CHIP-FORMING CUTTING TOOL

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ABSTRACT
In a chip-forming machining operation improved results accrue from imparting to the chip — in the course of its formation — a longitudinally extending bulge or thickened portion which significantly stiffens the chip and desirably modifies its form. Locating the bulge adjacent the central part of the chip influences a ring-shaped form of chip, while locating the bulge adjacent an edge of the chip results in a cylindrical form of chip having a fairly constant radius of curvature and a great relatively constant pitch. The cutting tool which provides this stiffened chip has a groove or concavity at the locus where the thickened portion of the chip is desired.

5 Claims, 10 Drawing Figures
CHIP-FORMING CUTTING TOOL

The present invention relates to a method of, and tools for, chip forming machining. In such operations the chip breaking and the chip form are often of great importance for an uninterrupted production. Modern machines having high productivity thus make great demands upon good chip removal. Long uncontrolled chips can easily cause stoppages and rejections and involve also great risks of accidents. Therefore, the chip breaking must be given great attention and must determine to a high degree the shaping of the cutting tools.

It heretofore was known that good results in cutting could be attained by means of chip breakers shaped in different ways. For such chip breakers, (older types consisting of cuts in the tool or of detachable chip breaker as well as newer types consisting for instance of chip breakers in hard metal inserts), there has often been a desire that they should control and break the chip in a satisfactory way under most varying cutting conditions. In many cases of cutting applications, however, the chip breaking or chip formation is unsatisfactory and makes suitable or economically advantageous tools or methods impossible.

According to the invention a method is now revealed, which in a very effective way makes good chip formation and chip breaking possible under the most varying working conditions, tool types and materials in both tool and in workpiece. The invention is based upon a method which is different from what has been earlier used or known in the field of chip forming machining.

The new features of the invention are derived from the idea of attaining satisfactory chip forming and a desirable separation course by means of a suitable stiffening of the very chip during the cutting thereof.

Besides the new method of improving the chip form, the invention also involves a cutting tool, which is provided with at least one cutting edge and connecting chip respectively clearance- faces. The tool is characterized in that the chip face is provided with one or more grooves or cavities starting from the very cutting edge; meaning that also the cutting edge is provided with the mentioned grooves. The longitudinal direction of the cavities should form a substantially right angle to the cutting edge, preferably an angle of 90° ± 45°.

A chip formed according to the method of the present invention obtains the earlier mentioned stiffening by means of one or more beads or other localized thickenings being formed on the chip during the cutting thereof by the help of the mentioned grooves or cavities.

It has been known, for a very long time, that a thin plate may be stiffened by making a groove or bead, a so-called "crease", in the plate. By imprecedented application of a similar method in a different technical field, as chip forming machining, a surprising and favorable solution of long known difficult problems has thus now been found. The groove of the tool or the insert may be said to have the same task as for instance the groove roll of a creasing tool. In cutting, however, no additional tool is needed for the shaping in contrast to the normal conditions in creasing, but the chip is pressed against the groove in the tool by means of the cutting forces in the cutting operation and a bead or crease is formed by plastic deformation.

The invention will now be specifically disclosed from the following specification, taken in connection with the appended drawings which show:

FIG. 1, an insert having chip breakers and grooves according to an embodiment of the invention;
FIG. 2, a section along the line 2—2 in FIG. 1;
FIG. 3, the insert according to FIGS. 1 and 2 in engagement in milling and a resultant chip;
FIG. 4, a cutting-off tool having a groove in the cutting edge and the chip face according to the invention;

FIGS. 5, 6 and 7 show configurations of chips formed by a conventional insert for various values of cutting depth and feed/insert;
FIGS. 8, 9 and 10 show configurations of chips formed by the insert of the present invention for the same values of cutting depth and feed/insert.

FIGS. 1 and 2 show an insert 10 having a top face 20 and clearance faces 24, the intersections of the top and clearance faces forming cutting edges 19. The chip breakers 11, formed on the top face of the insert, extend along the edge 19 of the insert. According to the invention the insert is provided with grooves 12, situated adjacent the corners of the insert. It has been found suitable, as illustrated in FIG. 2, to form the groove 12 with cross-sectional area of a segment of a circle. Among other suitable forms may be mentioned a semicircular area form. The groove may have uniform cross-section along its principal extension or longitudinal direction.

In FIG. 3 there is shown an insert 13 of the same kind as illustrated in FIGS. 1 and 2, mounted in a milling cutter (schematically indicated) for face milling of a workpiece 14. The cutting depth corresponds to the distance t. A chip 15 obtained by such milling is characterized by the bead 16 formed in the chip at the groove 17 of the insert 13. Because of the cylindrical form given to the chip it can easier pass through the limited chip rooms, which often are the case for instance in milling tools. Larger cutting depths and feed are thus possible.

In FIG. 4 there is shown a cut-off tool 18 in which the cutting edge 19 respectively chip face 20 are provided with a groove 21 according to the invention.

The bead being imparted to the chip (usually in its lower part) i.e. for instance a milling tool according to the invention is formed by plastic deformation of the material on the chip face of the insert. The chip deformation is often less in the bottom of the bead than in the part 22 of the chip lying above the head. The material reduction measured has usually been 5–25 percent depending upon the cutting data and the material of the workpiece. The part of the chip lying below the head is normally dilated and obtains often a wedge-shaped appearance terminating in a point 23. At increased feed (thicker chip) this is more clearly seen. It sometimes is found to be advantageous to apply a chip-stiffening groove as near the corners of the insert of the outer borders of the cutting edge as possible, and in the case of face milling or the like as far down as possible towards the secondary cutting edges, i.e. the bottom or finishing cutting edges of the insert. With regard to the strain upon the insert corners, it has been found suitable in, for instance, milling to locate the groove about 2 millimeters, preferably 2±0.5 millimeters, from the secondary or finishing cutting edges of the insert.
Thus, a plastic formation with material reduction occurs which may explain that the tool is not worn down or damaged more than a corresponding standard tool, in spite of the seeming weakness of the tool because of the groove for stiffening the chip. From extensive actual cutting tests it has been established that the tools according to the invention often have even higher life and usefulness than corresponding standard tools. The power consumption has been shown to be mainly the same as, or lower than, the situation for standard tools.

The description in the following will mainly deal with applications of the invention in face milling of steel with indexable cutting inserts and in cut-off tools. As has been mentioned hereinafore, the invention may successfully be used in other kinds of cutting tools in cutting of different materials as for instance metals and plastics, the tools being made of among other materials cemented carbide, high speed steel or carbon steel.

Example I

A standard indexable insert milling cutter for face milling with positive cutting angles has the following recommended cutting data:

Cutting depth \( a = 6 \) 8 10 mm

Feed/insert \( S_e = 0.5 \) 0.4 0.3 mm

The task was to increase the cutting field by providing the insert with chip breakers.

Tests with conventional sintered chip breakers showed that desired results could not be obtained for all the working field, which contained a cutting range of feed/insert \( S_e = 0.1, 0.2, 0.3, 0.4 \) and 0.5 millimeters for each of above-mentioned cutting depths. As a result, there was too large scattering of the form of the chip. It was found that at least two or more shapings of the chip breaker were necessary in the mentioned working range.

By means of the invented method and introduction of inserts having grooves for stiffening the resultant chip, the research program could be accomplished in a highly satisfactory way. The results is illustrated in FIGS. 5-10 which show the obtained chip forms in milling with conventional inserts respectively inserts according to the invention. The cutting was done in the material SIS 2244, and the engagement of the milling cutter was 100 percent of the cutter diameter, \( B = \Phi \).

From the views FIGS. 5-10 it is seen that the conventional insert has given acceptable result only at lowest feeds (\( S_e = 0.1 \) and 0.2 mm), while the insert provided with grooves according to the invention has given favorable chip form in the entire examined working range. It is also seen that, in cutting according to the invented method, the diameter of the chip decreases at an increase of the feed \( S_e \) contrary to the situation for the conventional insert. The last-mentioned fact or result of the invention is extremely advantageous and important in consideration of the hitherto existing difficulties in making sufficient chip space for the chips in the milling cutter body, particularly at great cutting depths and feeds.

Thus by means of the invented method, the chip obtained in this case a principally cylindrical form after the separation. During the separating it also obtained a smaller and fairly constant radius of curvature and a greater — relatively constant — pitch.

In the mentioned example the groove for stiffening the chip was advantageously so formed that its depth — measured from the chip face — was about 0.1—1.0 mm, preferably 0.3 mm. At a cross-section formed as a segment of a circle the radius was between 0.5—5 mm, for instance about 2.5 mm, and the largest width of the groove was 0.5—5 mm, for instance about 2.3 mm. Its length, measured from the cutting edge, was between 0.5—5 mm, for instance about 2 mm. The inner limitation of the groove on the chip face was also formed with a radius of about 0.5—5 mm, for instance about 2.5 mm. Furthermore, the groove formed an angle of \( +15^\circ \), for instance about \( +5^\circ \), with the milled surface plane. Its distance from the nearest insert corner or secondary cutting edge, measured from the central longitudinal axis of the groove, was 0.5—5 mm preferably about 1.5—3 mm.

Example II

A cut-off tool consisting of a relatively narrow and thin insert, mechanically clamped in a holder shaft, was provided with a centrally situated groove on the chip face of the tool perpendicular to the cutting edge. The length of the cutting edge was about 4 mm, and the groove was formed by means of spherical grinding point so that the cross-section had the principal form of a segment of a circle with a depth below the chip face of about 0.05—0.5 mm at the cutting edge, usually 0.1—0.2 mm, and a width of 0.5—2 mm, suitably about 1.0—1.5 mm. The groove was formed with about \( +25^\circ \) — \( +15^\circ \) cutting angle and obtained by this formation also a widening of the width inwards measured from the cutting edge. The length of the groove was between 0.5—5 mm, for instance about 2 mm and its largest width, in its inner part, was about 0.5—3 mm, suitably about 2 mm. The inner limitation of the groove was rounded because of the way of preparation (radius of the grinding sphere was in the example 2 mm).

By means of the shaping of this tool, which relates to the invented method, a changed and particularly favorable chip formation was obtained compared to earlier methods in which tools with normal cutting edge and conventional chip breaker had been used.

In cutting off thick work pieces, satisfactory chip form was earlier obtained only at the starting stage of the operation: after a feed of about 5—6 mm into the work piece there occurred satisfactory chip breaking and also stoppage and straightening out of the chips. However, by application of the principle of the present invention work pieces having diameters of about 60—70 mm and more can be cut off without difficulties. Satisfactory chip bending and chip separation can be observed during all the machining operation. Among the causes for this favorable effect there may be mentioned the fact that besides stiffening of the chip there was observed a decrease in the width of the chip, — in this case about 0.01—0.02 mm, — because of the changed chip formation. It was found that the chip (its width in conventional tools being somewhat larger than the width of the cut) had a somewhat smaller width than the cut when being formed by a tool according to the invention. By these means there was obtained an increased scope and less friction between chip and work piece, which caused a favorable, desired chip removal. The chip produced in this case an increased up-rolling (less radius of curvature) and a ring- or spring-like form.

In the present method the stiffening is usually obtained by giving the chip a thickening or bulge or sinu-
The embodiments of the invention, the examples and so forth, which have been mentioned have mainly dealt with milling at positive cutting angles and with inserts having chip breakers. It should therefore be mentioned that also at negative inserts for milling and other operations, often without use of chip breakers, it has been found possible to obtain good chip form and considerable increase in the work range by applying the principle of the present invention.

I claim:

1. A chip forming cutting tool forming a chip having a longitudinally extending stiffened portion thereby decreasing from normal the radius of curvature of the chip, the tool having a top face and at least one clearance face, the intersection between said faces forming an elongated cutting edge, a chip breaker groove in said top face spaced from and running along said cutting edge, an additional groove in said top face running from said cutting edge to said chip breaker groove, said additional groove being spaced from an end of said elongated cutting edge.

2. A chip forming cutting tool according to claim 1, wherein the intersection of the chip breaker groove with said top face closest to said cutting edge is substantially parallel thereto.

3. A chip forming cutting tool according to claim 1, wherein the depth and width of the chip breaker groove increases with increase of distance from said additional groove.

4. A chip forming cutting tool according to claim 1, wherein said additional groove is substantially perpendicular to said cutting edge.

5. A chip forming cutting tool according to claim 1, wherein the tool is a polygonal insert, each of whose sides is a cutting edge and each cutting edge is provided with a chip breaker groove and additional groove as set forth.