J. Hugel

Instructions

For using the EXCEL tables:

<DrillPerformance.XLS>

With 33 Figures

Contents:

Notations in the text:

<XXXX>	EXCEL Files
{XXXX}	Worksheets and Charts (Graphs)
{[XXX]}	Boxes in a worksheet
“XX-> XX⋯”	Pull-Down Menus
[XX]	Keys

B02-C05

1. General Remarks

The EXCEL tables <DrillPerformance.XLS> are a useful tool to investigate drill grinding jigs for conically or cylindrically shaped flanks. The application of the worksheets is very simple and no special knowledge of mathematics or computer programming is required. However it is necessary to know the jigs geometrical features. Additionally two figures must be known from the drill to be ground, the diameter and the half tip angle. These and some other input data are set in the {Input Output}-table in boxes with green frames and a bluish green background. The cell to be altered is selected by a mouse click and then the new data can be introduced. An [Enter]-stroke or clicking another cell completes the input. EXCEL immediately actualises the worksheets and diagrams.

Calculated data are found in yellow boxes with red frames. No provisions were foreseen to regard any setting restrictions because this would be impossible in general and in advance. If input data are set and no solution exists, the message "#NUM!" is displayed in the cells concerned. The input data are transferred into the {Table for Graphs} and there all calculations are performed. No inputs are necessary in this table which is protected. Records of files with modified data and backup copies of the worksheet are saved in the usual way to the hard disk of the PC or another suitable storage medium.

The input data to judge a specific jig must be derived from its geometrical properties. The data are received from the drawings if available or from simple measurements. This is explained in general and then four examples are presented to show those investigations in more details.

Regarded are normal twist drills with helical flutes. In the national and international standards dimensions and tolerances are found, also core diameters, tip and helix angles, back rakes and some other data, but no information is provided on the tip geometry. Sometimes this is suggested by manufacturers of drill grinding equipment. The flanks usually are small sections from the envelope of a cone.[1] The tolerance of the diameter mainly is h8, the drilled holes shall be within H10 and therefore shall have no undersize. In the diameter range 10 to 18 mm for example 43 μm oversize is allowed. As already mentioned no data for clearance angles at the cutting edge are found in the standards and nothing is said on the back rake or the flanks' shape; these data however are crucial for the drill's performance. The reason is that these data depend on the materials and drilling equipment and especially the industrial production always asks for combined technical and economical optimum conditions.

[1] Drill grinding equipment also was designed and built for cylindrical and helical surfaces.

2. Drill- and Cone-Parameters

The grinding jig is responsible that the drill's flanks are ground to the wanted conical shape; the generating cone is defined by the jig's design in the ambient coordinate system, the *A*-system. The drill's coordinates however are given in the tool or *T*-system. The coordinates of both systems are distinguished by the index *A* or *T* in front of the main character, the number behind designates the axis. For example ${}_{T}X_2$ is the coordinate *X* in the 2-direction of the *T*-system.

The axis of the basic cone is the ${}_{A}1$-axis; the tip shows into the positive direction. This is the green cone in Figure 1. The basic cone is rotated an angle κ about the ${}_{A}2$-axis which is perpendicular to the plane of projection. The angle κ usually is a fix parameter of the drill grinding equipment.

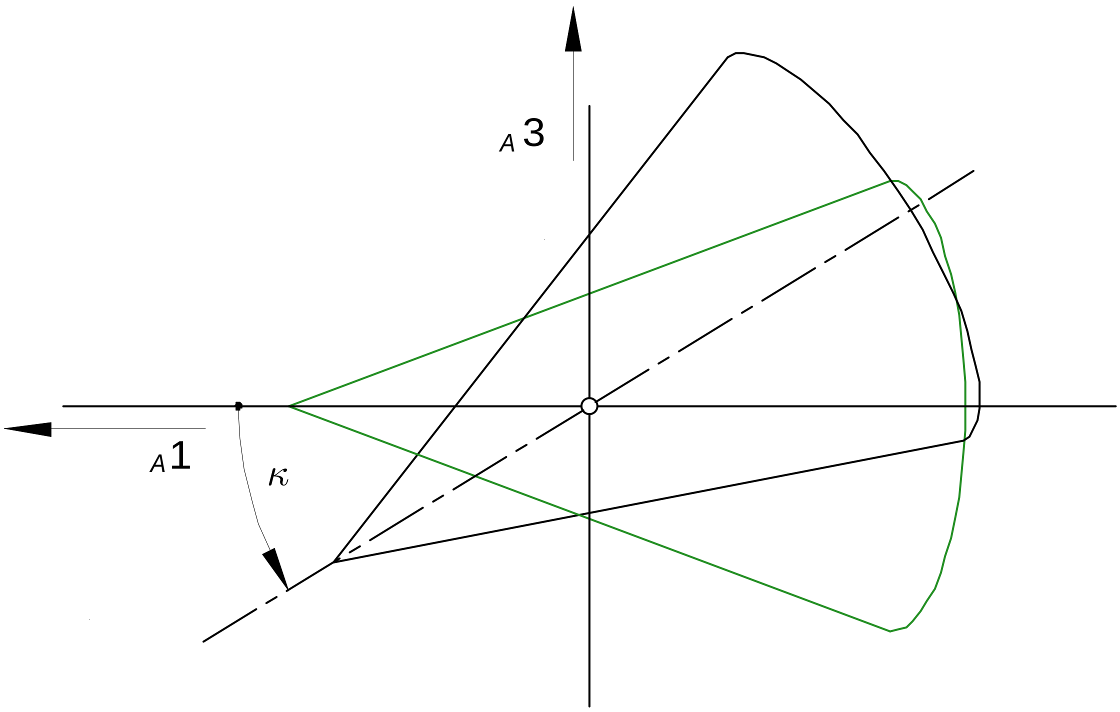


Figure 1: The basic cone in the *C*-system

For the time being the 1-axis of the *T*-system, the axis of the drill, shall be coincident with the $_A1$-axis. The lips are parallel to the $_T1$-$_T3$-plane; the drill’s tip meets the *T*-coordinate's origin. The *A*- and *T*-system are parallel but distant in the 1-direction and the drill’s tip has the distance *R* from the cone’s axis, then the distance between the origins of the two coordinate systems is $d_{AT} = R/\sin\kappa$. In the next step the drill together with the *T*-system are rotated about the 1-axis the drill's azimuth τ and this situation is seen in Figure 2. In the drawing the drill's lip that actually is ground and the cone’s tip are on the same side but also the opposite situation is possible, the first case is seen in Figure 3, the second in Figure 4.

The direction of the cone’s tip depends on the drill’s half tip angle γ and the inclination angle κ of the cone’s axis; the same is true for the half cone angle ψ. A special case is $\psi = 0$, the flank’s shape then is cylindrical. Very good drill grinding results can be expected from machines for cylindrical flanks.

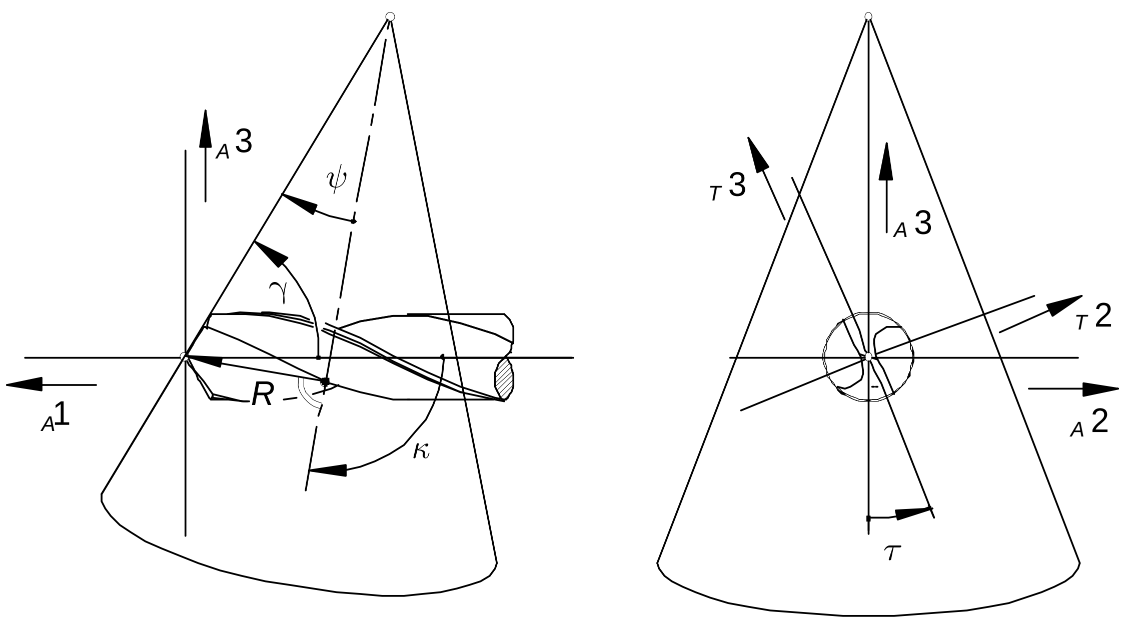
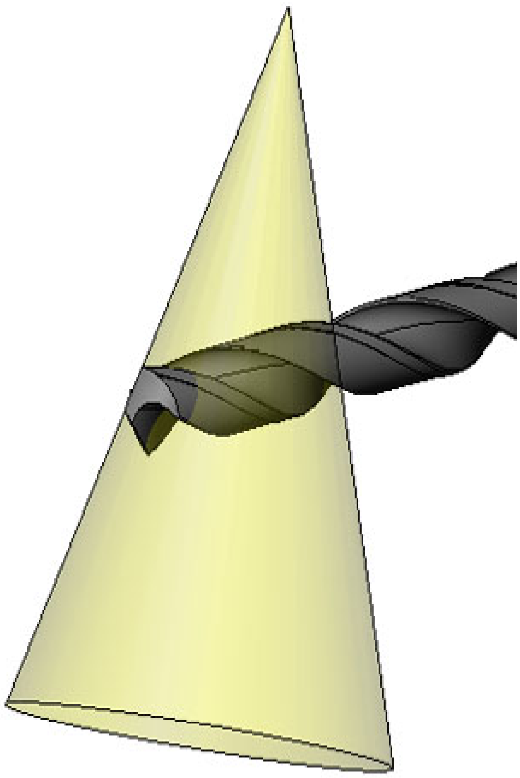


Figure 2: Drill and cone in the same plane



The cone's tip angle should be in the range $0 \le \psi \le \psi_{max}$ with $\psi_{max} \approx 35^0$ to have a surface with enough curvature. For higher angles the surface becomes too flat and for $\psi = 90^0$ the cone degenerates to a plane.

Figure 3: The cone's tip adjacent to the lip to be ground

Therefore also the drill's tip must not be located too far distant from the tip of the cone, the radius R is limited. If this rule is violated by the particularities of the jigs design perfectly restored drill tips cannot be expected. Regrettably a remarkable number of jigs are available on the market with R much too high.

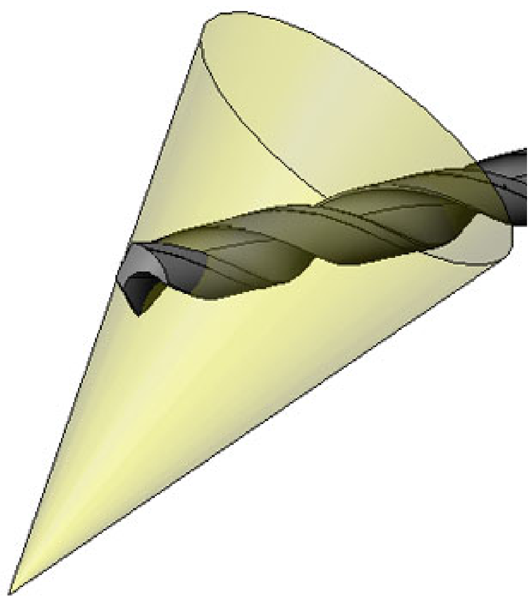
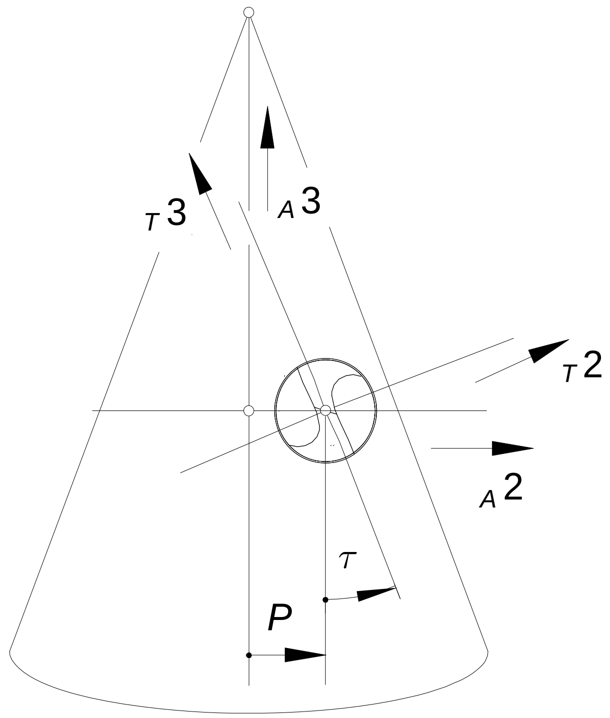


Figure 4: The cone's base adjacent to the lip to be ground



To bring the drill into the final position the last step is to shift the T- system the distance *P* in direction of the $_A2$-axis as seen in Figure 5. The right distance *P* is as important as the correctly selected Radius *R*.

Figure 5: The drill shifted in direction of the $_A2$-axis the distance *P*.

Any drill grinding jig is completely described by four parameters:

κ	the inclination angle of the cone's axis
τ	the azimuth of the drill
P	the shift parameter
R	the radius parameter.

Additionally we must know from the drill:

D_D	The drill diameter
γ	The drill's half tip angle.

If the absolute distance parameters are related to the radius $R_D = D_D / 2$ the relative parameters are received:

$$p = \frac{P}{R_D} = \frac{2 \cdot P}{D_D} \qquad r = \frac{R}{R_D} = \frac{2 \cdot R}{D_D} \qquad {}_T x_{2L} = \frac{{}_T X_{2L}}{R_D} = \frac{2 \cdot {}_T X_{2L}}{D_D}. \tag{2.1}$$

${}_T X_{2L}$ is the distance between the lip and the 1-3-plane. The numerical value always is negative because the lip is advanced in the negative ${}_A 2$-direction. The relative value in the {Input Output} table is ${}_T x_{2L} = -0,2$.

A good drill grinding jig should allow to set *P* and *R* individually; with constant values for *p* and *r* for different diameters D_D the tips become geometrically similar. Then the ratio $P/R = p/r$ is a constant; jigs based on this principle can be adapted to the diameter D_D with one setting element only.

As already said for using the worksheets to investigate a jig the only challenge is the determination of the setting parameters from the geometry and kinematic of the jig; different methods are discussed later in general as well as with four examples.

3. The Input and Output Data

The table for the input and output data is seen in Figure 6. The parameters in the boxes {[Input Data]} and {[Drill Diameter]} have already been explained and shall be known. The {[Drill's Flute Angles]} are explained later together with the reliving characteristics and normally remain unchanged, therefore the cells show overlaid hatchings.

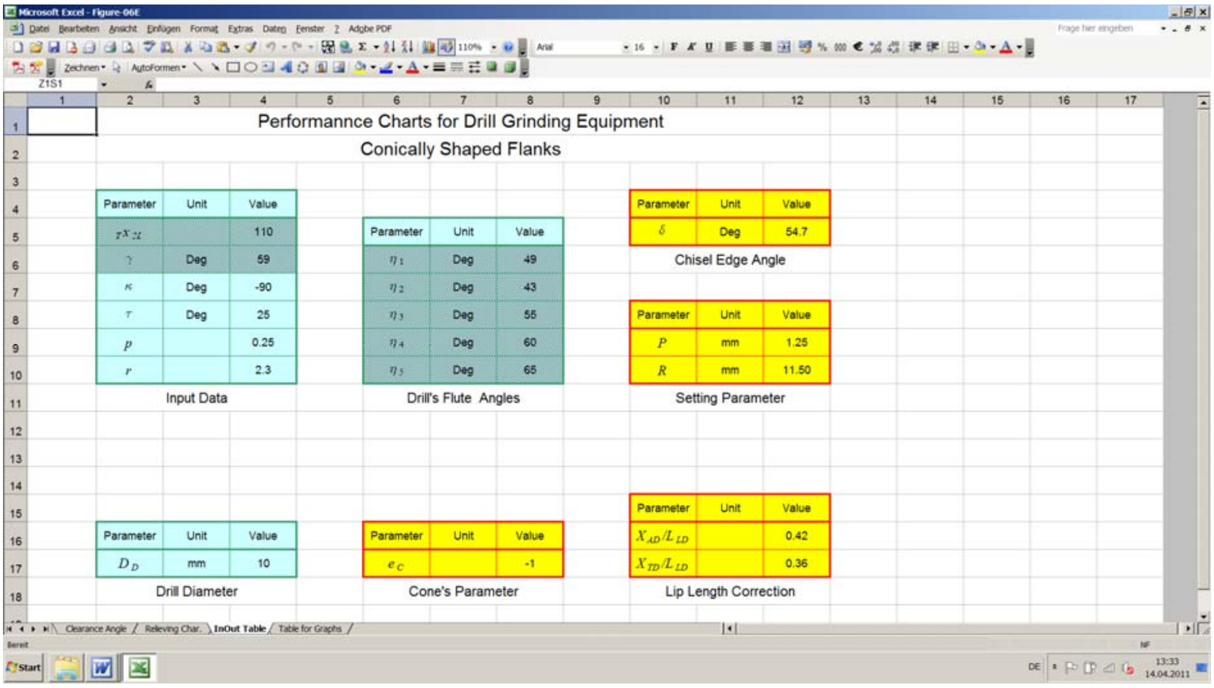


Figure 6: The {Input Output} table for Settings and Results

The absolute value of the lip's related position ${}_T x_{2L}$ is nearly exact the half core diameter. The sign is always negative because the cutting edge is shifted in the negative ${}_T 2$-direction. The default value ${}_T x_{2L} = -0.2$ is rounded up to one decimal place and valid for drills up to 16 mm diameter, in Figure 7 exact values are found. The default value for the drill's half tip angle is $\gamma = 59^0$ and in case must be adapted. All calculations in the background are performed with related parameters for the distances in the {[Table for Graphs]}.

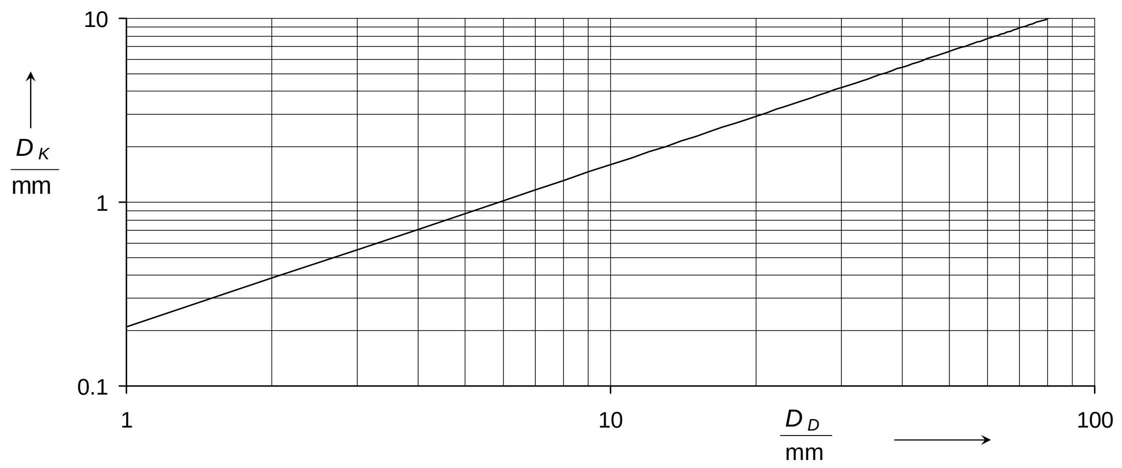


Figure 7: The core diameter from DIN 1414

For setting the equipment however the absolute values P and R may be necessary and these are displayed in the yellow box {[Setting Parameter]}. Above the {[Chisel Edge Angle]}is found. According to Figure 8 this is measured from a line in the 1-3-plane parallel to the lips. Sometimes it is said, this angle should be $\delta = 55\,\text{Deg.}$ for perfectly ground drills. That's wrong, the angle δ is not critical and no indicator for the drill's performance.

The {[Cone's Parameter]} shows the orientation of the cone's tip in relation the flank to be ground. For $e_C = 1$ both have the same direction (Figure 3) and are opposite for $e_C = -1$ (Figure 4).

The lips of correctly ground drills must have the same length, this is a very important condition. Quality grinding equipment guarantees this automatically as long as the drills are straight. Collets with three slots should be regarded very critically, with those it is difficult to mount drills concentrically. The lip's length difference L_{LD} must not exceed 0.05 mm in the diameter range $D_D \approx 3 \cdots 13$ mm.[2] Drills with different long cutting edges produce oversized holes and it

[2] For the DAREX SP2500 Ultra Precision Drill Sharpener L_{LD} = 0.025 mm is specified

makes not much sense to have drill sets ready available with 0.1 mm diameter steps which generate holes several times larger than this value.

The familiar drill point gauges offered by the trade to check the tip angle and lip's length have only a mm scale and are therefore not accurate enough. For checking the lips' lengths 10-x-magnifiers with a 0.1 mm scale, 10 or 15 mm long have proved to be of great value. Scales on a steel rules are better than those on glass plates. Very convenient are also CCD-cameras with electronically overlaid scales.

For reasonable length differences between the two lips a correction is possible by feeding the flank with the shorter lip closer to the wheel in the final grinding passes. Two cases must be distinguished. If the drill is fed together with the grinding apparatus the additional distance is X_{TD}. If only the drill is moved and the jig remains stationary X_{AD} would be the correct distance. Both distances are calculated by multiplying the lips' length difference L_{LD} with the accordant factor from the box {[Lip Length Correction]}. From the measured length difference the final feed position is calculated. This grinding method to a defined target is performed fast and works very reliable. However the very important lip length corrections cannot be performed with drill grinding jigs that do not offer the possibility to feed each of both flanks individually and exactly with a scale.

4. Relieving Characteristics and Clearance Angle Function

If a drill, pointing down, is turned about its vertical axis and a suitable DTI would touch a flank the ball of the pointer moves on a circular path on the flanks. We expect that the deepest point is at the cutting edge. With such a setup we could record how the flanks are backed off behind the lip; the maximum height should be at the end of the path, at the flute. For different distances of the contact point from the drill's axis different profile curves are received Based on this principle 100 years ago GEORG SCHLESINGER has evaluated drill grinding machines experimentally and he had coined the term "Relieving Characteristics". These also are reliably found by calculations.

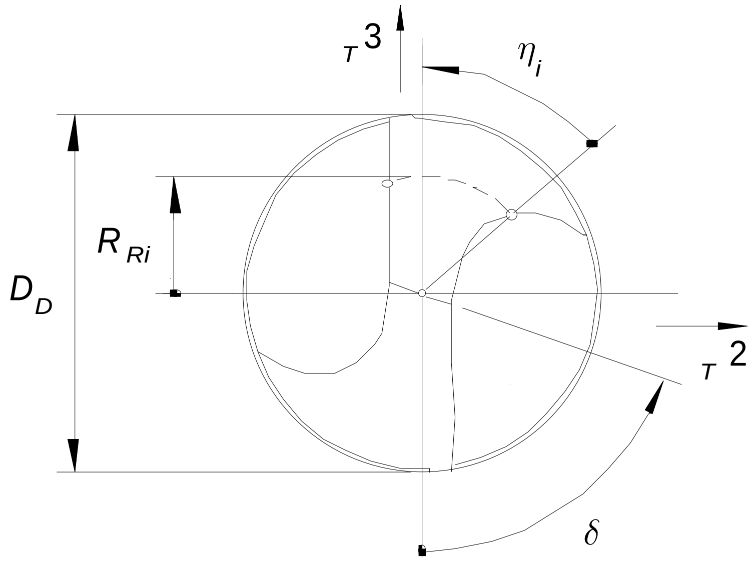


Figure 8: The path parameter R_{Ri} and η_i

With five paths, one is seen in Figure 8, at a glance a good overview is received on the drill's operational behaviour. The arcs start at the cutting edge with the abscissa ${}_TX_{2L}$ respective ${}_Tx_{2L}$, the radii are R_{Ri} and the ends at the flute are denoted by the angles η_i from the table {[Drill's Flute Angles]}. To make different characteristics comparable the path radii are also related to the drill's radius as all distance parameters, it is $r_{Ri} = R_{Ri} / R_D$.

An example for the relieving characteristics is seen in Figure 9. For clearness the curves are shifted horizontally the amount r_{Ri}; the peripheral path with the radius $r_{Ri} = 1$ ends at the drill's heel.

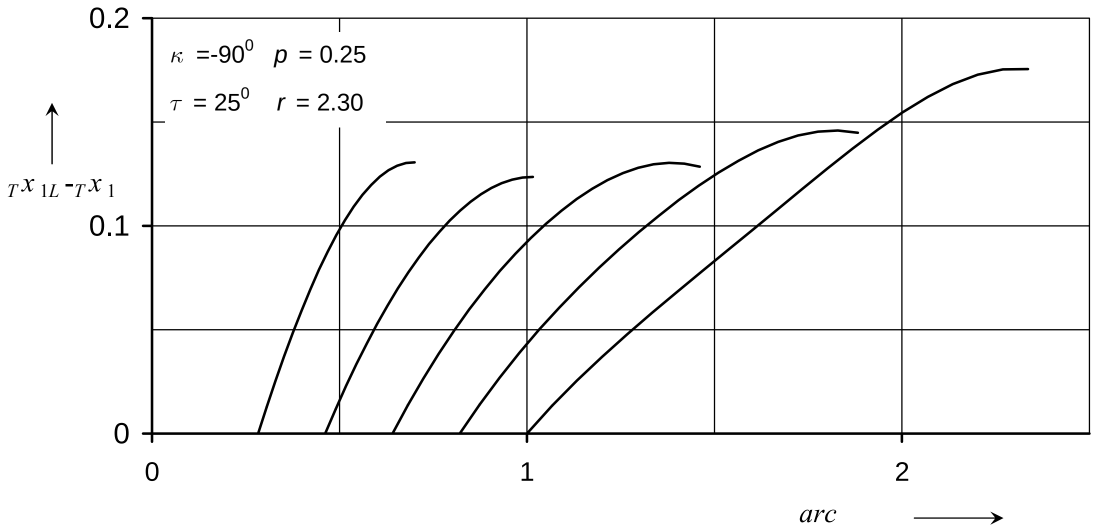


Figure 9: The relieving characteristics

In principle the relieving characteristics contain the complete information on the geometry of the drill's flanks. The clearance angles at the cutting edge are the curves' inclination angles at the starting points. But these are not the angles we see and the extraction from the figure would be somewhat cumbersome. The scales on both axes and additionally for the individual curves are all different. For convenience the clearance angle function along the cutting edge is made available in a separate diagram; to Figure 9 related is Figure 10.

The abscissa is the radial distance of the paths from the drill's centre axis, related to R_D. The clearance angle grows from the periphery to the web and this feature is very welcome. The clearance angle reduction by the feed speed is inversely proportional to the centre distance of a point on the lip. This effect is at least partly compensated by the drill's increasing geometrical clearance angle in direction to the centre.

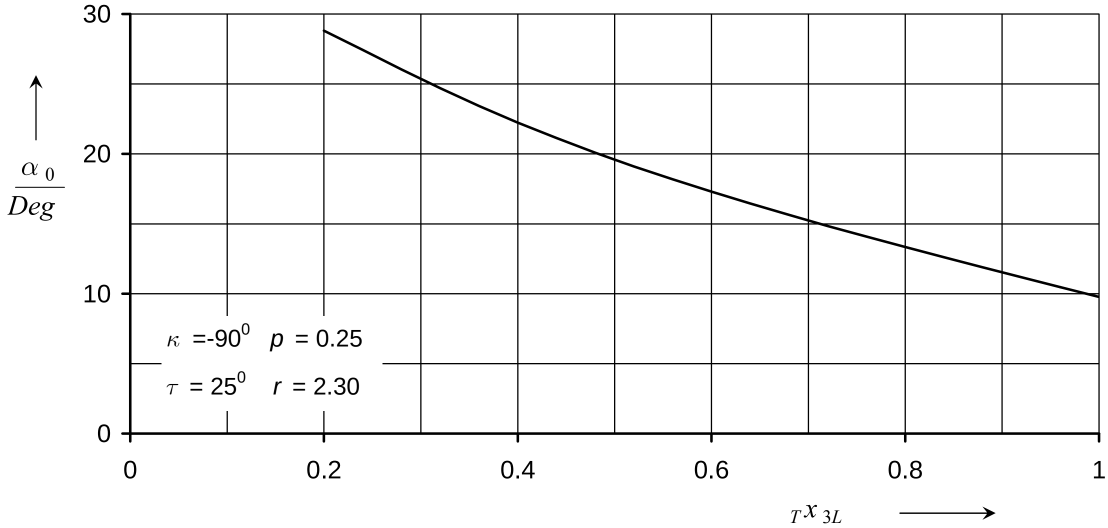


Figure 10: The clearance angle function

With the EXCEL-Software installed on the computer the scales and divisions of the diagrams are simply adapted to special needs. A mouse click on the axis opens a window for modifying the different data.

The diagrams of Figures 9 and 10 are valid for a good general purpose drill. For the diameters below 3 mm usually higher clearance angles are foreseen. With clearance angles too high the performance of the drill becomes "aggressive" and problems may arise if the drill is manually fed. The optimum drill geometry and the interpretation of the related performance charts depends on a series of parameters but mainly on the material characteristics and the features of the drilling machines.

4. Relieving Characteristics and Clearance Angle Function

5. Jig Analysis

As already pointed out the jig analysis is the first step to be able to use the EXCEL worksheet for calculating the drills characteristic data and for plotting the performance charts. The analytical approach normally asks for some knowledge on spatial geometry and therefore is rather a matter for specialists. A much simpler method to determine the data for κ, p, r and eventually for τ is based on the design drawings. With a three dimensional CAD-model the dimensions directly can be determined but it is also not difficult to get the data from conventional drawings. But if these are not always available, then analytical investigations or experimental methods and measurements can be taken into consideration.

The drill diameter D_D shall be known. The first task is to locate the cone's axis and determine the inclination angle κ. The range is from γ-180 Deg. to γ. For the standard drill with $\gamma = 59$ Deg. the range of κ is between -121 Deg. and 59 Deg.; the sign is important. In the next step the radius R and the radius parameter r are determined. The radius R is the distance of the drill's tip from the cone's axis. In the third step the distance P between the axes of cone and drill must be found; both in general are askew but sometimes also parallel or perpendicular.

If the two distances P and R are proportional to the drill diameter D_D the related parameters p and r are constant and independent from D_D. Then the tips of all drills become geometrically similar and the diagrams are valid for all sizes. Not all jigs have this feature. If p and r depend on D_D the jig must be investigated for a couple of different diameters D_D to receive an overview. The parameters p and r may depend more on D_D than wanted, this feature is found with many simple drill grinding jigs.

Finally the angle τ must be found. Sometimes τ is determined by a stop but in principle this angle can be set without any restrictions. Sometimes τ is the only parameter that is selectable. The optimum value is quickly found with the EXCEL table. The first approach best is performed with coarse steps of say 30 Deg. Then the procedure is continued with finer increments. The tendencies of the functions in both performance charts go into the same direction. For a reduced τ both the clearance angle function and the relieving characteristics become reduced. It may happen that no angle leads to a satisfying result. Then in principle the jig is useless. However if two charts are found similar to Figures 9 and 10 in shape and figures the jig would be alright.

There are many jigs on the market which do not offer the possibility to adapt p and r to the drill's diameter and some are anything but cheap. In the instructions sometimes it is stated the adjustment of τ would be sufficient to perform any necessary adaption. This is nonsense. All three parameters p, r and τ are important and only κ can be selected within ample limits.

At the end of this chapter a special class of drill sharpeners shall be regarded that could be called "fuzzy jigs". These are in between freehand grinding and the jigs with a determined kinematical structure. A reliable analysis and judgement of those jigs is impossible. An example is the BOSCH S41, driven by an electrical hand drill. It is bewildering that such a highly respected company produces and sells such a really poor device. There are enough perfect designs available and also those not too expensive that can resharpen any twist drill authentically.

6. Example 1: Drill Grinding with the QUORN

The QUORN tool and cutter grinder was designed in the seventies by Prof. D.H. CHADDOCK; there is some relationship to the DECKEL grinder for engraving cutters which is produced until today. The QUORN is not ready available on the market, only the castings are offered for building the machine individually. Meanwhile many thousands machines were built worldwide according to the drawings and instructions of Prof. CHADDOCK. He himself didn’t recognize the possibility to sharpen drills with conically shaped flanks, therefore he suggested to grind twist drills with four facets. However with the QUORN's very flexible adjustment features nearly all possible conical drill tips can be ground and this means practically that nearly any jig could be simulated. For an arbitrarily selected κ an angled mounting bar for the tool head is necessary which is not difficult to produce. In the basic configuration the bar is straight and then we have $\kappa = -90$ Deg.

Figure 11: Setting the QUORN’s tilting bracket

To grind drills with 118 Deg. tip angle the work head is set with the tilting bracket to $\psi = 31\,\text{Deg.}$ as seen in Figure 11.

For the QUORN a jig's analysis is not necessary because the parameters P, R and τ directly are set. Recommended setting data for different drill diameters are found in the "Useful-Files" section of the SMEE homepage with the workshop chart "In Six Steps to the Perfect Drill with the QUORN Tool and Cutter Grinder"[3]. The method described there is straightforward, simple and foolproof.

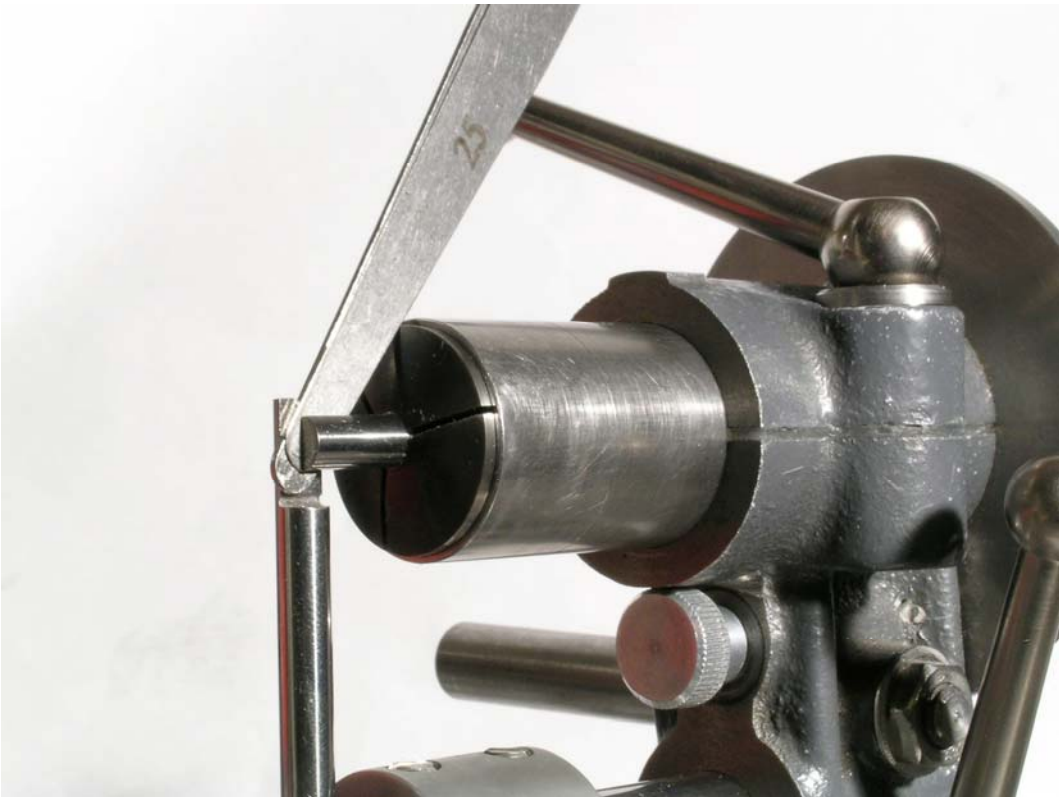


Figure 12: Setting the axes distance P

In the first step, Figure 12, the distance P between the axes of cone and drill is set. Then according to Figure 13 the radius R is adjusted. In step 3, Figure 14, the drill is aligned to $\tau = 0$.

[3] http://www.sm-ee.co.uk/resources/files/jh-connical-method.pdf

Figure 13: Setting drill tips distance R from the cone's axis

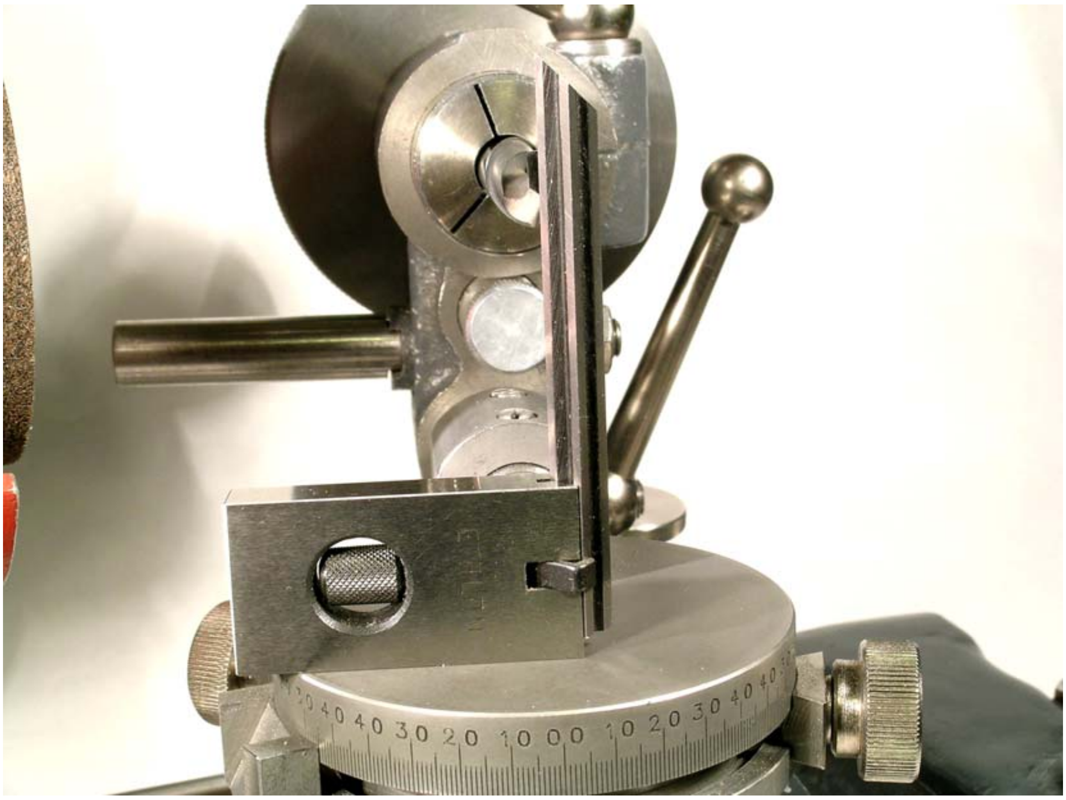


Figure 14: Aligning the drill's azimuth $\tau = 0$

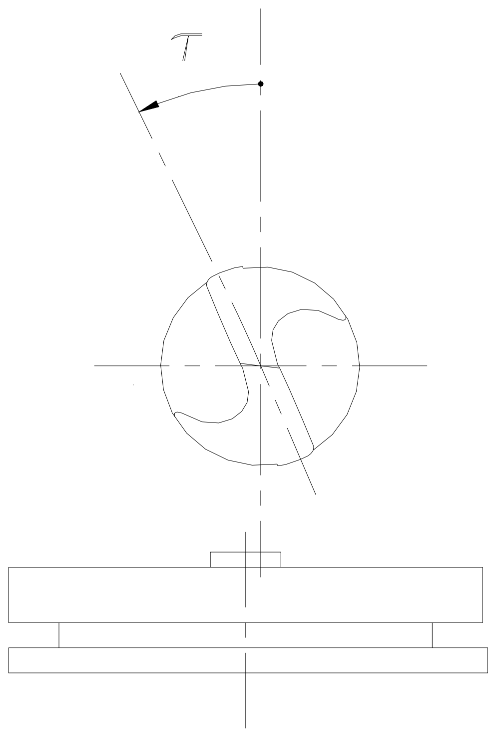


Figure 15: Setting the drill's azimuth τ

Then as seen in Figure 15 the drill's azimuth τ is set. With these adjustments both front faces are ground to identical positions of the QUORN's front bar micrometer. Steps five and six are measuring the lips' lengths and if different a correction must be performed. The shorter lip is fed X_{TD} closer to the wheel than the longer.

With the QUORN tool and cutter grinder it is possible to realize among many others exactly the drills that are characterized by the diagrams Figure 9 and Figure 10.

7. Example 2: The V-Clamp Jig

In Figure 16 a very simple drill grinding jig is seen and many similar designs are commercially available.

Figure 16: A simple drill grinding jig

The tool is held accurately and securely in a clamp between two V-shaped jaws. At the front two hardened bushings are provided, one for each flank, to be set on a hardened pin and its centreline is the cone’s axis. The distance between this and the drills axis, the parameter *P*, is determined by the design and depends on the diameter D_D. The axial position of the drill’s tip can be set freely but a minimum value is given by the clamp. The azimuth, the angle τ is unrestricted.

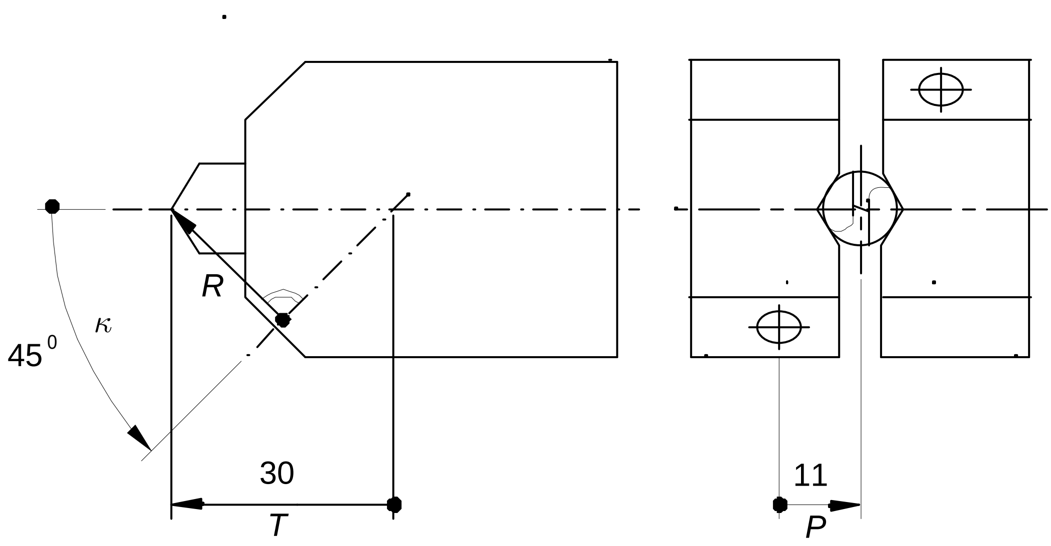


Figure 17: The jig's dimensions

The jigs dimensions with a 10 mm drill are shown in Figure 17 and based on this drawing the analysis is simple. The cone's inclination angle is $\kappa = 45^0$. The distance between the cone's and drill's axes is $P = 11\text{mm}$, the relative value is $p = 2 \cdot P / D_D = 2.2$. The absolute radius parameter is $R = T / \sqrt{2} = 21.2\text{mm}$ and the relative parameter becomes $r = 2 \cdot R / D_D = 4.24$. The reliving characteristics are shown in Figure 18 for three different azimuths τ.

Here we have the situation adumbrated above, the clearance angle function and the relieving characteristic show the same tendency for a variable τ, this is not surprising if we regard the close interrelationship of both diagrams. The characteristics for $\tau = 30$ Deg. come down nearly to zero and the drill's heel may foul the material. Together with the clearance angle function Figure 19 it becomes clear that no azimuth τ exists that would be really satisfying.

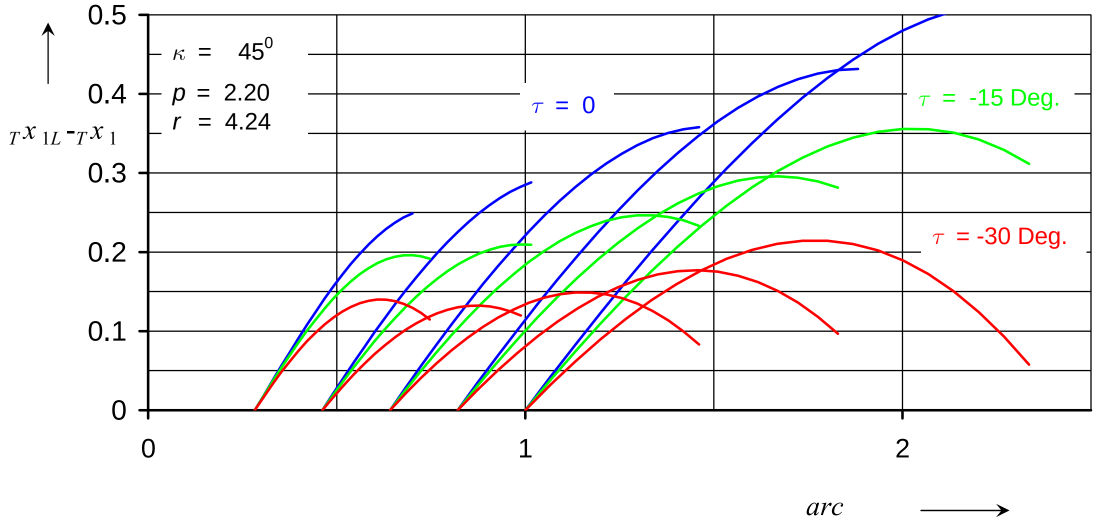


Figure 18: The relieving characteristics of the V-clamp jig

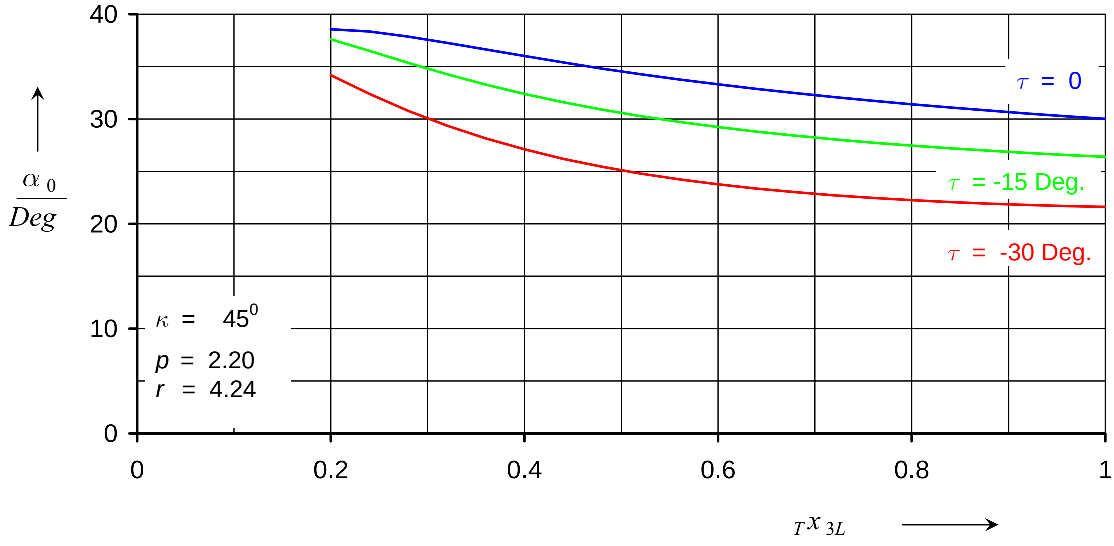


Figure 19: The clearance angle function of the V-clamp jig

The situation becomes even worse for smaller drills. Summed up in one sentence the V-clamp jig clearly is not a member of the premium league for drill grinding equipment and similar designs must be regarded with suspicion. The relieving characteristics and clearance angle function are an objective tool for those judgements.

8. Example 3: The Skew-Slide Jig, Part I

Since more than a century the design of a drill grinding jig is known, based on a slide that moves askew to the drills axis. This belongs to the devices with a constant *P*/*R* ratio. Only one setting element is necessary to adapt the jig to the drill diameter D_D and geometrically similar flanks are generated.. An example from industry[4] is seen in Figure 20, it belongs to the grinding machine for engraving cutters mentioned at p.18.

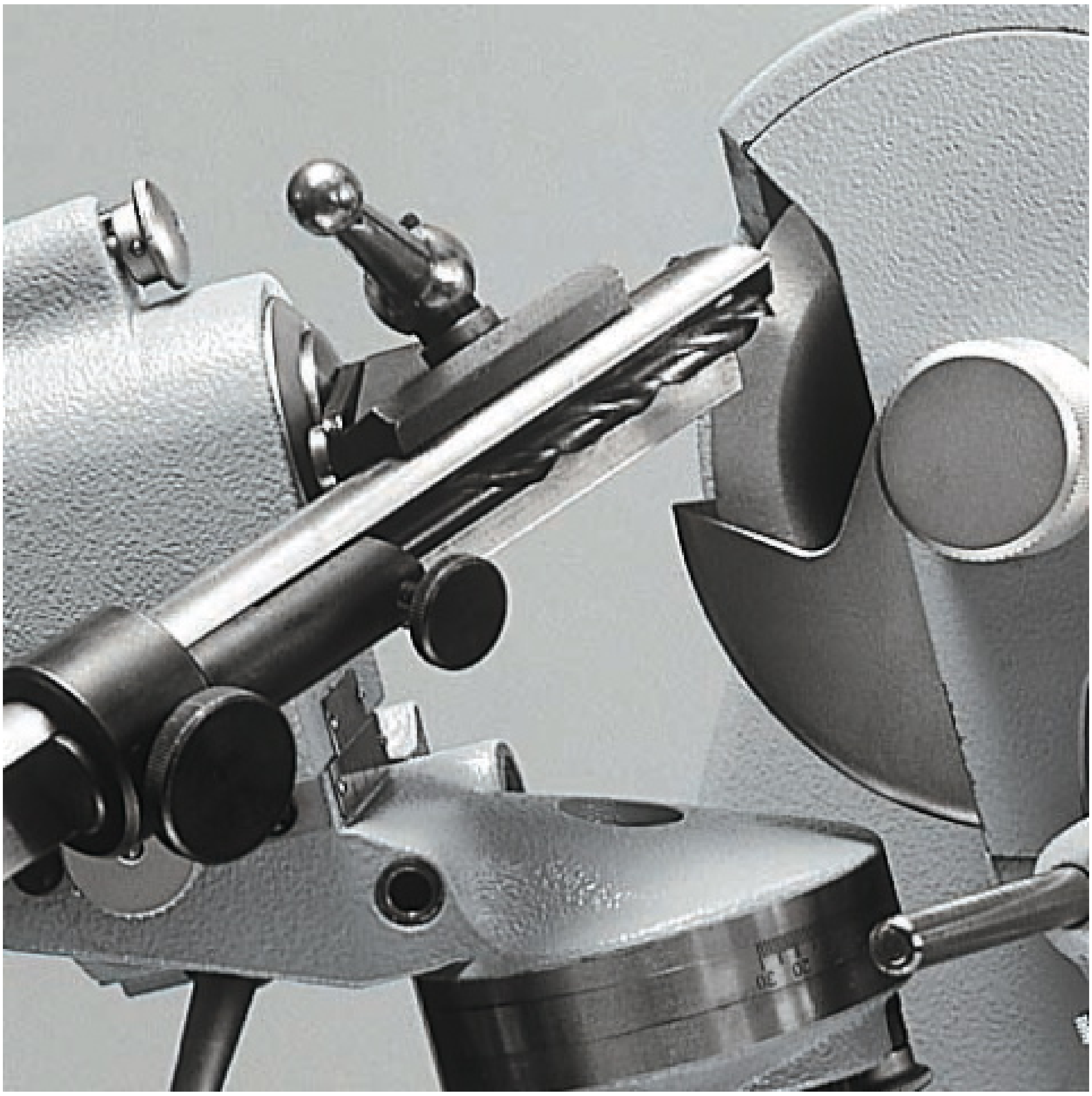


Figure 20: The DECKEL drill grinding attachment

[4] Courtesy MICHAEL DECKEL AG, Weilheim(Germany); http://www.michael-deckel.de/

Also the jig from G.P. POTTS, designed many decades ago, is based on the skew slide principle and seen in Figure 21[5],[6].

Figure 21: The POTTS drill grinding attachment

The pivot to swing the drill is mounted on a stage and points $\psi = 14$ Deg. inclined from the vertical to the wheel's face. On the pivot's top a slide base is provided and inclined $\kappa = 45$ Deg. in relation to the pivot's axis; the sum or total inclination angle is $\gamma = 59$ Deg., the half tip angle. The drill's rest, a 90 Deg. angled bar or "Vee" is mounted to the slide and this can be moved askew to the drill's axis; the angle is $\beta_S = 6$ Deg.. With a clamp, not shown in Figure 21, the drill is fixed securely to the Vee. This slide's movement has two components, one in the drills direction to adapt the radius *R*; the second component is

[5] Courtesy Mr. STUART WALKER, Walton on Thames, England who has built the jig and made the photo available.
[6] From Hemingway Kits Bridgnorth (England) <http://www.hemingwaykits.com/> kits are available for the POTTS Drill grinding attachment; the code number is HK1311.

perpendicular to the first one and responsible for the adjustment of P. For positioning the slide two jaws are provided similar to those found with vernier callipers and the drill is used for setting the diameter D_D; the DECKEL attachment is adapted with a scale. The jaws of the POTTS device are not perpendicular to the Vee but askew to magnify the shift, in the following the scale factor $t = 1.5$ is assumed, one mm drill diameter is equivalent to 1.5 mm slide shift. For the setting position $D_D = 0$ the pivot's axis must meet the elongated Vee's edge exactly at the wheel's face. For sharpening the drill is axially fed by a micrometer screw; the relative setting parameters p and r then are always maintained and not changed. The drill's azimuth τ is zero and set by a guide for the lip at the front end of the Vee.

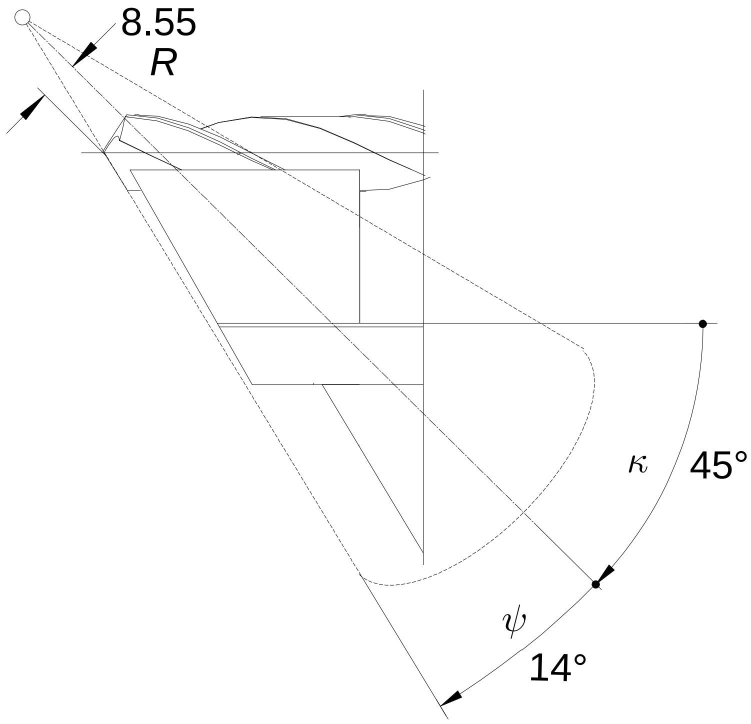


Figure 22: Side view of the jig's front part

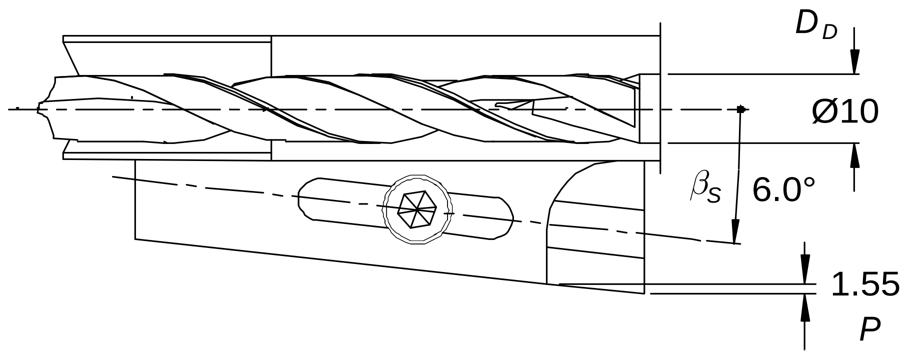


Figure 23: Top view of the jig's front part

In the side view

Figure 22 and the top view Figure 23 all relevant dimensions found for judging this jig. With the drill's diameter $D_D = 10$ mm the setting parameters are:

$$P = 1.55\text{ mm} \qquad p = \frac{2 \cdot P}{D_D} = 0.31$$

$$R = 8.55\text{ mm} \qquad r = \frac{2 \cdot R}{D_D} = 1.71$$

These figures are now introduced into the box {[Input Data]} of the table {Input Output} together with $\kappa = 45$ Deg. and $\tau = 0$. From the relieving characteristics in Figure 24 and the clearance angle function in Figure 25 we see at a glance that a perfect drill can be expected. The performance charts are very similar to that of Figure 9 and Figure 10. The chisel edge angle is $\delta = 70.8$ Deg. and higher than usual.

There are three possibilities to adapt and optimize the design. We can change the slide angle β_S, the scale factor t and the azimuth τ, the last two parameter would be adjustable in any case with any jig. Under these aspects a scale would be somewhat more complicated but more flexible than the calliper jaws.

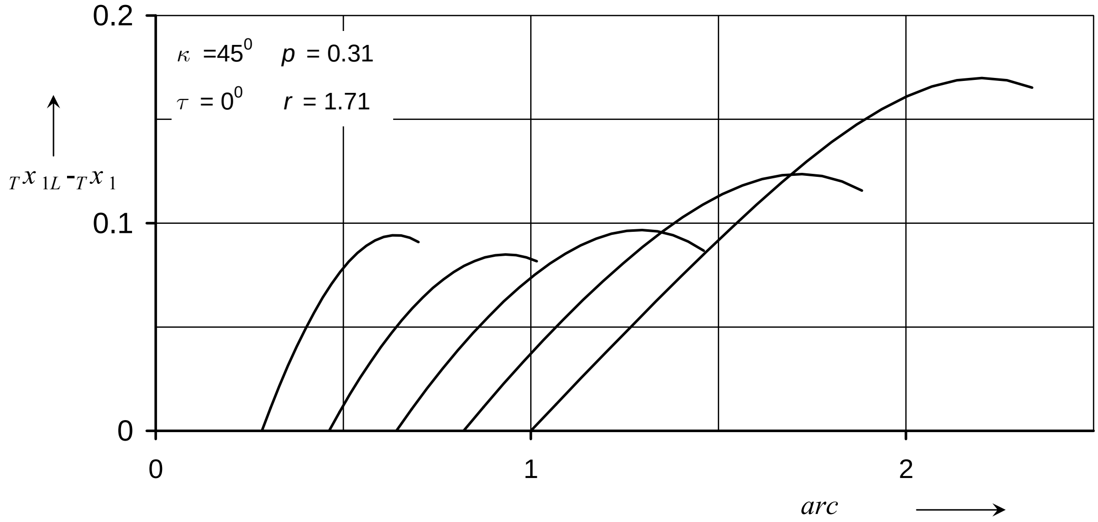


Figure 24: The relieving characteristic of the skew- slide jig

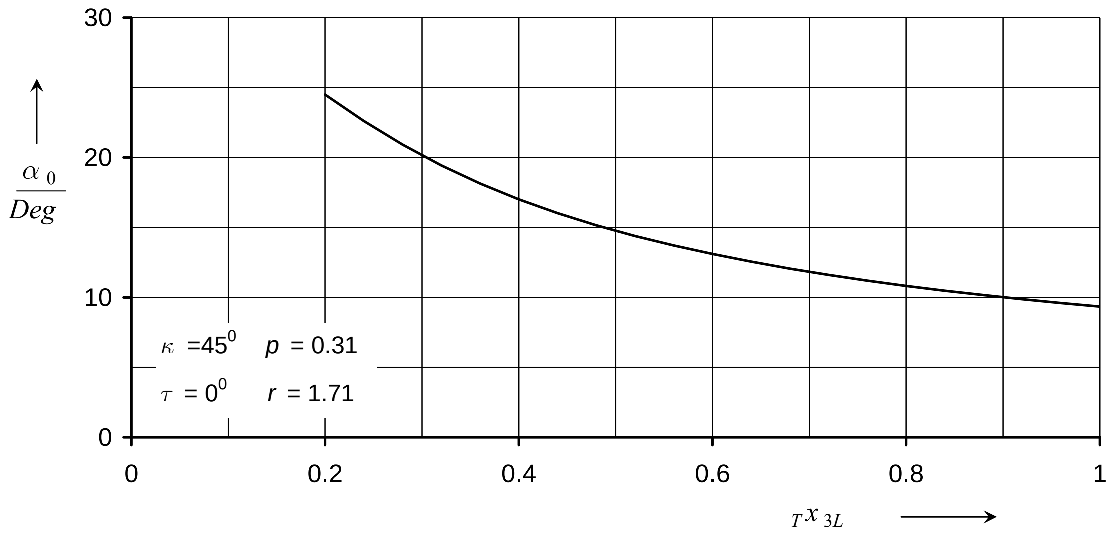


Figure 25: The clearance angle function of the skew-slide jig

The drill is fed to the wheel in axial direction and then for the lip's length corrections the distance X_{AD} must be regarded.

8. Example 3: The Skew-Slide Jig, Part I

9. Example 3: The Skew-Slide Jig, Part II

The skew-slide jig belongs to the drill grinding attachments that are based on sound design principles; this is by no means a matter of course. Within the Vee the drill is turned exactly about its axis. However small drills with diameters less than 3 mm are somewhat difficult to clamp down. The problem is solved with adapter sleeves. This example is used to show how the setting parameters can be found analytically and this knowledge is useful for enthusiasts who want to design individual jigs. These are characterized by the following data:

κ	Angle between the axes of drill and cone	$\kappa = 45$	Deg.
β_S	Angle between slide and drill	$\beta_S = 6$	Deg.
m	Scale factor for the slides movement	$m = 1.5$	
τ	Drill's azimuth	$\tau = 0$	Deg.
α_V	Half Vee angle	$\alpha_V = 45$	Deg.
X_{WV}	Distance between the wheel and the Vee	$X_{WV} \approx 1$	mm

From the drill the parameters necessary to know are:

γ	Half tip angle	$\gamma = 59$	Deg.
D_D	Drill diameter	$D_D = 10.$	mm

The denotations are explained with Figures 22, 23 and 26. The half cone angle is given by:

$$\psi = \gamma - \kappa, \qquad \psi = 14 \text{ Deg.} \qquad (9.1)$$

From Part I we already know that for $D_D = 0$ the elongated edge of the Vee and the pivot's axis must meet each other exactly at the grinding wheel's surface which is X_{WV} distant from the Vee's front face and this figure is independent of the diameter D_D. In the setting procedure with the jaws or a scale the jig is moved back and the Vee's position is not shifted in relation to the wheel. Different possibilities exist to move the jig. Using the base's cross clamp, seen in Figure 21, is not very comfortable. Better would be to mount the jig on a slide. With a spacer or suitable feeler gauges the jig is set to the distance X_{WV} in front of the wheel. However the feed for grinding must be performed only with the adjustment screw at the end of the drill and never with the slide. This screw should bear a scale to be able for feeding the two flanks individually if correction of the lip's length would be necessary.

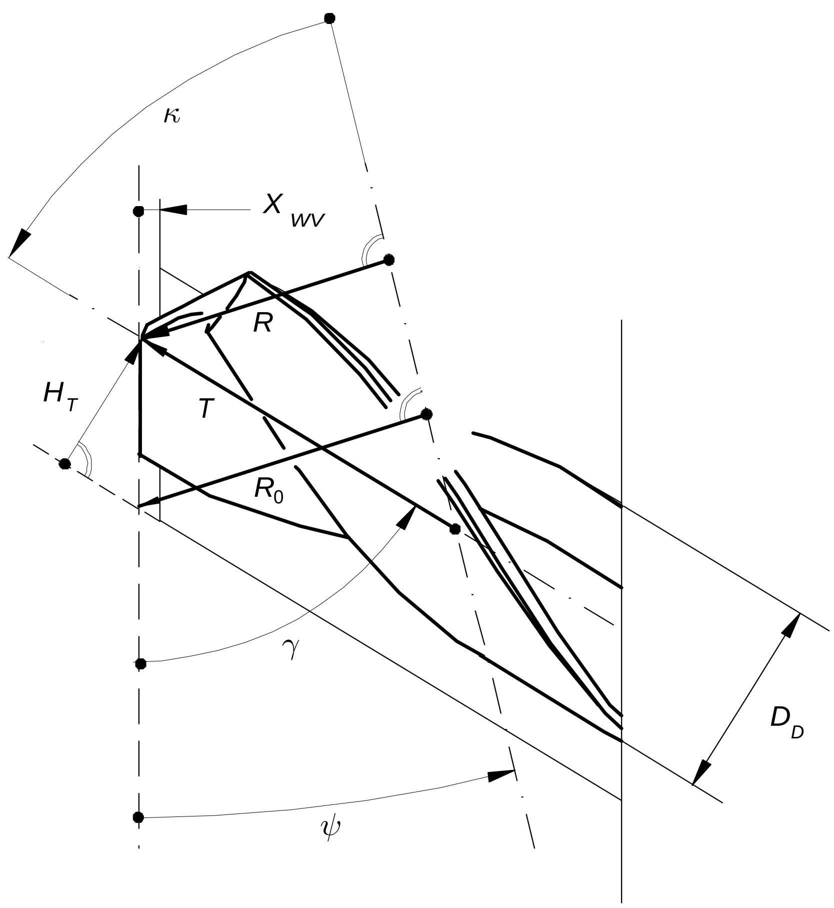


Figure 26: Further denotations for the jig and drill

The slide with the Vee for the diameter adaption in axial direction is shifted the distance:

$$T = t \cdot D_D, \qquad T = 15\,\text{mm}. \tag{9.2}$$

Then the lateral shift, perpendicular to the drill is:

$$P = T \cdot \sin\beta_S = 2 \cdot t \cdot \sin\beta_S \cdot \frac{D_D}{2}, \qquad P = 1.55\,\text{mm}. \tag{9.3}$$

With the jig correctly positioned the radius from the cone's axis to the intersection point of the elongated Vee's edge with the wheel is:

$$R_0 = t \cdot \cos\beta_S \cdot \sin\kappa \cdot D_D, \qquad R_0 = 10.55\,\text{mm}. \tag{9.4}$$

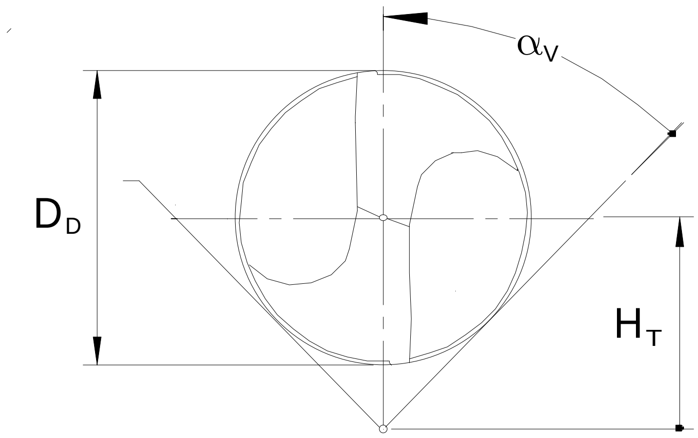


Figure 27: The drill's centre height in a Vee

The drill however is raised in the Vee the height H_T as seen in Figure 27. The view of this figure is perpendicular to the Vee's edge and the drill's axis and we receive:

$$H_T = \frac{D_D}{2 \cdot \sin \alpha_V}, \qquad H_T = 7.07\ \text{mm}. \tag{9.5}$$

The consequence is a radius reduction as seen in Figure 26:

$$R = R_0 - H_T \cdot \frac{\sin \psi}{\sin \gamma}, \qquad R = 8.55\ \text{mm}. \tag{9.6}$$

Equations(9.4) to (9.6) combined give:

$$R = \left(2 \cdot t \cdot \cos \beta_S \cdot \sin \kappa - \frac{\sin \psi}{\sin \alpha_V \cdot \sin \gamma} \right) \cdot \frac{D_D}{2}, \qquad R = 1.71 \cdot \frac{D_D}{2}. \tag{9.7}$$

With this relation and Equation (9.3) the setting parameters, already known from the last chapter are now found analytically:

$$\begin{aligned} p &= \frac{2 \cdot P}{D_D} = 2 \cdot t \cdot \sin \beta_S, & p &= 0.31, \\ r &= \frac{2 \cdot R}{D_D} = 2 \cdot t \cdot \cos \beta_S \cdot \sin \kappa - \frac{\sin \psi}{\sin \alpha_V \cdot \sin \gamma}, & r &= 1.71. \end{aligned} \quad . \tag{9.8}$$

For drills in adapters a correction is necessary for X_{WV}. The parameter P is not influenced by the drill's raised position; the skew-slide must be set for the diameter D_D. But with the larger sleeve diameter D_S the height H_T of the sleeve-drill combination in the Vee is increased and in the usual grinding position the radius R would be much too small. The radius reduction is:

$$R_\Delta = \frac{\sin \psi}{2 \cdot \sin \alpha_V \cdot \sin \gamma} \cdot \left(D_S - D_D \right), \qquad R_\Delta = 0.200 \cdot \left(D_S - D_D \right).. \tag{9.9}$$

Therefore the drill must additionally protrude in axial direction from the Vee:

$$T_\Delta = \frac{R_\Delta}{\sin\kappa}, \qquad T_\Delta = 0.282 \cdot \left(D_S - D_D\right). \tag{9.10}$$

Normally the Vee is X_{WV} distant from the wheel in horizontal direction. The correction that now must be added is:

$$X_{WVcorr} = T_\Delta \cdot \cos\gamma = \frac{R_\Delta \cdot \cos\gamma}{\sin\kappa}, \qquad X_{WVcorr} = 0.145 \cdot \left(D_S - D_D\right).. \tag{9.11}$$

Now the modified distance between wheel and Vee is:

$$X_{WVmod} = X_{WV} + X_{WVcorr}. \tag{9.12}$$

With this correction drills ground with adapters are geometrically similar to those sharpened in the usual way. The distance can be set with suitable spacers or feeler gauges. If the slide has a feed screw with scale on the hand wheel the distance adaption becomes much more comfortable.

10. Example 4: The Poly-Trademark Jig

This jig, seen in Figure 28 is offered since decades under many different trademarks, therefore the name. Constructional data were not available, it is necessary to determine the parameters κ, P and R by measurements. The jig can be adapted to different drill tip angles as seen in the photo. There are notches for five fix angles from 41 Deg. to 88 Deg., with a wing nut the jig is fixed to the lower part with the pivot pin. The familiar half tip angles 45 Deg. and 65 Deg. are not regarded. The jig shall be investigated for $\gamma = 59$ Deg. an for the time being the drill diameter shall be $D_D = 10$ mm.

Figure 28: The jig with the trademark DRAPER

The measurements are very simple with a vertical milling machine, the pivot pin is held perpendicular to the table with a tree jaw chuck. The reference positions for the table's axes are determined with two needles, one in the chuck and the other fixed to the spindle head.

Figure 29: The table's zero position at the chucks centre.

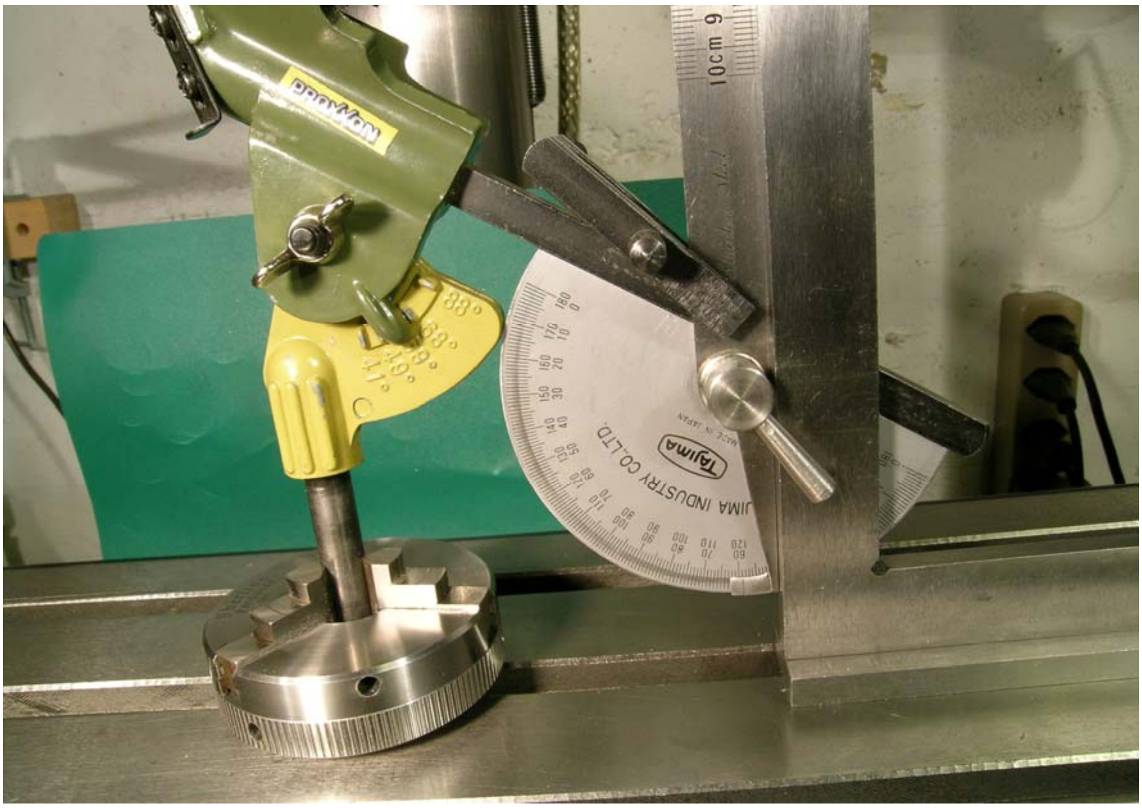


Figure 30: Determination of the angle κ

The pivot pin in the chuck is perpendicular to the table as in the stage. Then the angles $\kappa = \gamma = 59^0$ are given. In Figure 30, this is checked again. Regarding Figures 1 and 2, the basic cone is turned in the clockwise or negative direction and this would give $\kappa = -121\,\text{Deg.}$ which is equivalent to $\kappa = 59\,\text{Deg.}$[7]. The half cone angle ψ is zero; the flanks' surfaces become cylindrical. This case already was mentioned and if the other parameters are right perfect drills can be received. Now the jig must be aligned to the tables X-axis which is parallel to the T-slots. In Figure 31 a try square together with a precision ground angle plate was used. In this position the chuck is firmly closed to fix the jig.

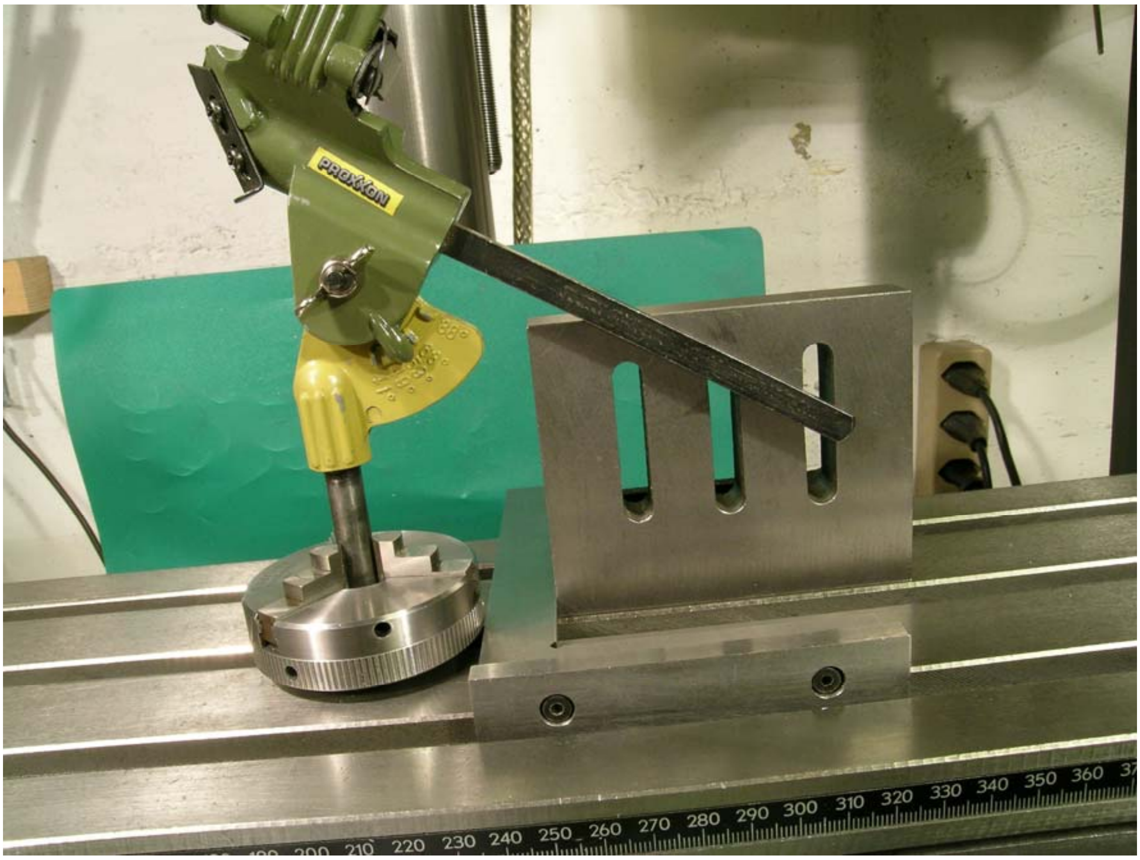


Figure 31: Alignment of the jig to the table's X-axis.

[7] Both angles can be set alternatively in the box {[Input Data]} of the Excel worksheet.

Finally a drill is inserted into the jig and the table is moved that needle of the spindle head meets the drill's tip as seen in Figure 32. The table's coordinates are the absolute setting parameters, it is $X = R$ and $Y = P$.

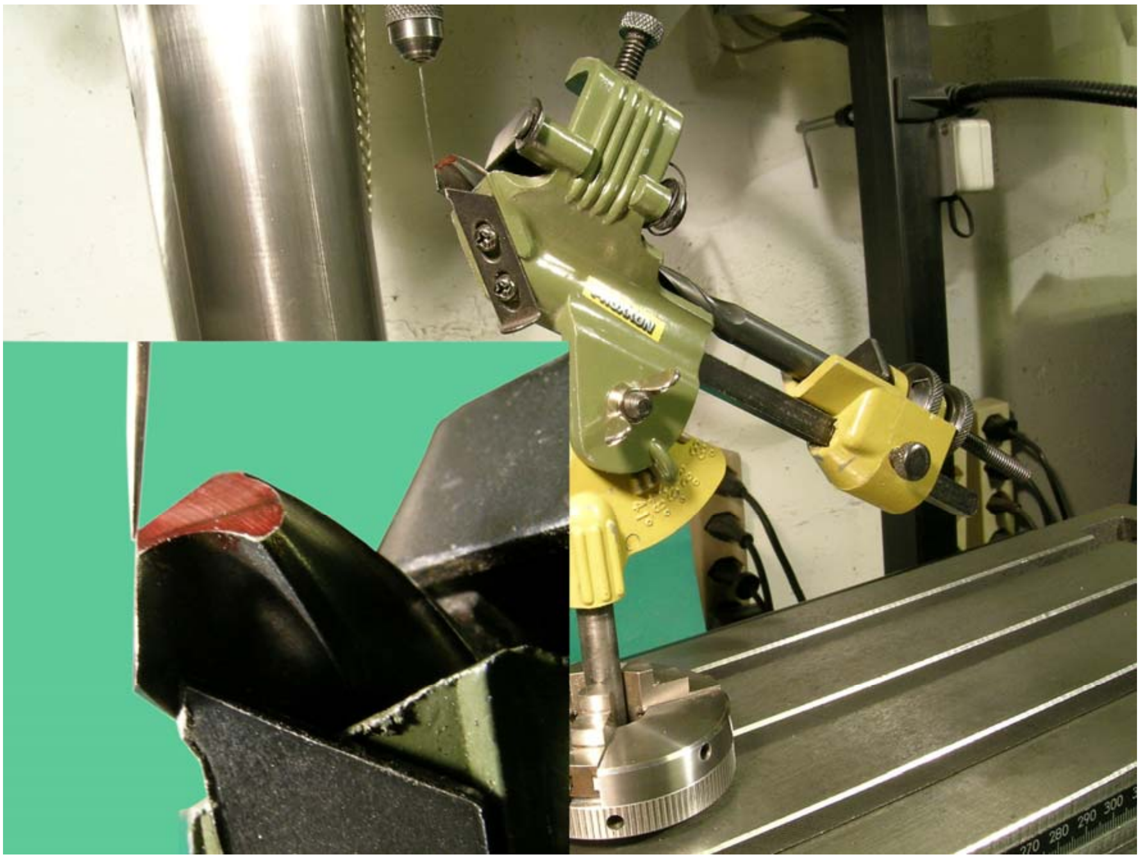


Figure 32: Measuring the drill tip's position

With the drill diameter $D_D = 10$ mm the distances $P = 4.4$ mm and $R = 24.2$ mm were found. The relative parameters then are:

$$p = \frac{2 \cdot P}{D_D} = 0.88 \qquad r = \frac{2 \cdot R}{D_D} = 4.84$$

The drill's azimuth is determined by a gauge plate identical to that of the Potts jig Example 3, as for the skew slide jig it is $\tau = 0$.

The setting parameters depend on the drill's diameter; this is a serious disadvantage as we already have seen with the V-Clamp jig in Example 2. Also the angle $\tau = 0$ is not the optimum value. The distance parameters p and r are seen in Figure 33 as functions of the drill diameter D_D. The judgement of the relieving characteristics and clearance angle functions is left to the reader; only he can decide if his Poly-Trademark jig generates drill tips he would like to have in his workshop.

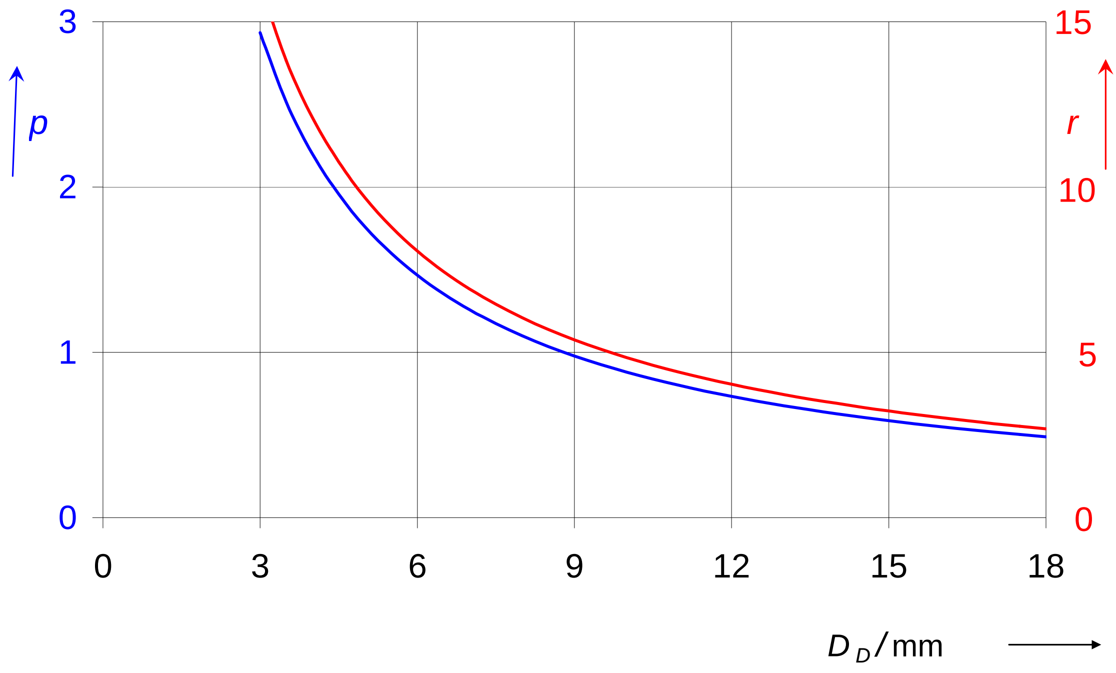


Figure 33: The parameters p and r as functions of D_D