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Rigid machining centre

The invention relates to a cutting machine tool, in particular a milling machine, comprising a tool-holding device, a workpiece-holding device, at least one moving device for performing relative movements between the tool-holding device and the workpiece-holding device, a frame to which the workpiece-holding device, the tool-holding device and the moving device are attached, and wall elements which form a machining space.

In industrial production, machine tools are used for the machining of workpieces by stock removal. It is known that different requirements are imposed on these machine tools, such as, for example, milling machines or else lathes. Thus, on the one hand, as high a production accuracy as possible is to be achieved with this means of production. On the other hand, efficient production is to be possible with such machines, which normally requires high cutting capacities. As a rule, however, this can only be achieved with high rotational speeds and high cutting forces, which have an adverse effect on the machining result of the machine and thus make it more difficult to maintain close production tolerances. In addition, in order to achieve cost-effective production, the machines are to be as inexpensive as possible, which as a rule can only be achieved by a simple construction. As can easily be seen, requirements which are basically inconsistent with one another are therefore imposed on machine tools.

In order to be able to absorb loads occurring during the machining of workpieces, milling machines as a rule are of heavy construction. They consist of load-bearing elements such as beds, columns, extension arms, etc., which together form the frame structure, are partly stationary, partly move and carry further traversable elements such as slides, rotary spindles, etc. Such a

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load-bearing structure of these previously known machine tools therefore has, as a rule, a type of bar structure of pillars and beams. The moving elements themselves may also be provided with bar structures for
5 absorbing loads. Thus it is conventional practice in machining centres and milling machines to mount, for example, rotary spindles in individual frame parts, such as the beds and columns already mentioned. If need be, the frame parts may also be moved relative to one
10 another.

It is previously known in this connection that these parts of the frame, which are arranged outside the machining space, are each self-contained, for example
15 due to a box-shaped design. In this case, the rotary spindles are mounted in their respective frame part in such a way that they project with the work holder or tool holder attached to them from the frame part.

20 In order to obtain a closed machining space, booths made of sheet metal or transparent materials are used. The function of these walls is to ensure personnel protection and to catch cooling lubricants and, in particular, chips. During high-speed cutting (HSC
25 machining), the work-space panelling, due to the high energy density of possibly bursting tools or workpieces, is given an additional protective function for the operator and must accordingly be designed and dimensioned in a secure manner.

30

However, this machine concept has the disadvantage that the machines are relatively voluminous and heavy. If a machine is to be more compact, this is done as a rule by reducing the frame cross-sections. However, this
35 also reduces the rigidity of the frame. In effect, therefore, a reduction in the dimensions and thus in the costs of a machine, as already explained above, leads to a lower loading capacity and to a reduction in the attainable production accuracy and productive

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capacity of a machine tool.

A heavy load-bearing structure is especially disadvantageous when the relevant components themselves are moved. This is the case, for example, in machines constructed in the bed form. In this case, relatively large masses have to be moved, which on the one hand requires high drive forces and on the other hand brings about poor dynamics of the machine.

10

The object of the present invention is therefore to specify a machine tool, the frame of which has good rigidity properties, but which can be made more compact.

15

In a machine tool mentioned at the beginning, this object is achieved according to the invention in that the wall elements are an integral part of the frame and are arranged and designed in such a way that the loads developing during the machining of workpieces can be absorbed by means of these wall elements.

As has surprisingly been found, it is possible with this construction of the frame to considerably reduce the number and/or size of the beams or other struts for a machine tool. This construction therefore does not consist only of beams but also of wall elements which are connected to one another in such a way that a closed box construction is created. In order to obtain certain rigidity properties, it is advantageous in the machine concept according to the invention if all the wall surfaces available are used and no longer only individual members or parts of the frame independent of one another. Such load-bearing elements can now be completely or at least partly avoided without having to tolerate disadvantages with regard to the static or dynamic rigidity. On the contrary, by the selection of a suitable construction of the wall elements, machine tools can be designed which, despite a more compact

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construction, have better properties with regard to the rigidity of the frame than is the case in previously known machine tools. It has been found that a machine designed according to the present invention, given a
5 comparable work space, is about 20 % smaller than conventional machines.

In a preferred embodiment of the invention, the load-bearing structure of a machine consists of only wall
10 elements which are arranged in a fixed position relative to one another and are joined together in one piece by joints, such as welds for example.

In further embodiments, the frame is made of grey cast
15 iron or a mineral casting. In addition, a closed structure consisting merely of beam elements may be provided which is preferably stiffened by latticework or other strut structures. Wall elements may be allocated to such beam elements or strut structures
20 alternatively on the inside, between the beam elements or on the outside, on which beam elements or strut structures, for example, workpiece-holding devices, tool-holding devices and moving devices are arranged and by means of which loads developing during machining
25 of workpieces can be absorbed. Any combination of the arrangement of wall elements and beam elements, or the omission of wall elements, is also within the scope of the present invention.

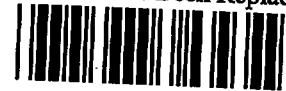
30 With regard to the rigidity and the resonance behaviour of the machine, it is especially advantageous here if the wall elements are arranged relative to one another in a cube or parallelepiped shape. A closed flux of force can thus be realized in the frame in all spatial
35 directions, by means of which flux of force distortions of the frame can be reduced or avoided in an especially successful manner.

In machine tools according to the invention, the

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machining space is therefore formed from load-bearing wall elements. The frame encloses the machining space all round. The tool holder and work holder are located inside the frame. Unlike in the case of previously known machine concepts, the machine-tool frame according to the invention is expediently designed in one piece, all axes of motion being supported on this frame. Due to this machine concept, a basis can therefore be created for keeping the "moving masses" of a machine tool as small as possible. In order to be able to transmit the loads occurring at an axis of motion, it is no longer necessary to design the latter as a heavy frame part which has to be movably arranged relative to other frame parts. Likewise, the loads no longer need to be transmitted from one frame part to another.

A further aspect of the invention, which may also be of importance independently of the design of the machine frame, is that the guides of the moving devices are arranged outside the machining space. It is preferable, however, to provide this arrangement of the guides in combination with a frame designed according to the invention.

In order to be used as a support for guides, the outer surfaces of the wall elements are appropriately machined and prepared. By means of the stiff or ribbed wall elements, it is possible without additional cost to arrange the guides at virtually any point outside the machining space. In preferred embodiments of the invention, the guides are arranged on outer walls, remote from the machining space, of the wall elements. This avoids a situation in which chips or cooling lubricants reach guides of the moving devices. A further advantage consists in the fact that only easily accessible outer surfaces have to be machined during the manufacture of the machine tool. Complicated machining operations on guides or supporting surfaces

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of guides arranged in the interior of the frame are now dispensed with.

In order to obtain a further improvement of the
5 rigidity of the machine tool it is preferable if at
least one of the usually three translatory or linear
axes of the moving device drives the workpiece-holding
device. In such a preferred embodiment according to
the invention the workpiece-holding device is therefore
10 operationally connected with a moving device.

In preferred embodiments of the invention, linear
drives, such as magnetic linear drives for example, are
used for the moving devices. As already mentioned, it
15 is expedient in the present machine concept if all
guides and drives of the individual axes of motion are
arranged on outer walls of the wall elements. It is
therefore possible to use the linear drives, which as a
rule are very sensitive to dirt, without their
20 serviceability being impaired by contamination, such as
caused by chips or cooling lubricants for example,

Further expedient developments of the invention follow
from the subclaims.

25

The invention is explained in more detail with
reference to the exemplary embodiments shown
schematically in the figures, in which:

- 30 Fig. 1 shows a perspective representation of a
machine tool according to the invention;
Fig. 2 shows the machine tool from Fig. 1, in
which wall elements are partly shown in
cut-away section;
35 Fig. 3 shows a representation corresponding to
Fig. 2 of a machine tool according to
the invention, in which a further
possible construction of the wall
elements is shown;

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Fig. 4 shows the machine tool according to the invention from Fig. 1 in another perspective representation;

Figs. 5 a) b) show two further embodiments of machine tools according to the invention;

Fig. 6 a) shows a side view of a conventional milling machine;

Fig. 6 b) shows a plan view of the machine tool from Fig. 1.

The machining centre according to the invention shown in Fig. 1 has a frame 1, a moveable resp. traversable tool-holding device 2 and a moveable workpiece-holding device 3.

According to the invention, the frame 1 is designed as a closed box which is provided with a plurality of plate-shaped wall elements 4, 5, 6, 7, 8, 9. The wall elements 4-9 essentially comprise ribbed hollow bodies.

A possible construction of these wall elements 4-9 is shown in Fig. 2. As can be seen in Fig. 2 at the wall elements 4, 8 shown in cut-away section, the wall elements 4-9 each consist of two, for example 15 mm thick, metal plates 12, 13 and 12', 13' which are

connected to one another by metal ribs 14 of approximately the same thickness and arranged in a "honeycomb" fashion. The wall elements thus obtain a thickness of, for example, 150 to 200 mm. The ribs 14 are fastened by welded joints (not shown) to the plates 12, 13 and 12', 13', in each case running essentially parallel, of the corresponding wall element. The wall elements 4-9 are closed at their end faces by the plates of the respectively adjacent wall elements, which additionally increases the rigidity of the frame.

In this case, ribs 14 are also welded in each case to these adjacent plates.

As can be seen in Fig. 1, the wall elements 4-9 are arranged in the form of a parallelepiped, so that a

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wall element is located at each side surface of the parallelepiped. The respective side surface of the parallelepiped is completely formed by the corresponding outer plate 12, 12' of the wall element.

5 The wall elements 4-9 are joined to one another by welds along abutting edges (Fig. 2). Apart from the wall elements, frame 1 has no further load-bearing elements.

10 A machining space 16 is formed by all inner surfaces 13, 13' of the wall elements 4-9. The machining space is therefore enclosed all round by the single frame part, of one-piece construction, of the machining centre. A base element 9 of the frame 1 is provided
15 with an inclined plate 17 on its inside below the work holder. This plate 17 serves as a chute for chips and cooling lubricants, which thereby pass into a channel-shaped recess 18. Furthermore, a metal sheet 19 is arranged opposite the plate 17, which metal sheet 19 is
20 likewise inclined towards the channel 18.

A chip conveyor (not shown) can receive the chips located in the channel 18 through an opening 20. As shown in Figs. 1 to 3, the wall element 4 opposite the
25 workpiece-holding device 3 may have a rectangular opening 22 for the operator. The wall element 4 is closed by plates 24 at the boundary surfaces of the opening 22. Furthermore, the wall element 7 opposite the tool-holding device 2 is provided with a further
30 opening 23, through which, for example, a pallet changer (not shown) removes workpieces from the machining centre and transfers workpieces still to be machined to the machine. Tools which can be removed from a magazine (not shown) can be interchanged through
35 a further opening (likewise not shown), which may be located, for example, above the spindle of the tool-holding device 2. All these openings are closed by doors during the cutting process. In accordance with the requirements imposed in practice, the openings



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described in the wall elements may be omitted or may also be larger than shown in the figures.

Fig. 3 shows a further possible design of wall elements 5 4-9. Here, the stiffening of the plates or the hollow bodies is achieved by ribs 14' arranged in a "saw-tooth" shape in the wall elements 4-9. In principle, the stiffening ribs may be arranged in the wall elements 4-9 in virtually any manner provided they 10 stiffen the hollow bodies. Thus, for example, the stiffening of the wall elements 4-9 in a further alternative could also have a configuration similar to a corrugated metal sheet.

15 The moving elements of the machining centre can be seen in Fig. 4. The tool-holding device 2 is moveable along the two axes of motion X and Y indicated by double arrows. To this purpose, the tool-holding device 2 is fastened to a moving device 25 which is arranged in a 20 rectangular aperture of the wall element 5. The moving device 25 is equipped with a cross slide 27 which is arranged on guide rails 28, 28' of linear guides (not shown in more detail) in such a way as to be moveable in the X-direction in a translatory manner. In this 25 case, the guide rails 28, 28' of the linear guide are located according to the invention outside the machining space 16 on the outer surface 12'' of the wall element 5. Likewise, the guide rails of the Y-axis are fastened to side surfaces 29, 29', remote from the 30 machining space 16, of the cross slide 27. The electric drives (not shown) of the cross slide 27 are also located outside the machining space 16 formed by the wall elements 4-9.

35 A drive 30 for an axis of rotation (tool axis) of a tool located in the tool-holding device 2 is likewise arranged in the region of the outer surface 12'' of the wall element 5.

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The workpiece-holding device 3 is provided with a moving device 32 for a further translatory axis of motion, the Z-axis, which together with the X- and Y-axis forms a Cartesian coordinate system. The moving device 32 for the Z-axis also has guide rails 31, 31' arranged on the outer surface 12''' of the corresponding wall element 6. Furthermore, the workpiece-holding device 3 is rotatably arranged about two axes of rotation A and B (Figs. 1 to 3). In this case, the A-axis is oriented perpendicularly to the Y-Z-plane, whereas the B-axis runs orthogonally to the X-Z-plane. The drives and media feeds, not only for the linear guides but also for the rotary guides, can thus be arranged outside the work space.

As becomes clear from the above explanations, all electric motors of the individual axes of motion are arranged outside the encapsulated machining space 16. Since the heat produced by the drives can be dissipated here without problem, production inaccuracies to be attributed to this heat, such as heat distortion of guides for example, can be avoided to the greatest possible extent.

The danger of machining inaccuracies due to thermal deformations can be further reduced if wall elements, preferably all wall elements, and the machining space are thermally stabilized. In order to achieve such a thermal stabilization the wall elements can be filled with a - preferably liquid - coolant. By means of a heat exchanger, which is integrated in the circulation of the coolant, heat resulting from the machining within the machining space can be conducted outside the machining space although the machine tool is capsulated.

Likewise, all linear guides are arranged outside the machining space 16 on the side surfaces 12, 12', 12'', 12''', remote from the machining space, of the wall

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elements 4-9. This measure, in contrast to otherwise conventional arrangements of the guides in the machining space, ensures that the guides are not contaminated by cooling lubricants and chips.

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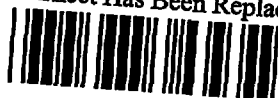
Figs. 5a) and 5b) show further embodiments of machining centres according to the invention. Unlike the machines described above, the moving devices here are attached to other wall elements. Thus, in the machining centre from Fig. 5a), the moving device 32 of the workpiece-
10 holding device 3 is attached to the top element 8. In contrast thereto, the cross slide 27 in the machining centre shown in Fig. 5b) is arranged with the tool-
holding device 2 on the corresponding top element 8. In
15 addition, the machining centre shown in this figure differs from the machining centres described above by a different allocation of linear axes of motion. Here, the tool-holding device 2 is moveable in the X- and Y-
direction and the workpiece-holding device 3 is
20 moveable in the Y-direction. In accordance with the respective requirements, however, the axes of motion in other embodiments may be allocated to the individual wall elements and the workpiece- and tool-holding
device in virtually any manner. In Figs. 6a) and 6b),
25 the flux of force, indicated by broken lines 40, 41, in a conventional milling machine (Fig. 6a)) is compared with the flow of force in a machining centre according to the invention (Fig. 6b)). As can be seen in Fig.
6a), the flow of force in the conventional milling
30 machine runs from a tool 42 into a first frame part, namely the column 43, and from there via guides 44 into a second frame part, a bed 45. The flow of force passes via a slide 46 into the workpiece 47. A large bending
load (indicated by arrows 48) develops here on the
35 column 43 and the slide 46, which bending load can scarcely be counteracted by the frame, in particular the bed 45.

During the same machining of workpieces in a machining

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centre according to the invention, the forces
developing during the machining are only passed into
the one-piece frame. Due to the wall elements, a closed
flow of force is obtained in the frame, as a result of
5 which the bending load can be absorbed and compensated
for. Deformations of the frame can therefore be avoided
in a far better manner.

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Patent Claims



1. Machine tool for cutting machining, in particular
a milling machine, comprising a tool-holding
5 device, a workpiece-holding device, at least one
moving device for performing relative movements
between the tool-holding device and the workpiece-
holding device, a frame to which the workpiece-
holding device, the tool-holding device and the
10 moving device are attached, and wall elements
which form a machining space, characterized in
that the wall elements (4, 5, 6, 7, 8, 9) are an
integral part of the frame (1) and are arranged
and designed in such a way that loads developing
15 during the machining of workpieces can be absorbed
by means of these wall elements (4-9).
2. Machine tool according to Claim 1, characterized
in that the wall elements (4-9) designed as load-
20 bearing elements comprise one-piece, plate-shaped
elements (12, 12', 12'', 12''', 13, 13').
3. Machine tool according to Claim 2, characterized
in that the wall elements (4-9) each have two
25 plates (12, 13; 12', 13'), of which at least
sections are arranged essentially parallel to one
another and which are connected to one another in
one piece by reinforcing ribs (14).
- 30 4. Machine tool according to one or more of the
preceding claims, characterized by a beamless
and/or pillarless frame (1) which has wall
elements (4-9) connected solely to one another for
absorbing loads.
- 35 5. Machine tool according to one or more of the
preceding claims, characterized in that the wall
elements (4-9) are arranged in such a way that
there is a closed flow of force in all directions

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of load.

- 5 6. Machine tool according to one or more of the preceding claims, characterized in that the wall elements (4-9) are arranged relative to one another in a parallelepiped or cube shape.
- 10 7. Machine tool according to one or more of the preceding claims, characterized in that the machining space (16) is enclosed by the wall elements (4-9) forming the frame (1).
- 15 8. Machine tool according to one or more of the preceding claims, characterized in that one guide of the at least one moving device is provided on an outer surface (12, 12') arranged outside the machining space (16).
- 20 9. Machine tool, in particular according to Claim 8, characterized in that the guides of all linear axes of motion (X, Y, Z) of the moving devices (25, 32) are arranged outside the machining space (16).
- 25 10. Machine tool according to Claim 1 or 9, characterized in that a frame (1) - on which a workpiece-holding device, a tool-holding device and a moving device are arranged - comprises beams by means of which loads developing during machining of workpieces can be absorbed.
- 30 11. Machine tool according to one or more of the preceding claims, characterized in that a drive of at least one moving device (25, 32; 34) is arranged outside the machining space (16).
- 35 12. Machine tool according to one or more of the preceding claims, characterized by linear drives for at least one of the moving devices (25, 32).

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13. Machine tool according to one ore more of the
preceding claims, characterized in that the
workpiece-holding device is operationally
5 connected with at least one linear axis of the
moving-device.

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