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⑤④ **Flow drill for the provision of holes in sheet material.**

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Description

The invention relates to a flow drill for the provision through the intermediary of friction heat and pressure of a hole surrounded by a collar in metal sheet or metal tube walls, said drill having a shaft and a smooth tapering operative end, the cross-section of said operative end being based on a regular polygon and has a convex contour situated within the circle circumscribing the body hole.

Such flow drills are known, e.g. from the French Patent 1,189,384 and the Dutch Patent 160499.

According to the French Patent the cross-section of the operative drill end is a square, having rounded apexes. It has been found, that such a drill is suitable for the provision of holes in the softer metals such as aluminum and copper or brass, but for the provision of holes in harder metals, such as bronze and steel offers not so good results and will wear already after having made a relatively small number of holes.

The flow drill according to the Dutch Patent 160499 is based in its shape of the cross-section of the operative part on an equilateral triangle, having apex radiusses comprising two arcs merging in the apex and having different radius of curvature and different length. In between the apex radiusses the contour likewise may be in the shape of an arc, but having a larger radius of curvature, or by a straight line. The apexes of the triangle are too much accentuated due to said transitions in radius of curvature, whereby instability in the operation of the drill may occur, particularly if said drill is used for flaring tube ends. Thereby said ends are formed into a somewhat square instead of a circular shape.

Furthermore with said known flow drill the pressure per unit of area becomes too large in the short arc, which leads to heat stresses and small fissures in the drill and thereby to a shortening of the useful life. For it is that the radiusses of the arcs have not been adapted to a mixed lubrication, i.e. partly hydrodynamical as a result of the flowing material and partially dry. Almost exclusively dry friction and thereby a strong wear of the drill occurs. On the other hand the drill is too much relieved relative to the hole wall at the position of the longer one of both apex arcs, whereby at that point adhesion of material to the drill occurs which material has to be removed periodically. A self cleaning action of the drill by a reverse of the direction of rotation is impossible due to the non-symmetry of the apex arcs.

Finally grinding the drill can only be carried out by means of a cam in connection with the special transverse contour which is not really continuous due to the steps in the curvature radiusses of the arcs. For each different diameter or topcone of the drill a different cam must be used.

The invention aims at providing an improved flow drill not having the above mentioned disadvantages. This is achieved according to the invention in that the contour of the cross-section may be shown by the formula:

$$R(\phi) = R_0 - \frac{1}{2}e + \frac{1}{2}e \cos \left\{ \arccos \left(\delta \sin^2 n\phi + \frac{|\cos n\phi|}{\cos n\phi} \sqrt{\delta^2 \sin^4 n\phi - \delta^2 \sin^2 n\phi + \cos^2 n\phi} \right) + \alpha \right\}$$

in which the condition is valid for the solutions of $R(\phi)$:

$$(\sin n\phi) \cdot \sin \left\{ \arccos \left(\delta \sin^2 n\phi + \frac{|\cos n\phi|}{\cos n\phi} \sqrt{\delta^2 \sin^4 n\phi - \delta^2 \sin^2 n\phi + \cos^2 n\phi} \right) \right\} \geq 0,$$

and in which R = Radius vector from the drill center, R_0 = radius vector in a starting point of the contour in one of the apexes of the polygon, ϕ = the angle between R and R_0 , $e = R^{\max} - R^{\min}$, δ = the modulation factor and α = the non-symmetry factor.

Thereby a really continuous contour is obtained which is based on a complex harmonic curve and thereby a uniform load distribution along the part thereof entering into engagement with the hole wall.

The relief relative to the hole wall in the remaining contour part is very small or absent, in which last mentioned case there always is a small contact pressure whereby growth or adhesion of material is minimized. With non-ferrous metals still some growth may occur but this may be immediately removed by reversing the direction of rotation of the drill, which is possible due to the symmetrical extension of the contour. Moreover, the wear of the drill may be made more uniform by intermittent reverse of rotation. Moreover, a mixed lubrication between the drill and the hole wall occurs due to the extension of the contour according to the invention.

If in the above mentioned formula $n = 3$ then the basic shape of the contour is a triangle. However, it may also be a square, pentagon or hexagon. The embodiments preferred in practice are drills based on a square since their operational stability is greater than that of drills based on a triangle, while those drills based on a pentagon or hexagon too closely approximate the circular shape. For

manufacturing the drill no cams are necessary. The drill may be ground in accordance with the contour according to the formula on a numerically controlled grinding machine.

The invention will hereunder be further explained with reference to the drawing.

Fig. 1 shows a side view of the drill with therebelow, show in section, a hole manufactured through that drill.

Fig. 2 is a cross-section according to I—I of Fig. 1 of a possible cross-sectional contour of the drill.

Fig. 3 shows a plurality of different possible contours, wherein for each contour the values of the parameters according to the formula are shown.

The drill as shown has a first conical part 3, having a pointed centering portion 2, a prismatic second part 4, a collar 5 having a shoulder 6 and a shaft 7 by means of which the drill may be secured in a drilling machine head.

The drill according to the invention, which is suitable for making holes in copper, aluminum, bronze and steel, may be used in both rotational directions, remains free of material growth or adhesion, with a maximum in stability and life and has an operative portion 3 and 4, the cross-section of which has the contour according to the formula, examples of which are shown in Fig. 2 and 3.

In Fig. 3 the number of sides or apexes of the polygon on which the contour is based is indicated by n, e indicates the difference between the maximum and the minimum value of the radius vector R in the relative contour, δ indicates the so called modulation factor and determines the radius angle in the points of the curve. In practice δ is usually between 0 and 0.9. α is the so-called non-symmetry factor. If α is not equal to 0, the contour is composed of n equal parts each being non-symmetrical relative to the radius vector, situated between both end points from that contour part.

The left column of contours as shown in Fig. 3 is relative to contours based on a triangle, the right column shows contours based on a square.

25 Claim

1. A flow drill for the provision of a hole in metal sheet or metal tube walls, surrounded by a collar, said hole being made through the intermediary of frictional heat and pressure, said drill having a shaft (7) and a smooth tapering operative end (2), the cross-section of said operative end being based on a regular polygon and having a convex contour, situated within the circle circumscribing the polygon, characterized in that the contour of the cross-section is shown by the formula:

$$R(\phi) = R_0 - \frac{1}{2}e + \frac{1}{2} \operatorname{ecos} \left\{ \arccos \left(\delta \sin^2 n \phi + \frac{|\cos n \phi|}{\cos n \phi} \right) \right. \\ \left. \sqrt{\delta^2 \sin^4 n \phi - \delta^2 \sin^2 n \phi + \cos^2 n \phi} + \alpha \right\}$$

in which the condition applies to the solutions for R(ϕ) that:

$$(\sin n \phi) \cdot \sin \left\{ \arccos \left(\delta \sin^2 n \phi + \frac{|\cos n \phi|}{\cos n \phi} \right) \sqrt{\delta^2 \sin^4 n \phi - \delta^2 \sin^2 n \phi + \cos^2 n \phi} \right\} \geq 0,$$

in which R = the radius factor from the drill center, R_0 = radius vector in a starting point of the contour in one of the apexes of the polygon, ϕ = the angle between R and R_0 , $e = R^{\max} - R^{\min}$, n is the number of apexes of the polygon, δ is a modulation factor and α is a non-symmetry factor.

Patentanspruch

1. Fließbohrer zur Herstellung eines Lochs in einem Blech oder in Metallrohrwänden, welches Loch von einem Kragen umgeben ist, und mittels Reibungserhitzung und Druck dargestellt wird, welcher Bohrer eine Schaft und ein glattes kegeliges wirksames Ende aufweist von welchem wirksamen Ende der Querschnitt auf einem regelmässigen Vieleck basiert ist und ein konvexes Profil aufweist, welches Profil innerhalb des den Vieleck umschreibenden Kreises liegt, dadurch gekennzeichnet, dass das Profil des Querschnitts durch den folgenden Formel dargestellt wird:

$$R(\phi) = R_0 - \frac{1}{2}e + \frac{1}{2}e \cos \left\{ \arccos (\delta \sin^2 \eta \phi + \frac{|\cos n \phi|}{\cos n \phi} \right.$$

$$5 \quad \left. \sqrt{\delta^2 \sin^4 n \phi - \delta^2 \sin^2 n \phi + \cos^2 n \phi} + \alpha \right\}$$

worin für die Lösungen für $R(\phi)$ die Bedingung gilt dass:

$$10 \quad (\sin n \phi) \cdot \sin \left\{ \arccos (\delta \sin^2 n \phi + \frac{|\cos n \phi|}{\cos n \phi} \sqrt{\delta^2 \sin^4 n \phi - \delta^2 \sin^2 n \phi + \cos^2 n \phi} \right\} \geq 0,$$

15 worin R = der Radiusvector vom Bohrermitelpunkt aus ist, R_0 = der Radiusvector in einem Anfangspunkt des Profils in einem der Winkelpunkte des Vielecks ist, ϕ = der Winkel zwischen R und R_0 ist, $e = R^{\max} - R^{\min}$, n = der Zahl der Winkelpunkte des Vielecks ist, δ = ein Modulationsfaktor und α eine a-Symmetriefaktor ist.

Revendication

20 1. Foret remollissant pour prévoir un trou en une tôle ou dans des tubes métalliques, ledit trou étant entouré par un collet, et étant prévu à l'intermédiaire de la chaleur générée par friction et de pression, ledit foret comprenant une tige et une partie opérative terminale conique et lisse, la section transversale de la partie terminale operative étant basée sur un polygone régulier et ayant un contour convexe, situé à l'intérieur du cercle circonscrivant du polygone, caractérisé en ce que le contour de la
25 section transversale est donné par la formule:

$$30 \quad R(\phi) = R_0 - \frac{1}{2}e + \frac{1}{2}e \cos \left\{ \arccos (\delta \sin^2 \eta \phi + \frac{|\cos n \phi|}{\cos n \phi} \right.$$

$$\left. \sqrt{\delta^2 \sin^4 n \phi - \delta^2 \sin^2 n \phi + \cos^2 n \phi} + \alpha \right\}$$

35 dans laquelle la condition s'applique au solutions pour $R(\phi)$ que:

$$40 \quad (\sin n \phi) \cdot \sin \left\{ \arccos (\delta \sin^2 n \phi + \frac{|\cos n \phi|}{\cos n \phi} \sqrt{\delta^2 \sin^4 n \phi - \delta^2 \sin^2 n \phi + \cos^2 n \phi} \right\} \geq 0,$$

45 dans laquelle R = le vecteur radial sortant du centre du foret, R_0 = le vecteur radial au point de départ du contour dans un sommet d'angle du polygone, ϕ = l'angle entre R et R_0 , $e = R^{\max} - R^{\min}$, n = le nombre de sommets du polygone, δ = un facteur de modulation et α un facteur d'a-symmetrie.

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FIG.1

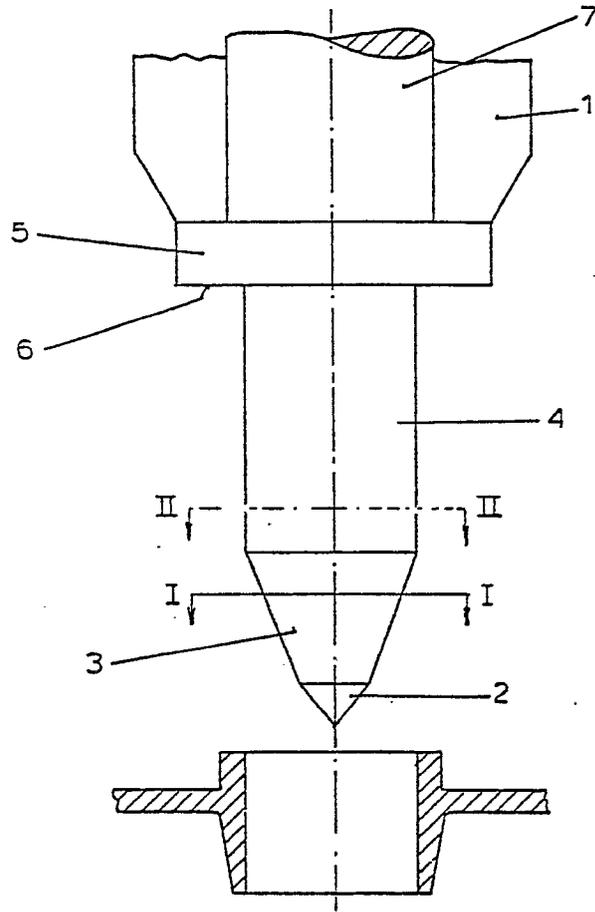


FIG.2

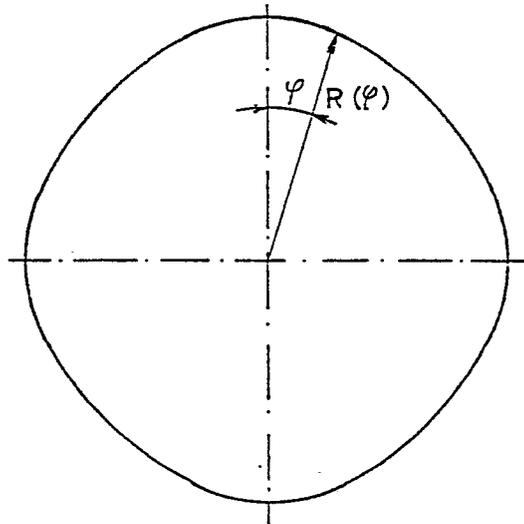
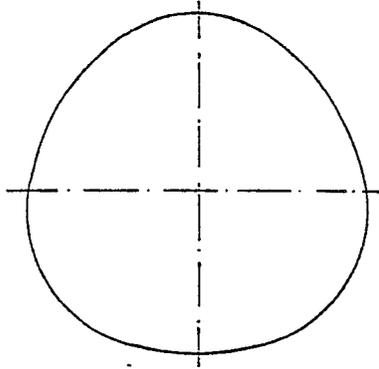
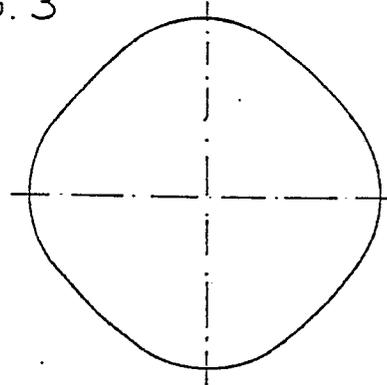


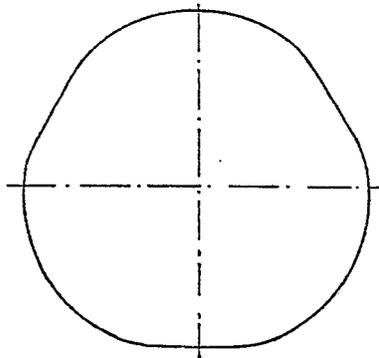
FIG. 3



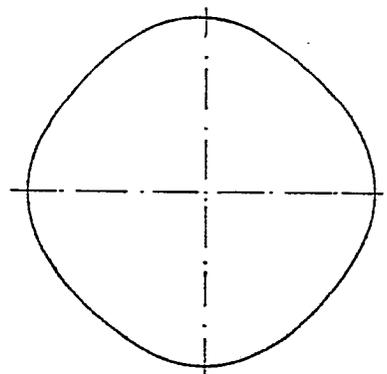
$n = 3$
 $e = 2$
 $\delta = 0$
 $\alpha = 0$



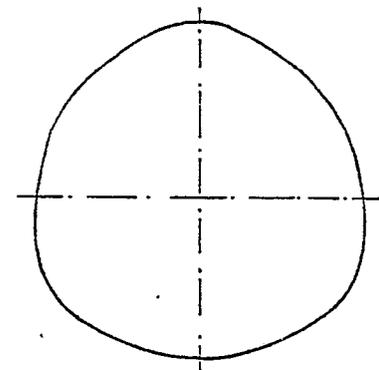
$n = 4$
 $e = 2$
 $\delta = 0$
 $\alpha = 0$



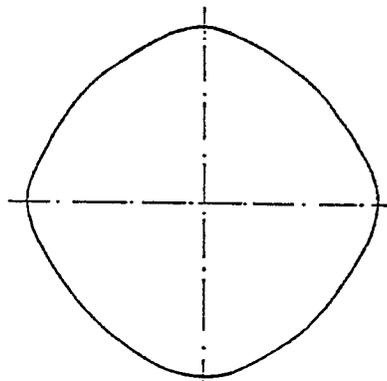
$n = 3$
 $e = 2$
 $\delta = 0,67$
 $\alpha = 0$



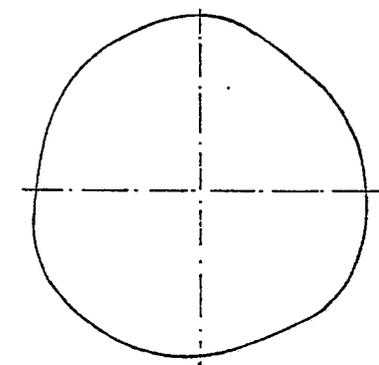
$n = 4$
 $e = 1,5$
 $\delta = 0$
 $\alpha = 0$



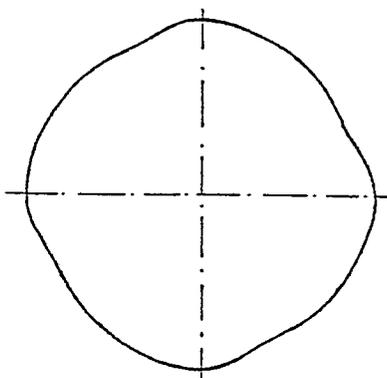
$n = 3$
 $e = 2$
 $\delta = 0,67$
 $\alpha = \pi$



$n = 4$
 $e = 2$
 $\delta = 0,67$
 $\alpha = \pi$



$n = 3$
 $e = 2$
 $\delta = 0,67$
 $\alpha = \frac{1}{2} \pi$



$n = 4$
 $e = 2$
 $\delta = 0,67$
 $\alpha = \frac{1}{2} \pi$