

The invention relates to a shell end mill comprising a holder, a cylindrical cutting section connected to the holder, at least two helical chip grooves arranged in the cutting section at a spacing from one another in the peripheral direction, and in each case one row of insert seats which are arranged one after the other along one side of a chip groove and which each have a substantially radially aligned base support surface and a side support surface radially delimiting the latter on the side of the groove base for receiving cutting inserts which are preferably designed as indexable inserts, which can be fastened on the cutting section by means of a central clamping screw engaging in a screw bore in the area of the base support surface and which have a substantially rectangular outline, in an arrangement of axially overlapping pairs at the facing ends of the cutting inserts, which cutting inserts project radially over the periphery of the cutting section with a main cutting edge and a free surface adjoining the latter, the front outermost cutting inserts of each cutting insert row projecting axially over the cutting section with a face cutting edge and with a free surface adjoining the latter, and the inner cutting inserts, of each cutting insert row, disposed behind the front outermost cutting insert projecting in an abutment-free manner axially over the associated insert seat with an active cutting edge disposed on the receiving side and with a free surface adjoining the latter cutting edge.

In shell end mills with full-cutting rows of cutting inserts, when the inner cutting inserts are disposed behind the front outermost cutting insert, conventionally it is the cutting edge arranged on the receiving side which is active whereas the cutting edge arranged at the front is covered by the adjacent active cutting edge and is therefore inactive. In order to be able to absorb the axial cutting force components acting on the cutting inserts, the inner cutting inserts were therefore supported at the front against an axial abutment surface (DE-A-3 812 150). However, the production of an insert

seat with an axial abutment surface requires considerable manufacturing expenditure. The insert base has to be created by an end mill there in view of the axial abutment surface to be created at the same time, which end mill, because of the deep machining positions, requires a relatively large cantilever length and which, in order to avoid collisions with adjacent interfering edges, can cooperate only with relatively narrow tool holders. As a result thereof both the machining precision and the machining speed leave much to be desired. Furthermore, in the case of the known shell end mills, the cutting section is conventionally integrally connected to the holder so that extensive storage is needed for various mill sizes and holder designs.

The object of the invention is to develop a shell end mill of the initially mentioned type which can be manufactured easily and economically and nevertheless meets high demands with respect to operation.

The features of Claim 1 are proposed in order to achieve this object. Advantageous constructions and developments of the invention emerge from the subclaims.

The way of achieving the object according to the invention is essentially based on the idea that the inner cutting inserts engage with their inactive cutting edge arranged at the front and with a free surface adjoining the latter without abutment and axially in a free space which is formed by an undercut of the adjacent insert seat and behind the cutting insert adjacent at the front. By virtue of these measures the insert seats can be produced by hob cutters (and not, as previously, by face milling). When the helical chip grooves have been created with an end mill and the groove sides on the insert side have been prepared by shell end milling in order to create the insert seats, the base support surfaces and the undercuts for receiving the front cutting edges are created in a single operation one after the other by an end mill in a hob

cutting process. The manufacturing speed of the insert seats is increased by at least a factor of 3, which signifies a considerable advance from the point of view of manufacturing techniques, in the case of the large number of insert seats present in one plain milling cutter.

In order to avoid an undesired axial movement of the cutting inserts in spite of the lacking axial abutment surfaces, it must firstly be ensured that the cutting inserts are urged in an adequately force-locking manner against the base support surface and the side support surface by means of the central clamping screw. The latter is possible since the centre distance between the screw bore and the side support surface has an undersize of 0.1 to 0.2 mm with respect to the relevant dimension of the cutting insert.

Furthermore structural measures can ensure that the axial components of the cutting forces acting on the insert largely cancel one another. In order to achieve this, in accordance with a preferred construction of the invention it is proposed that the base support surface of the insert seat and the main cutting edge of the associated cutting insert together define an acute angle converging towards the receiving side.

A further improvement in this respect can be achieved in that the side support surface is divided into two surface parts defining a two-point abutment and being arranged at a spacing, and in that, in accordance with a further preferred construction of the invention, the side surface of the cutting insert abutting the side support surface is slightly curved or bevelled and is thus urged in an interlocking and force-locking manner against the surface parts which in this case are aligned spatially in a different manner.

In order to reduce the storage requirement, it is particularly advantageous if the cutting section and the holder of the plain milling cutter are releasably and exchangeably connected

to each other and if, possibly, the cutting section additionally consists of a face cutting section arranged at the front and a cylindrical part arranged on the receiving side, which are likewise releasably connected to one another. This measure enables the same cutting sections to be provided with different holders as required and cutting sections of different lengths to be combined. In this respect the face cutting sections advantageously have two cutting inserts per cutting insert row whereas the cylindrical parts comprise at least two and preferably three to six cutting inserts per cutting insert row. It is in principle also possible for the cylindrical part to be formed as an extension or reducing piece preferably with terminating chip grooves and without any cutting edges. Thus the cutting section and the holder are connected to one another in an interlocking and force-locking manner by coupling members. In addition it is possible to arrange between the cutting section and the holder an adapter piece for the reciprocal adaptation of coupling members having different dimensions to the cutting sections and holders so that cutting sections and holders of different sizes can also be combined with one another, which results in a further reduction of the storage requirement.

The coupling members can, for example, be formed by at least two axial follower pins arranged at a defined angular spacing from one another on the one side and correspondingly arranged mating bores for receiving the follower pins on the other side. The force-locking connection can be brought about by a clamping screw which extends through the cutting section and engages in a taphole in the holder.

In accordance with a further advantageous construction of the invention the coupling members are designed as a transverse rib which projects over the receiving-side end of the cutting section over a plane surface, which can be guided into a transverse groove of the holder, which groove is delimited by a flat countersurface, and which can be clamped there by means

of clamping screws, and as a centring pin, which can be inserted in a central mating hole in the holder and projects in an axially central manner over the transverse rib. In order to bring about the clamping connection, conical recesses are arranged offset relative to one another in the longitudinal direction of the transverse rib in two opposite boundary surfaces of the transverse rib, which boundary surfaces are perpendicular to the plane surface, into which recesses can be screwed the conical tip of a screw, which is guided in a taphole in the holder and extends through flanks of the transverse groove, with such an axial offset that the cutting section and the holder are axially urged against one another at their facing plane surfaces. This connection principle can also be used between the face cutting section and the cylindrical part. Furthermore, in a kinematic reversal it is also possible to arrange the transverse rib and the centring pin on the one side and the transverse groove and the mating hole on the other side such that they are interchanged with one another.

In the following, the invention will be explained in greater detail with reference to the embodiments shown schematically in the drawings, in which:

Figures 1a to e show a modular shell end mill in side view and partially in section, a front side view partially in section, a section along the line C-C of Figure 1b and one view each along the lines D-D and E-E of Figure 1a;

Figure 2 shows a side view of the face cutting section of the shell end mill partially in section;

Figures 3a and b show a side view and a plan view of the cylindrical part of the shell end mill partially in section; and

Figure 4 shows a diagram for the modular construction of different shell end mills of different basic modules.

The modular shell end mill essentially comprises a cutting section 10 and a holder 12 which is releasably connected thereto, the cutting section 10 being in turn divided into a face cutting section 14 and a cylindrical part 16. The cutting section 10 contains three helical chip grooves 18 which are disposed at an angular spacing from one another, which extend from the face cutting section 14 to the cylindrical part 16 and in one groove side of each of which, which is the rearward groove side in the clockwise sense of rotation, insert seats 20 are arranged with substantially radially aligned base support surfaces 22. The inserts 20 arranged in a stepped manner are to receive indexable inserts 24 which are substantially rectangular in outline and which are secured by a central clamping screw 26 in a screw bore 28 on the cutting section 10, which screw bore extends perpendicularly through the base support surface. The indexable inserts 24 project radially with their main cutting edge 30, which extends obliquely in the direction of the chip groove, and with their free surface 32 adjoining the main cutting edge over the cylindrical periphery of the cutting section 10 and rest with their side surface 34, which is opposite the free surface 32, against a side support surface 36. The side support surface 36 comprises two surface parts, which are arranged at a spacing from one another, which are not shown in the drawing, and which guarantee a reliable two-point abutment of the side surface 34. The spacing between the screw bore 28 and the side support surface 36 has a small undersize of 0.1 to 0.2 mm with respect to the corresponding spacing in the indexable insert, so that a force fit is obtained when the clamping screw 26 is tightened. Since the side surface 34 of the indexable insert 24 is curved or bevelled in the longitudinal direction and the surface parts of the side support surface 36 define a corresponding obtuse angle with one another, an interlocking

connection is additionally obtained when the indexable insert is urged against the side support surface 36, which interlocking connection is able to absorb resulting axial cutting forces acting on the indexable insert. As Figure 1a shows for example, the main cutting edge 30 of the indexable insert 24 defines with the base support surface an acute angle which diverges towards the receiving side and which results in a reduction of the axial cutting force component acting on the indexable inserts.

The inner indexable inserts of each cutting insert row, which inner indexable inserts are arranged behind the front outermost cutting insert 24', project with their active side cutting edge 38 arranged on the receiving side and with the free surface 40, adjoining the latter edge, without abutment over the associated insert seat 20 whilst they engage, with their inactive cutting edge 42 arranged on the front side and with the free surface 44, adjoining the inactive cutting edge, without abutment in a free space which is formed by an undercut 46 and is behind the cutting insert 24 adjacent at the front. In this respect the arrangement is such that the axial cutting forces acting on the indexable inserts 24 are substantially compensated. Thus an axial support has proved unnecessary. An axial support is only needed on the front outermost cutting insert 24' of each cutting insert row since it projects axially over the cutting section 10 with its front cutting edge 42 and the adjoining free surface 44 and is acted upon by the latter with axial cutting forces acting in the receiving direction. A cylinder pin 48 is provided for axially supporting each front outermost indexable insert 24', which cylinder pin is inserted at a defined spacing from the front surface in a bore 50 in the face cutting section. The indexable insert 24' rests with a partially cut section 52 against the cylinder pin 48 so that the similarly partially cut front cutting edge 42, which is at a defined spacing from the partially cut section 52, can be arranged with high dimensional accuracy on the face cutting section.

In spite of the complicated insert shape, the insert seats can be created with a high feed speed in the area of the base support surfaces 22 and of the adjoining undercuts 46 in steps by hob cutting into the groove sides. The preparatory work necessary for this purpose in the chip groove side can also be carried out economically by hob cutting. This manufacturing advantage is of particular importance if a large number of insert seats is to be provided.

The connection between the face cutting section 14, the cylindrical part 16 and the holder 12 is brought about by means of a clamping screw 57 which extends through a central bore 54, 54' in the face cutting section 14 and cylindrical part 16 and can be screwed into a taphole 56 in the holder, the parts being mutually centred by means of fitted pins 58, 60 which engage in corresponding mating holes 62, 64 in the adjacent part. The associated rotation is brought about by axially parallel, eccentrically arranged cylinder pins 66, 68 which engage in corresponding bores 70, 70' and 72, 72', respectively, in the parts to be connected to one another.

In the embodiment shown in Figure 1a the holder 12 is in the form of a steep-angle taper. As Figure 4 shows, instead of the steep-angle taper holders 74, 74', 74'' of different sizes shown there, other basic holders such as a fitted pin/plane surface coupling 76, 76', 76'', a Morse cone coupling (not shown) or a flange coupling (not shown) can be used. What is important in this respect is only that the mating coupling members, such as the cylinder pins 68 or the mating bores 64, are provided on the side of the cutting section 10. Smaller cutting sections 10 can in principle be connected to larger holders 12 by the interposition of suitable adapters 78, 78', which adapt the different connection measurements of the above-mentioned coupling members and can be designed as relatively simple, disc-shaped intermediate parts.

If necessary, it is also possible to use insert-free cylindrical parts 16' which act as an extension or reduction piece and which have only chip grooves 18 terminating on their surface, instead of the cylindrical parts 16 equipped with indexable inserts 24. Thus the illustration of Figure 4 shows that the modular structure of the shell end mill permits a great number of combinations of various holders 12, cylindrical parts 16, 16' and face cutting sections 14 which, even if they are of different sizes, can be combined with one another with the interposition of adapters 78, 78'. The advantages which can be attained thereby for storage are obvious.

The following can be stated in conclusion: The invention relates to a shell end mill with a holder 12, a two-part cylindrical cutting section 10 which is releasably connected to the holder 12 and is in turn in two parts, at least two helical chip grooves 18 arranged in the cutting section 10 at a spacing from one another in the peripheral direction, and in each case one row of insert seats 20 arranged one behind the other along one chip groove side and each having a substantially radially aligned base support surface 22 and a side support surface radially defining the latter on the side of the base of the groove for receiving indexable inserts 24 in an arrangement of axially overlapping pairs. The inner cutting inserts 24 arranged behind the front outermost indexable insert 24' are clamped axially without abutment on the insert seats. In particular, the inner cutting inserts 24 engage without abutment with their front inactive cutting edge 42 in an undercut 46 of the adjacent insert seat. This design enables the base support surfaces 22 of the insert seat and the undercuts 46 adjoining them on the receiving side to be produced particularly simply and economically by hob cutting in the cutting section 10.

CLAIMS

1. A shell end mill comprising a holder (12), a cylindrical cutting section (10) connected to the holder, at least two helical chip grooves (18) arranged in the cutting section at a spacing from one another in the peripheral direction, and in each case one row of insert seats (20) which are arranged one after the other along one side of a chip groove and which each have a substantially radially aligned base support surface (22) and a side support surface (36) radially delimiting the latter on the side of the groove base for receiving cutting inserts (24, 24') which are preferably designed as indexable inserts, which can be fastened on the cutting section (10) by means of a central clamping screw (26) engaging in a screw bore (28) in the area of the base support surface (22) and which have a substantially rectangular outline, in an arrangement of axially overlapping pairs at the facing ends of the cutting inserts, the cutting inserts (24, 24') projecting radially over the periphery of the cutting section (10) with a main cutting edge (30) and a free surface (32) adjoining the latter, the front outermost cutting inserts (24') of each cutting insert row projecting axially over the cutting section (10) with a face cutting edge (42) and a free surface (44) adjoining the latter, and the inner cutting inserts (24), of each cutting insert row, disposed behind the front outermost cutting insert (24), projecting in an abutment-free manner axially over the associated insert seat (20) with an active cutting edge (38) disposed on the receiving side and with a free surface (40) adjoining the latter, characterized in that the inner cutting inserts (24) engage with their inactive cutting edge (42) arranged at the front and with a free surface (44) adjoining the latter cutting edge without abutment and axially in a free space (46) which is formed by an undercut in the adjacent insert seat and behind the cutting insert (24, 24') adjacent at the front.



2. Shell end cutter according to Claim 1, characterized in that the front outermost cutting insert (24') in each cutting insert row is supported in the region of its cutting edge (38) on the receiving side or of the free surface (40) adjoining this cutting edge on an axial abutment (48) which is rigid with the cutting section.

3. Shell end cutter according to Claim 2, characterized in that the abutment (48) is in the form of a cylinder pin (48) which is embedded in the cutting section (10) and projects with one end over the groove base.

4. Shell end cutter according to any one of Claims 1 to 3, characterized in that the base support surfaces (22) of the insert seats (20) and the undercuts (46), of the cutting section (10), adjoining the insert seats on the receiving side, are hob cut.

5. Shell end cutter according to any one of Claims 1 to 4, characterized in that the base support surface (22) of each insert seat (20) and the main cutting edge (30) of the associated cutting insert (24, 24') define with one another an acute angle diverging in the direction of the holder.

6. Shell end cutter according to any one of Claims 1 to 5, characterized in that the side support surface (36) is divided into two surface parts arranged at a spacing from one another and defining a two-point abutment.

7. Shell end cutter according to Claim 6, characterized in that the side surface (34), abutting the side support surface (36), or the free surface of the cutting insert (24, 24') is slightly curved or bevelled and is urged in an interlocking and force-locking manner against the surface parts of the side support surface (36) which are aligned differently in adaptation to the curvature or bevelling.



8. Shell end cutter according to any one of Claims 1 to 7, characterized in that the axial spacing between the screw bore (28) of the side support surface (36) has an undersize of 0.1 to 0.2 mm with respect to the relevant dimension on the cutting insert (24, 24').

9. Shell end cutter according to any one of Claims 1 to 8, characterized in that the cutting section (10) and the holder (12) are releasably and exchangeably connected to one another.

10. Shell end cutter according to any one of Claims 1 to 9, characterized in that the cutting section (10) comprises a face cutting section (14) arranged at the front and a cylindrical part (16, 16') arranged on the receiving side, which are releasably connected to one another.

11. Shell end cutter according to Claim 10, characterized in that the face cutting section (14) comprises two cutting inserts (24, 24') per cutting insert row.

12. Shell end cutter according to Claim 10 or 11, characterized in that the cylindrical part (16) comprises at least two and preferably three to six cutting inserts (24) per cutting insert row.

13. Shell end cutter according to Claim 10 or 11, characterized in that the cylindrical part (16') is in the form of an extension or reducer part preferably provided with terminating chip grooves (18).

14. Shell end cutter according to any one of Claims 9 to 13, characterized in that the cutting section (10) and the holder (12) are connected to one another in an interlocking and force-locking manner by coupling members.

15. Shell end cutter according to Claim 14, characterized in that an adapter (78, 78') for reciprocal adaptation of



coupling members of different dimensions is disposed on the cutting section (10) and holder (12) between the latter.

16. Shell end cutter according to Claim 14 or 15, characterized in that the coupling members comprise at least two axially parallel follower pins (66, 68) which are at a defined angular spacing from each other on the one side and mating bores (70, 70'; 72, 72') for receiving the following pins (66, 68) on the other side.

17. Shell end cutter according to Claim 15 or 16, characterized in that the coupling members comprise a clamping screw (57) which extends through the cutting section (10) and engages in a taphole (56) in the holder (12).

18. Shell end cutter according to any one of Claims 15 to 17, characterized in that the coupling members comprise a centring pin (58, 60) axially projecting on one part and a mating bore (62, 64) disposed on the other part (16, 12) and receiving the centring pin (58, 60).

19. Shell end cutter according to Claim 15, characterized in that one part comprises at one end a transverse rib which projects over a plane surface, can be guided into a transverse groove, on the other part, delimited by a flat countersurface and can be clamped by clamping screws and a centring pin which can be inserted in a central mating hole in the other part and projects axially and centrally over the transverse rib.

20. Shell end cutter according to Claim 19, characterized in that conical recesses are arranged offset relative to one another in the longitudinal direction of the transverse rib in two opposite sides of the transverse rib, which sides are perpendicular relative to the plane surface, into each of which conical recesses can be screwed the conical tip of a screw, which is guided in a taphole of the other part and



extends through the sides of the transverse groove, with such an axial offset that the two parts are axially urged against one another with their plane surfaces.