

COMPACT HIGH-SPEED FIVE AXIS MACHINING CENTRE

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Abstract

High performance and highly dynamic HSC 105 Linear machine tool made by DMG is designed for a permanent regime in conditions of high speed machining technologies and their related ones. Nowadays, there are few parts that are manufactured by only one machining technology on a single machine tool. Competition and economics of production leads to the integration of several methods of machining in the machine tool. Such machine tools often work with complicated parts that can be machined only in five axis mode or first gripping. Another way to reduce costs while increasing the product quality is the introduction of new advanced technologies such as High Speed Cutting (HSC) or High Speed Machining (HSM).

Key words

five axis machining tool center, high speed milling, CAM

Introduction

The basics of advanced splinter technology is enhances the quality of machined surface and removal of material with high cutting speeds, shrinks the tool life and reduces the cutting forces. The cutting velocity increases in the area of high speed cutting. In this area the occurrence of significantly different processes in comparison with conventional machining is induced. In typical conditions for HSC, the chip temperature will increases closely to the melting temperature of the material machined. High cutting velocity suddenly changes metallurgical and mechanical properties of the removal chip. The chip colour turns red and even a hardened steel chip is softened and reduce its adherences pressure – cutting force on the cutting edge. The friction force and total value of cutting resistance decreases and as a result the better surface quality by the finishing is a rule.

High speed machining tool centre HSC 105 Linear (Fig. 1) is designed with respect to the compactness of structure and is characterized in detail by many sophisticated innovations that contribute to improving the economy and precision manufacturing. The machine is

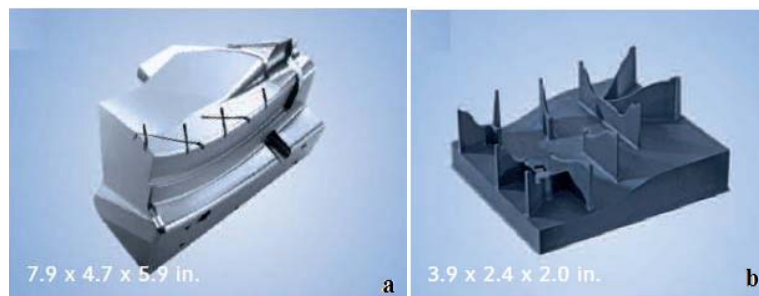
manufactured by the German company Deckel Maho Gildemeister - DMG, which has not only in Europe a long tradition.



Fig. 1. HSC 105 Linear [1]

Application

HSC 105 Linear targets the customers in the die form production with high shaped surfaces, which must be accurate and often require machining on five sides in one clamping. The machining centre also finds application in the machining of materials of steel, cast iron, nonferrous metals as well as during the operation in the manufacture of graphite electrodes (Fig. 2). The machine tool achieves high-precision contour (in the micrometer range) and an excellent surface quality ($R_a < 0.2 \mu\text{m}$), which opens new possibilities in the field of health.



*Fig. 2. Examples of typical components for 5-axis machining
a - die part, b-graphite electrode [1]*

The design and parameters

Frame machining centre is a massive structure (Fig. 3), which ensures the shape stability and high rigidity of the whole machine throughout its lifetime. Spindle moves to the portal structures in the Y and C axes. Turntable with a diameter of 900 mm moves in the direction of axis X. The fourth axis is turner the spindle in the range of -10° to 110° and a maximum torque of 750 Nm. The fifth axis is the above-mentioned rotary table with precise clamping T-grooves and in the middle of the table with a calibrated hole $\phi 50 \text{ H7}$. Maximum torque of table is 2320 Nm. Working space XYZ is dimensions 1110x800x600 mm. Other basic parameters can give a maximum speed of feed in each of the X, Y, Z axes $90 \text{ m}\cdot\text{min}^{-1}$. Feed

rate is provided by linear drives in all five axes, where the acceleration / deceleration exceeds 2g. Feed forces in the X, Z, Y axes are 20 kN, 11 kN and 9.5 kN. Ball linear drivers are lubricated by the lubricant reservoir and therefore achieve long-term durability, reliability and accuracy. Positioning accuracy of drivers is 0.008 mm. Minimum friction loss guaranteed temperature stability and energy saving for such linear drivers. To move rotary axes "Torque" engines with liquid cooling are used. The workspace of the machine is readily accessible, which is secured by two glass doors slides. Removing the chip provides the scraper belt conveyor with a height of discarded 850 mm.

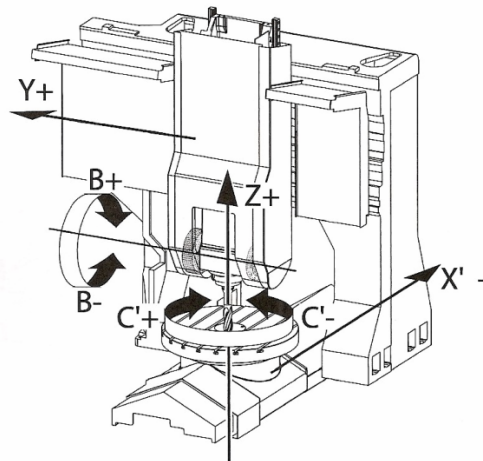


Fig. 3. Axis of HSC 105 Linear machine tool [3]

Spindle and control system

Machine tool design in five axes is equipped with water-cooled high-performance spindle with an air release / gripping held HSK E50 tool holder. Spindle maximum speed reaches 42000 min^{-1} and maximum power 13 kW (Fig.4). Coolant (cutting fluid / air) in the process of cutting can be supplied through the centre of the spindle and at the side of spindle there are six adjustable long-distance jets. In the machine is integrated smart rinsing workspace and workpiece by cutting fluid to remove the chips. To ensure the visibility of the workspace vapor extraction machine is integrated. Tools are stored in the automatic stack instruments with the number of 30 seats. Tools are measured using laser BLUM. Machine control provides a modern management system Heidenhain iTNC 530 (or Siemens 840D) in five axes with security packets. Heidenhain system runs on Windows XP Profesional background that supports NET Service. Graphical environment control system is shown at 19"LCD. Full control of the machine tool is in a new design Ergoline DMG Control. With iTNC 530 it can debug and verify all types of operations directly on the machine tool. Combining infrared measuring probe Heidenhain TS 649 and 3D quickSET can check the accuracy of the kinematic correction of all machine tool configurations. Machining centre is equipped with a production packet, which contains filter paper strip, including the coolant tank with the capacity of 980 liters, rotating transparent window, rinsing gun, oil extraction and emulsion and a control wheel.

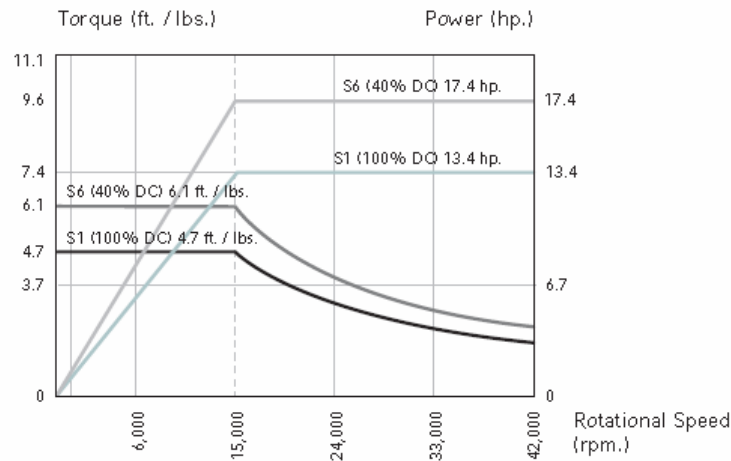


Fig. 4. Performance diagram [3]

HSC 105 Linear highlights [3]:

- linear drivers in all axes for the highest precision, with accelerations up to 2g and 90 000 m.min⁻¹ rapid traverse,
- 5 axis simultaneous machining with direct drive in the spindle head and the NC rotary table,
- 42 000 rpm for HSK E50,
- DMG ERGOline Control with a 19'' screen and 3D software,
- Heidenhain iTNC 530,
- DMG control features developed especially for HSC machining.

Computer aided five axis high speed milling - PowerMILL

Five Axis machining has been used in aerospace applications for many years but it is only recently that the toolmaking industry has shown similar interest. The main advantage of 5 Axis machining is the ability to save time by machining complex shapes in a single set-up. Additional benefit comes from allowing the use of shorter cutters that permit more accurate machining. PowerMILL now offers continuous 5 Axis machining (Fig.5). Continuous 5 Axis machining allows the user to create continuous 5 Axis toolpaths across complex surface, solid and triangulated models. The toolpaths are fully gouge checked and support a wide range of machining strategies and all tool types [2].

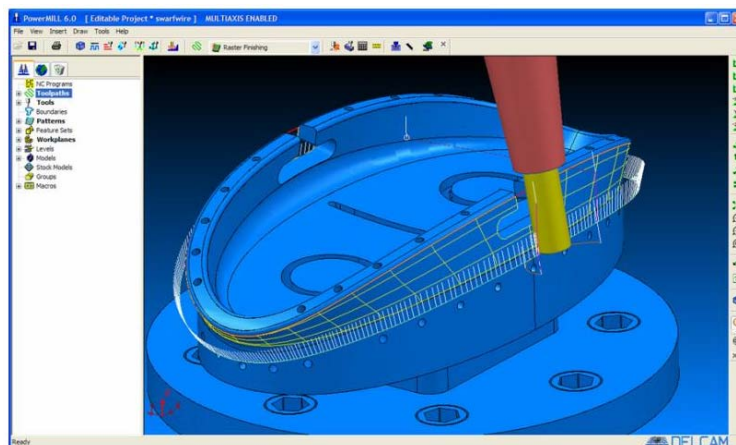


Fig. 5. Five axis machining by PowerMILL [2]

For many years Delcam has been at the leading edge in the development of High Speed Machining (HSM) strategies. These use a combination of techniques to ensure rapid delivery of high quality machined components. There are many elements to efficient High Speed Machining including; the cutting tool, the CNC machine, the material being cut not to mention the use of a high quality CAM system.

Conclusion

Modern machining tool centre DMG HSC 105 Linear finds wide applications at STU MTF Trnava, especially in the research of five axis high-speed machining of complex shape parts. The machine tool will become an integral part of numerous bachelor, master and doctoral theses, which will result in improving the learning process. It also opens the new possibility of solving difficult scientific activities for praxis. This machine tool is integrated in the CE5AM (Centre of Excellence five Axis Machining).

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