Customer……

KERN PYRAMID NANO Machining Centre

The KERN Pyramid Nano is an ultra-precision machining centre with the highest level of accuracy in a standard 3 axis configuration. It is also capable of having a 5 axis table easily fitted at a later date. In 3 axis configuration the working envelope is 500 x 500 x 400 mm. It is also possible to have the $4^{th}/5^{th}$ axis table situated at the rear of the machine table and to be able to work in 3 axes at the front of the table, (information at the end of this specification)

The machine bed is manufactured from a thermally stable and rigidly constructed concrete and steel frame "KERN Amorith" (patented). The table, even in 5 axis configuration, can carry loads up to 50 kg. The machine has an integrated air-feed system to allow workpiece clamping via workpiece reference systems (System 3R and Erowa are examples).

There is a choice of 2 spindles:

1. A vector controlled HSK25 spindle with a speed range from 500 to 50,000 rpm is fully integrated in the Z axis. The Z axis, spindle and coolant are temperature controlled to ensure the highest level of accuracy when machining. The power of the spindle is 6.4kW and it is a permanently grease packed spindle.

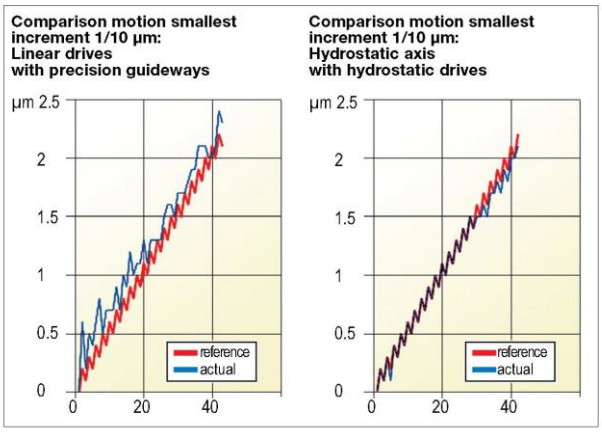
2. A vector controlled HSK40 spindle with through tool coolant capability and a speed range from 500 to 42,000 rpm is fully integrated in the Z axis. The Z axis, spindle and coolant are temperature controlled to ensure the highest level of accuracy when machining. The power of the spindle is 15kW and it is a permanently grease packed spindle.

Automatic compensation of the spindle position due to expansion by thermal and dynamic conditions is included to ensure the highest of precision of machine faces in the Z axis.

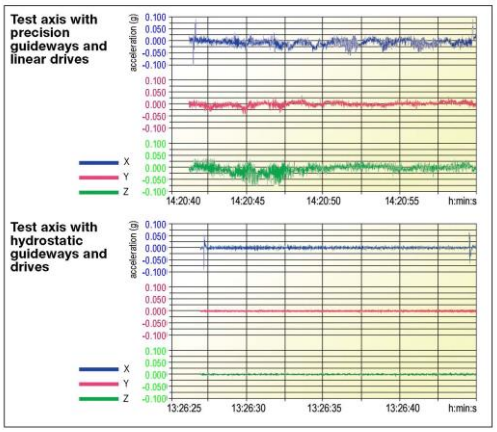
The KERN Pyramid Nano machine is fully thermally stable. Each hydrostatic axis, X, Y, and Z has its own temperature regulated circuit via a chiller system (which can be positioned up to 30 metres away from the machine to remove heat from the working environment).

The axis motion of the KERN Pyramid Nano machining centre is driven by hydrostatic drives consisting of a hydrostatic screw and nut and hydrostatic guideways. The hydrostatic drive system has a film of oil approximately 18µm between the hydrostatic screw and nut and opposing sides of the guideway, with no metal to metal contact. This feature eliminates the stick-slip issues of other drive systems. When designing the Pyramid Nano machine, KERN employed the University of Aachen to investigate drive and guideway systems and clearly established the benefits of hydrostatic drives and guideways over linear drives. The hydrostatic motion also enables the finest of surface finishes to be achieved by milling technology.

Movement Analysis
Linear motors v Hydrostatic drive



Vibration Analysis
Ballscrew v Hydrostatic guideway



Automatic workpiece changing systems are available and can be retro-fitted at a later date. There are 3 types of palletisation system:

- A 20 station integral system for pallets of 70 x 70 mm. Maximum workpiece height 150 mm.
- An external workpiece changing system (example System 3R or Erowa) with pallets up to 240 x 240 mm (number of pallets limited by the capacity of the magazine).
- Finally by using a 6 axis robot loading system, combined with a "bookcase magazine", pallets of different dimensions can be automatically positioned in the machine working area in either the chuck on the 3 axis table or the chuck on the 4th/5th axis table. The pallet grippers can also be changed automatically.

20 Station Integral Pallet Magazine

System 3R Workpal Compact Workpiece Magazine

6 axis Robot Loading Cell

To ensure the highest of accuracies and temperature control of all axes the machine must be of a rigid construction with the necessary protection systems (temperature control units).

The machine working area is easily accessible through two sliding doors on the front of the machine, which are interlocked for safety when the machine is working in automatic operation. The Heidenhain iTNC control unit is also positioned on the front of the machine on a swivelling pedestal that reaches to the optimum position by the doors when setting-up. The tool magazine situated on the right side of the machine and the doors can be opened while the machine is working, but a tool change is prevented by the machine operation safety system.

As mentioned previously, the rigidity of the machine is critical in the achievement of accuracy but control of any thermal effects is also paramount. The full temperature control of each axis, the spindle and the coolant ensures the most demanding of tolerances can be achieved. The tolerance set on the cooling system is ± 0.25°C.

A Heidenhain iTNC530 control system on the KERN Pyramid Nano is a powerful 3 and 5 axis control, very user friendly and particularly suitable for both prototype and medium batch manufacturing. It can be programmed by using MDI in Heidenhain language with lots of canned cycles for quick and easy input of information, as well as ISO language. The control includes many features required as standard in the modern machine shop environment.

Accuracy

The smallest programmable increment is 0.0001 mm (0.1 µm) and the axis positioning is via a closed loop feed-back from linear glass scales with a low pressure air purge to ensure absolute cleanliness.

KERN, being a German machine tool manufacturer, use VDI/DGQ3441 as a standard for the measurement of accuracy on their range of machining centres. Positional accuracy is ±0.0003 mm. Attached are axis measurement certificates for all three axes, X, Y and Z. It is important to understand the differences between German VDI and Japanese JIS national standards when comparing data. A good example is the data for Umax the maximum reversal error for hitting a certain point by approaching that point from both directions of movement.

Additionally KERN use the Heidenhain KGM measurement system to check both the positional accuracy and circular interpolation of movement. I attach a test result sheet for circular interpolation movement, again you will note reversal error results show a slight difference (circular interpolation moving clockwise to circular interpolation moving counter-clockwise). It would be very nice for me to say we can machine a circle by circular interpolation better than 0.001 mm and this is possible using a slow feedrate. However we are a company that bases its test results on practical applications and in the test results shown we are using a feedrate of 500 mm/minute and therefore expect a deviation greater than 0.001 mm. The critical results for us include a consistency when machining clockwise and counter-clockwise.

The spindle test sheet results show run-out at the spindle nose to be 0.0005 mm and on the face 0.0002 mm while our tolerance allows for 0.0015 and 0.0005 mm respectively.

This machine specification with an HSK25 spindle can be equipped with a tool magazine of 32, 63 or 95 tool positions, while an HSK40 spindle has 25, 50 or 75 tool positions. One position is reserved for the component touch probe and a second position for the laser tool measurement calibration gauge.

Thermal control and filtering of emulsion coolant is via a separate coolant tank that also includes a high pressure pump to supply coolant through the tool. The filter paper controls particles as small as 3µm and the temperature variation is controlled to ± 0.25°C.

Automated tool setting is controlled by a BLUM laser measuring system with a beam width of 30µm. The BLUM system is programmable to enable users to determine what is checked on each individual tool. Length, diameter, concentricity are standard examples and when using small or critical tools, tolerances can be set to check for tool breakage or tool wear. When detecting that breakage or wear is outside of the defined limits “sister tools” can be brought in from the tool magazine or the operation terminated. Within the Heidenhain iTNC control features for tool life monitoring can be used to measure the amount of “actual cutting time” a tool has performed, again if the

tool life monitor reaches a defined limit a “sister tool” can be brought in automatically the next time this tool is programmed to be used.

A Renishaw OMP40 optical machine probe is our standard probe with a repeatability of 1 µm and is used to check the positions of features on workpieces and can also include in-process workpiece measurement. As an option a Renishaw OMP400 optical machine probe with a repeatability of ± 0.25 µm can also be offered, however because this touch probe has an extremely low touching force the part to be measured has to be *very clean* in order to avoid incorrect measurements being recorded. It is also possible to have both touch probes integrated into the machine and tool magazine.

The data transfer from the probe to the machine control is via an infra-red data transmission receiver situated at the rear of the machine working area. The probe can be transferred automatically from the tool magazine. Importantly when touching on a workpiece e.g. a square form, the probe will always use the same point on the probe stylus. It touches one face, when it moves to the adjacent face the probe rotates through 90 degrees to use the same position on the stylus, thus ensuring the highest of accuracies are maintained in the position of the workpiece to the centreline of the spindle.

Swarf management is controlled either by a chip colletion tray or by an integrated swarf conveyor under the front panel of the machine. The swarf collection bucket (on wheels for easy movement) is behind the front left panel of the machine enclosure.

Jig-Grinding Capability

The Pyramid Nano machine is capable of jig-grinding (HSK40 spindle) bores and spigots in components. A number of elements are required to ensure optimum performance. These include a water cooled motor for the Z axis drive, PLC software modifications and the need to have a temperature controlled water based coolant system with paper band filtration to remove the grinding particles from the coolant.

This capability can be very productive with wheel dressing systems positioned on the work table and an ultrasound system to eliminate non -productive time when feeding the grinding wheel on to the workpiece. This system work very well when combined with an automatic workpiece changing system.

Service and Training

KERN have a “tele-service” system for quick diagnostics of machine tool problems with the service department linking directly into the machine via the internet. Additionally within the Heidenhain iTNC control there are lots of service alarms for advice on errors whether machine tool or programming. Members of the KERN application engineering and the KERN service department all speak English and are available to discuss methods of manufacture, programming strategies, offer advice on cutting tools or answer questions re machine maintenance.

A comprehensive training is offered to machine setters/operators to polish their existing manufacturing skills to a high level.

Additional Information

Additional information that is important for producing to the highest levels of accuracy on components include:

Spindle tooling

KERN can offer five systems for holding cutting tools, three are collet chucks:

1. The most accurate system grips the shank of the cutting tool in a D14/D20 collet with a very small close down. It is therefore important that tools of sufficient quality are used, with shanks having a tight diameter tolerance.
2. The second level holds an E14/E20 collet which allows for more tolerance on the cutting tool shank.
3. The third system is ESX collets which have a close down of either 0.5 mm or 1.0 mm depending on diameter. These are the least accurate when needing to maintain good concentricity on the cutting tool.
4. Heat shrink holders from 3 mm diameter to 10 mm diameter are available.
5. Schunk Tribos Systems for both HSK25 and HSK40 spindles.

Cutting tools should not be clamped in collet chucks while in the machine spindle. It is better to clamp the cutting tool with the collet chuck held in a special clamping fixture for HSK25 outside of the machine and to ensure consistency a torque wrench should be used.

Machine configuration

It is possible to have both a $4^{th}/5^{th}$ axis table on the machine bed and have either a clear working area in front of it (for fixtures) or have an automatic pallet clamping system.