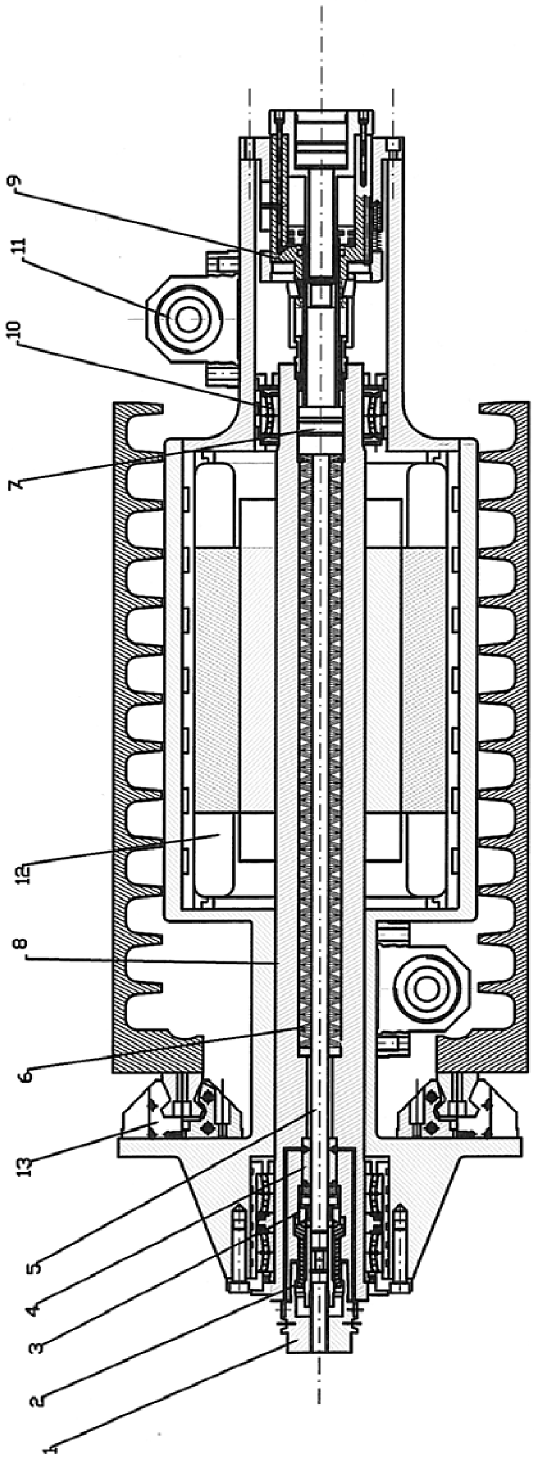


Horizontal High Speed Machining Center CPH 800
Power 22KV, spindle speed 140 - 14000 RPM, HSK 63