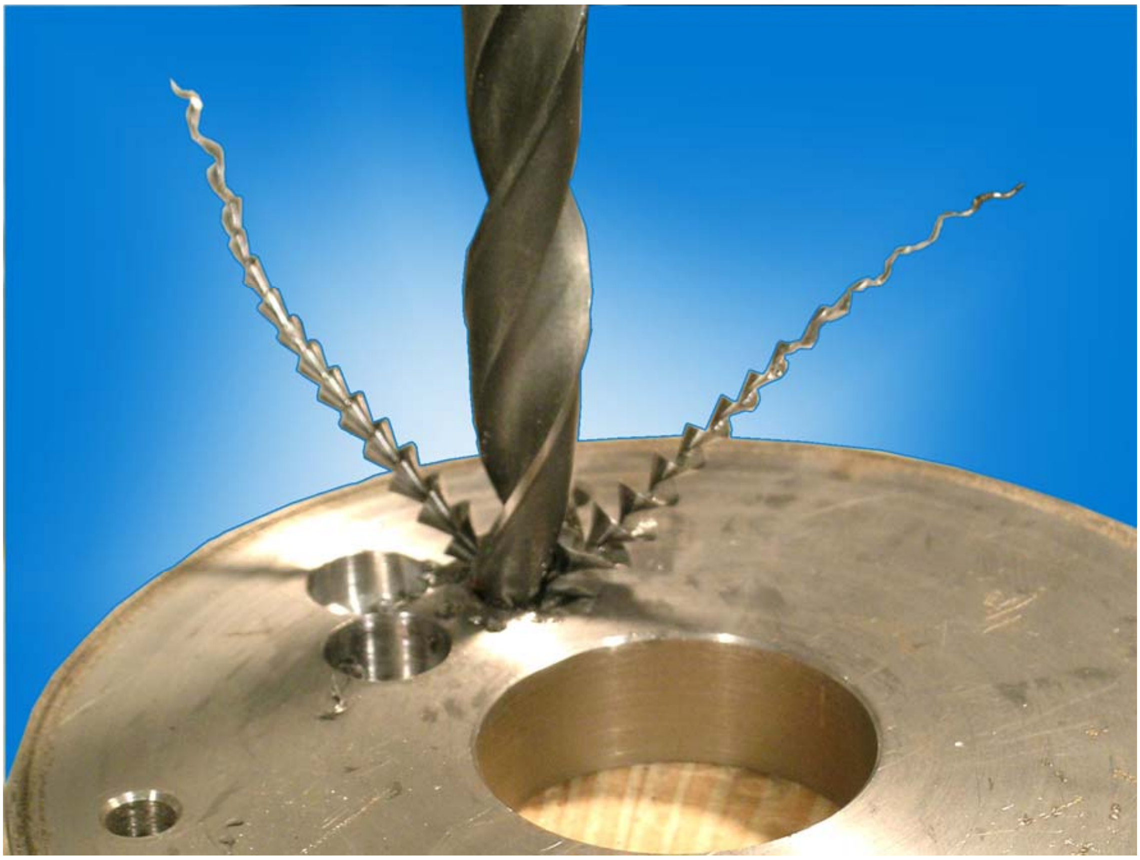
J. Hugel

Instructions

for using the EXCEL tables:

<DrillPerformance.XLS>



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<DrillPerformance.XLS>

With 34 Figures

Contents:

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EN-C 07

1. General Remarks

Formelabschnitt (nächster)

The EXCEL tables <DrillPerformance.XLS> are a useful tool to investigate drill grinding devices and jigs for conically or cylindrically shaped flanks. The application of the worksheet is very simple and no special knowledge of mathematics or computer programming is required. However it is necessary to know the jigs geometrical features which in any case can be described by four figures. 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 the boxes with green frames and a bluish green background. The cell to be altered is selected by a mouse click and then can be overwritten with the new data. 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 boxes concerned. The data are transferred into the {Table for Graphs} and in this worksheet 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 can be saved in the usual way to the hard disk of the PC or another suitable storage medium. The input data to judge a specific drill grinding device must be derived from its geometrical and kinematical properties. The data are received from the indicated dimensions in 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 standards dimensions and tolerances are found, also core diameters, tip and helix angles, back rakes and some other data. But a more detailed information on the tip geometry is not provided; even if this sometimes is suggested by manufacturers of drill grinding equipment. The flanks usually are small sections from the envelope of a cone.[1] In DIN 1412 several special shapes for the tip are described. Another important standard for drills, clarifying the terminology, is ISO 5419.. The tolerance of the drill's diameter normally is h8, the drilled holes shall be within H10 for drill diameters $D_D \leq 10$ mm and H9 for $10 < D_D < 30$ mm. This means up to the diameter $D_D = 30$ mm an oversize of 0.05 mm but no undersize for the drilled hole is allowed. As already said no data for clearance angles and the flank's relieving characteristics are found in the standards, these data however are crucial for the drill's performance. The reason is that for best drilling results these data depend on the material to be drilled and to some extent on the features of the drilling equipment. In commercial applications the production under optimum conditions is a must and the production engineer is responsible for the selection of the drills with the suitable parameters.

For cutting edges the back rake is also important, this is given by the pitch of the flutes. For special applications commercially available are drills with different values for the pitch.

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

2. The Parameters of Drill and Cone

Formelabschnitt (nächster)

The grinding jig shall give the drill's flanks 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 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 ${}_TX_2$ is the coordinate *X* in the second direction of the *T*-system.

The axis of the basic cone is the ${}_A1$-axis; the tip shows into the positive direction. This is the green cone in Figure 1. The two halves of the cone, separated by the ${}_A1 - {}_A2$-plane are distinguished by the cone parameter, it is $e_C = 1$ for the upper and $e_C = -1$ for the lower part. The basic cone is rotated an angle κ about the ${}_A2$-axis which is perpendicular to the plane of projection. The angle κ is a fix or, very seldom, an adjustable parameter of the drill grinding equipment.

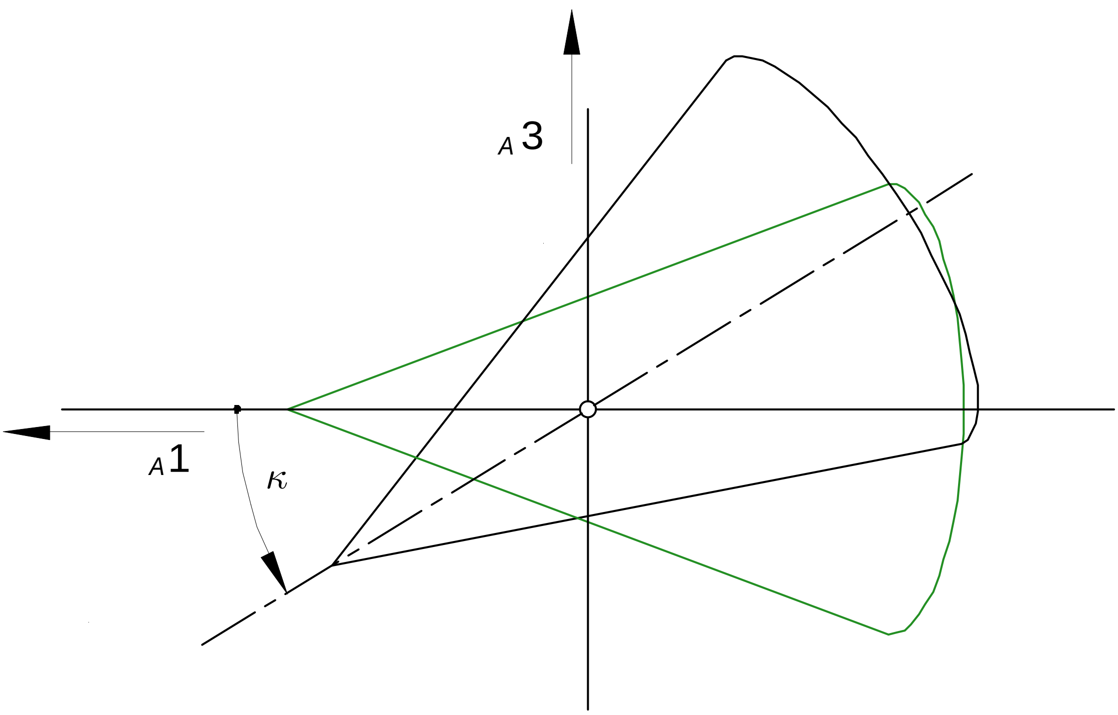


Figure 1: The basic cone in the *C*-system

For the time being the 1-axis of the *T*-system, the axis of the drill, is coincident with the ${}_A1$-axis and the lips are parallel to the ${}_T1$-${}_T3$-plane; the drill's tip meets the origin. The *A*- and *T*-system are parallel but displaced in the 1-direction. In the following it is always assumed that the cone and the upper lip are in contact. 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 is rotated the azimuth τ about the 1-axis and this situation is seen in Figure 2. In the drawing the drills lip that actually is ground is on the side of the cone's tip 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; by both also the half cone angle ψ is determined. A special case is $\psi = 0$, then lip's shape becomes cylindrically. Machines for cylindrically shaped flanks successfully were designed and built.

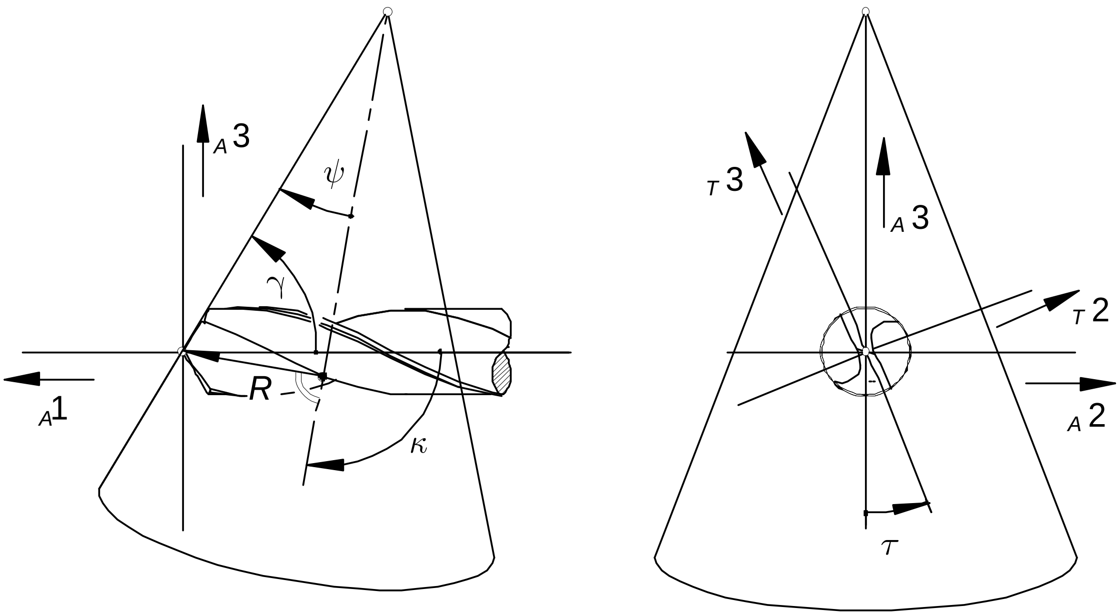
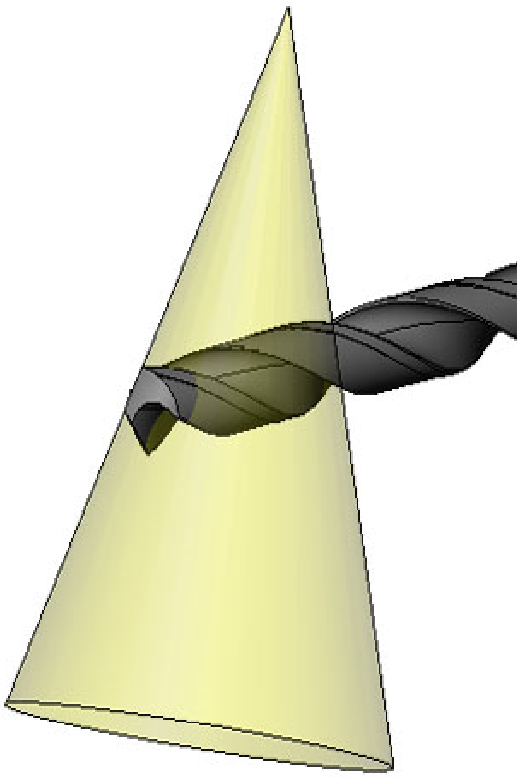


Figure 2: Drill and cone in the same plane



The cone's tip angle should be in the range $0 \le \psi \le \psi_{\max}$ with $\psi_{\max} \approx 36^0$ 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 drill's axis is inclined towards the cone's tip; $e_C = -1, \kappa < 0$

Therefore also the drill's front faces must not be located too far distant from the axis of the cone, the radius R is limited. If this rule is violated by the special particularities of the jig's design no perfectly restored drill tips can be expected. Regrettably there are jigs on the market with R much too high.

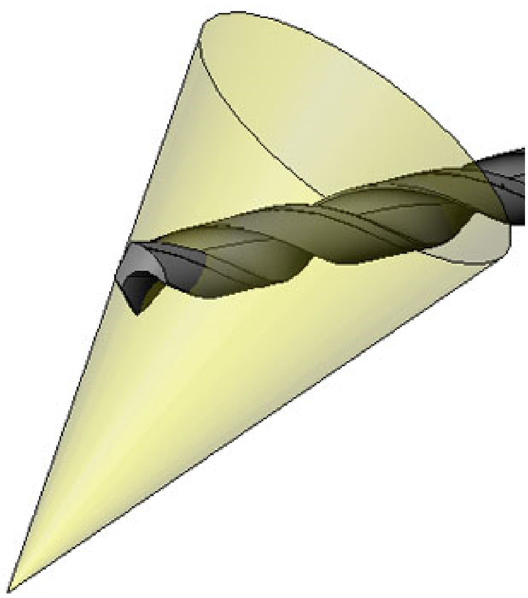
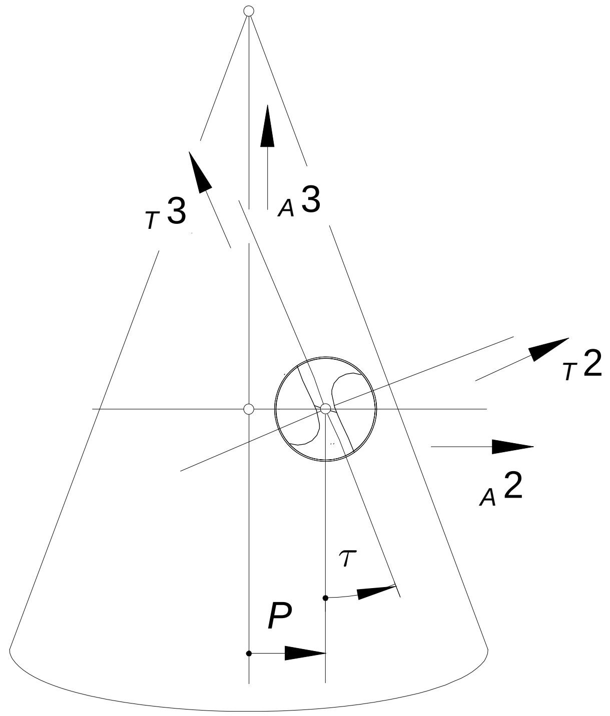


Figure 4: The drill's axis is inclined opposite to the cone's tip; $e_C = 1, \kappa > 0$



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 for 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 is ${}_T x_{2L} = -0,2$ in box {[R5C4]} of the {Input Output} table.

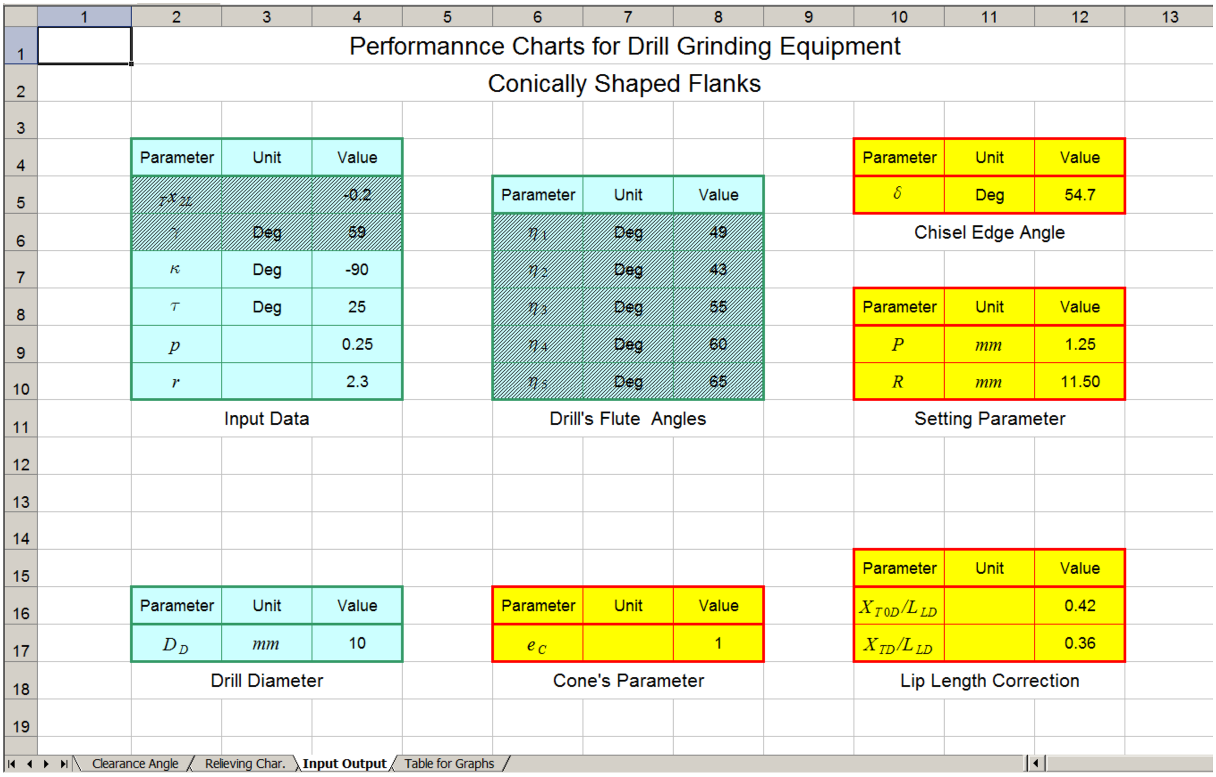
A good drill grinding jig should allow to set P and R individually or at least the ratio P/R; with constant values for p and r the tips become geometrically similar for different diameters D_D. Then the ratio $P/R = p/r$ also is a constant; jigs based on this principle can be adapted to the diameter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

As already said to investigate a jig with the worksheets the setting parameters must be evaluated from the kinematical and geometrical properties. Different methods are possible and these are discussed later in general and with examples.

3. The Input and Output Data

Formelabschnitt (nächster)

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



Performannce Charts for Drill Grinding Equipment

Conically Shaped Flanks

Parameter	Unit	Value
${}_T x_{2L}$		-0.2
γ	Deg	59
κ	Deg	-90
τ	Deg	25
p		0.25
r		2.3

Input Data

Parameter	Unit	Value
η_1	Deg	49
η_2	Deg	43
η_3	Deg	55
η_4	Deg	60
η_5	Deg	65

Drill's Flute Angles

Parameter	Unit	Value
δ	Deg	54.7

Chisel Edge Angle

Parameter	Unit	Value
P	mm	1.25
R	mm	11.50

Setting Parameter

Parameter	Unit	Value
D_D	mm	10

Drill Diameter

Parameter	Unit	Value
e_C		1

Cone's Parameter

Parameter	Unit	Value
X_{T0D}/L_{LD}		0.42
X_{TD}/L_{LD}		0.36

Lip Length Correction

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 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 this must be altered. All calculations in the background are performed with related distance parameters in the {Table for Graphs}.

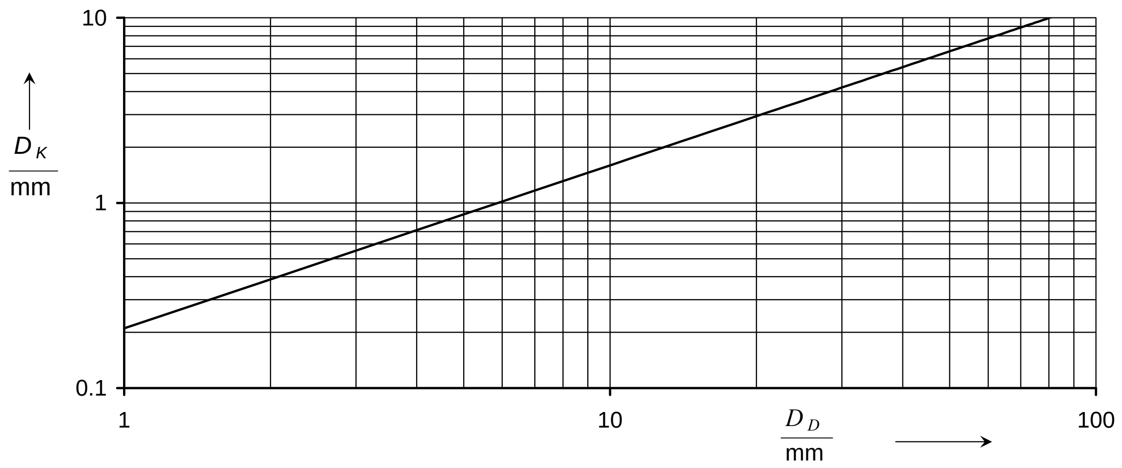


Figure 7: The core diameter from DIN 1414-1

For setting the equipment however the absolute values P and R may be necessary, these are evaluated with D_D from box [R17/C4] and then displayed in the yellow box {[Setting Parameter]}. In [R5/C12] the {[Chisel Edge Angle]}is found. According to Figure 9 this is measured from the $_T3$-axis. 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 reliable indicator for the drill's performance. The chisel edge angle depends on the clearance angle at the core. For the cutting performance of the drill the clearance angle near the periphery is important, this angle grows towards the core. One can ground drills with a negative clearance angle at the periphery, these will not cut but rub. Nevertheless the clearance angle near the core may have the right value for $\delta = 55\,\text{Deg}$.

The {[Cone's Parameter]} shows the inclination of the drill's axis in relation to the cone. For $e_C = -1, \kappa < 0$ the drill's front faces show towards the tip (Figure 3) and into the opposite direction for $e_C = 1, \kappa > 0$ (Figure 4). As already mentioned the upper flank of the drill must be in contact with the cone. If for the cone's inclination angle κ an unsuitable value is provided, the error message "Wrong kappa" would be displayed instead of $e_C = \pm 1$.

A very important condition for correctly ground drills are equal lengths of the lips. Quality grinding equipment guarantees this automatically as long as the drills are straight. If the drill is concentrically held in the fixture and this is easily checked with a DTI (lever gauge), a symmetrical grinding result can be expected. Critical are collets with three lips; with these it is very difficult to hold concentrically normal drills with two lips and two flutes. The length's difference L_{LD} must not exceed 0.05 mm in the diameter range $D_D \approx 3 \cdots 13$ mm.[2] Drills with cutting edges of different length produce oversized holes and it makes not much sense to have drills ready available in a 0.1 mm diameter gradation which generate holes several times larger than this step.

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 vetting the lips' lengths 10-x-magnifiers with an aplanatic lens system and a 0.1 mm scale, 10 or 15 mm long, are recommended for $D_D > 2$ mm. Scales on a rule are better than on glass plates. For the smaller drills with $D_D < 2$ mm measuring microscopes with a x25 magnification and 20 tick marks per mm should be used. In any case very convenient are CCD-cameras; the distances on the pictures can be measured with an electronically overlaid scale. The edges on the drill are not always have the wanted sharpness and then also with excellent measuring devices it becomes practically very difficult to receive the afore-mentioned accuracies. Finally only the diameter measurement of a drilled hole answers to the question if the drill's point was correctly resharpened.

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[2] For the DAREX SP2500 Ultra Precision Drill Sharpener 0.025 *mm* are specified

For reasonable length differences a correction is possible by feeding the flank with the shorter lip closer to the wheel in the final grinding pass. Two cases must be distinguished. If the drill is fed together with the grinding apparatus, perpendicular to the plane of the wheel, the additional distance is X_{TD}. If however only the drill is moved along its axis and the jig remains stationary X_{T0D} would be the correct distance. Both values are calculated from the lips' length difference L_{LD} and available in the box {[Lip Length Correction]}. This grinding method to a defined target is performed fast and works very reliable. Vetting and correcting lip length differences is impossible with drill grinding jigs that do not offer the possibility to feed both flanks individually and exactly with a scale.

4. Relieving Characteristics and Clearance Angle Function

Formelabschnitt (nächster)

A drill shall be mounted on a rotary table as seen in Figure 8, then the height of any point of the flanks can be measured with a DTI. If the drill is turned the tip of the DTI moves on a circular path. We expect that the highest point is at the cutting edge. With such a setup we can record how the flanks are backed off behind the lip; the deepest point should be at the end of the path, at the second flute opposite to the flute at the cutting edge.

Figure 8: Measuring the relieving characteristics

For different radial distances of the contact point, measured from the drill's axis a series of different profile curves are received. Based on this principle 100 years ago GEORG SCHLESINGER has evaluated drill grinding machines experimentally and he coined the term "Relieving Characteristics". In Figure 8 we have $D_D = 45\,\mathrm{mm}$. But for smaller diameters, say $D_D < 10\,\mathrm{mm}$, it would be difficult to perform those measurements. If however the design data of the grinding equipment are available the relieving characteristics reliably are found by calculations.

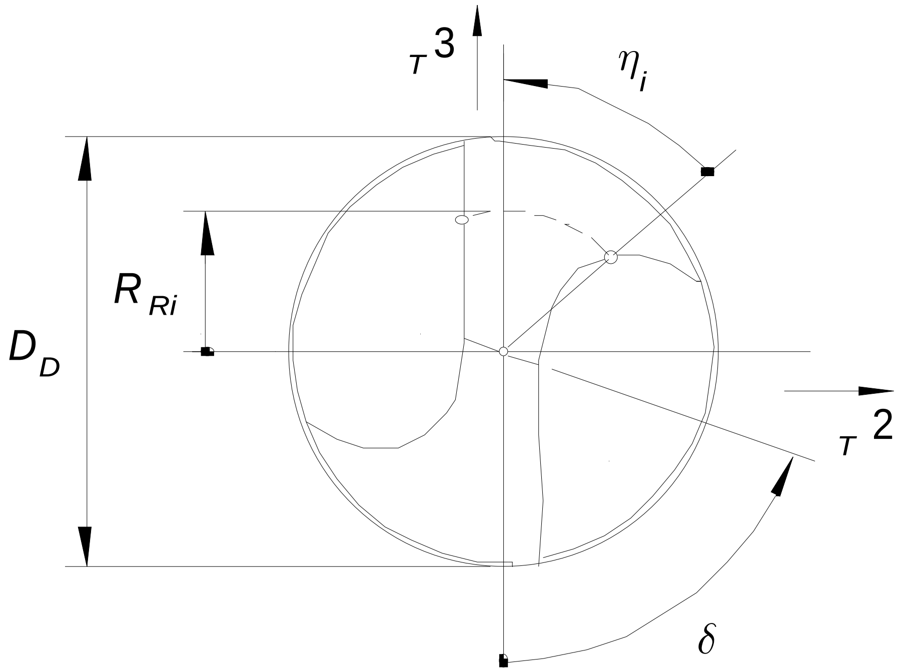

Figure 9: The path parameter R_{Ri} and η_i

With five paths, one is seen in Figure 9, a good overview is received. With some experience the performance of the drill that can be expected is seen at a glance. 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 height differences to the cutting edge are related to $R_D = D_D / 2$ as all other distance parameters.

The abscissa <*arc*> of the relieving characteristics is the angle in radians. For clearness in Figure 10 the different curves are shifted horizontally the amount $r_{Ri} = R_{Ri} / R_D$; the peripheral graph with the abscissa $r_{Ri} = 1$ ends at the flank's heel.

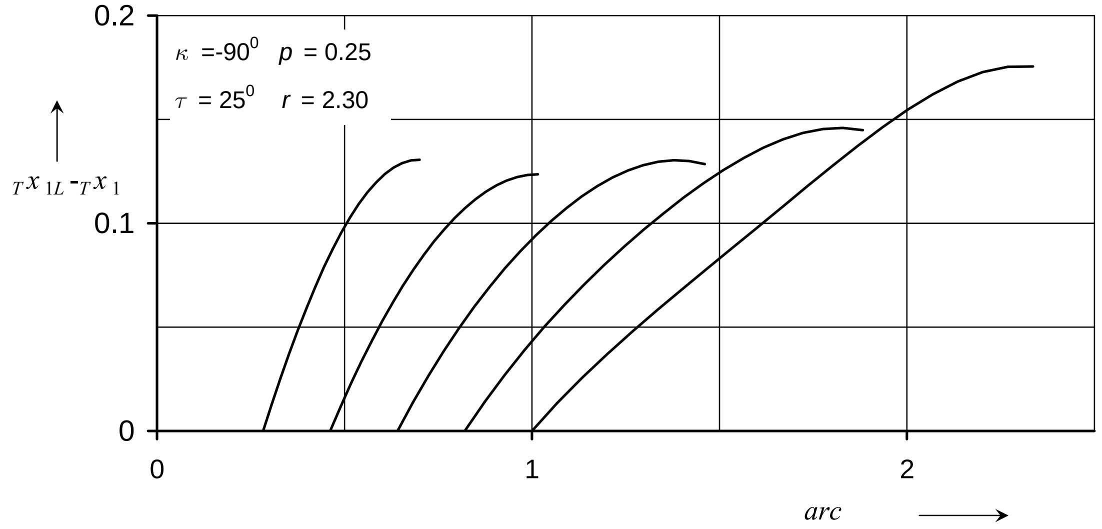

Figure 10: The relieving characteristics

The relieving characteristics contain in principle the complete information for evaluating a drill's performance. The clearance angles at the cutting edge are the curves' inclination angles at the starting point. But these are not the angles we see in Figure 10, the scales on both axes are different and the extraction of the correct angles from the figure would be very cumbersome.. For convenience the clearance angle function along the cutting edge is made available in a separate diagram; the clearance angle function to the relieving characteristics Figure 10 is shown in Figure 11.

The abscissa is the radial distance of the paths from the drill's axis, related to R_D. The clearance angle grows from the periphery to the web and this feature is very welcome. Regarded here up to now is the geometrical clearance angle. Under drilling conditions this angle is reduced by the feed speed, the reduction 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.

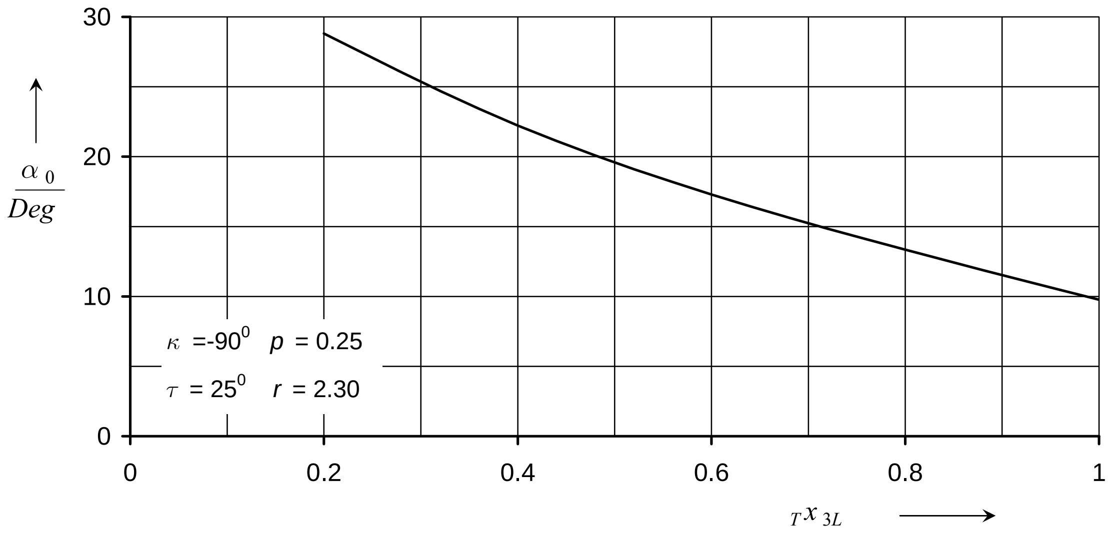

Figure 11: The clearance angle function

The scales of the charts are adapted by opening the diagram and then clicking the axis of the scale. With the pull down menu “Format-> xx->xx” the numerical values can be changed.

Both diagrams shown in Figure 10 and Figure 11 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 with manual feed. Dependent on materials and drilling machines additional points of view may come up which could have an influence on the individual drill parameters and the related diagrams.

5. Jig Analysis

Formelabschnitt (nächster)

The jig analysis is the first step to be able to use the EXCEL worksheet 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 for τ is based on the design drawings. With a 3D CAD-model the dimensions directly can be measured but it is also not difficult to find the data with conventional drawings. But drawings are not always available, then an analytical investigation or experimental methods and measurements must be taken into consideration.

The basic figure is the drill diameter D_D. The first task is to locate the cone's axis and determine the inclination angle κ. For the standard drill with $\gamma = 59$ Deg the range of κ for $e_C = 1$ is $23\,\text{Deg} \leq \kappa \leq 59\,\text{Deg}$; for $e_C = -1$ the limits are $121\,\text{Deg} \leq \kappa \leq 85\,\text{Deg}$. The sign of κ is important. In the next step the radius R must be evaluated, this is the distance between the drill's tip and the cone's axis. Then the radius parameter r can be calculated. 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. Now also its related value p is known.

If the related parameters p and r are constant and independent from D_D the tips of all drills become geometrically similar and the diagrams are valid for all sizes. Not all jigs have this feature. Then p and r depend on D_D and to receive an overview the jig must be investigated for a couple of different diameters. Now and not too seldom it can be observed that p and r depend more on D_D than wanted. Finally the angle τ must be found. Sometimes τ is determined by a stop but in principle this angle is selectable without restrictions. 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 drill tips as wanted simply cannot be ground and in principle the jig is useless. This can happen even with grinding equipment that was not really cheap. However if two charts are found similar to Figures 8 and 9 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 sometimes it is stated in the instructions 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 sharpener shall be regarded that could be called "fuzzy jigs". These are located between freehand grinding and the usual designs 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. Its bewildering that such a highly respected company produces and sells such a really poor device. There are enough perfect designs available that can resharpen fast, reliably and authentically any twist drill.

6. Example 1: Drill Grinding with the QUORN

Formelabschnitt (nächster)

The QUORN tool and cutter grinder was designed about 1970 by Prof. D.H. CHADDOCK. The apparatus is not ready available on the market, only the castings are offered for building the machine individually. To the drawings of Prof. CHADDOCK meanwhile many thousands were produced worldwide. He himself didn't recognize the possibility to sharpen drills with conically shaped flanks. With the very flexible adjustment features nearly all possible conical drill tips can be ground and practically any jig for conically or cylindrically shaped flanks 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 12: Setting the QUORN's tilting bracket

To grind drills with 118 Deg. tip angle the work head is set with the tilting bracket to $\psi = 31\,\text{Deg.}$, the setting is seen in Figure 12.

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 SM&EE 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.

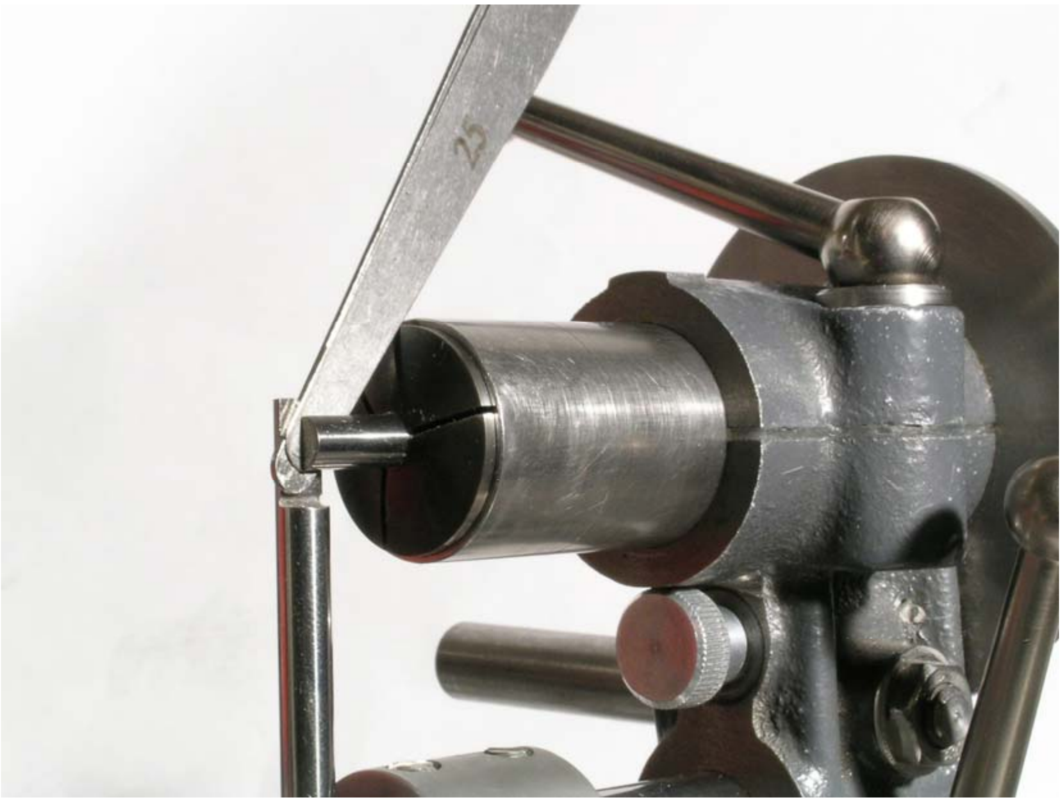

Figure 13: Setting the axes distance *P*

In the first step, Figure 13, the distance P between the axes of cone and drill is set. Then according to Figure 14 the radius *R* is adjusted. In step 3, Figure 15, the drill is aligned to $\tau = 0$.

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

Figure 14: Setting drill tips distance R from the cone's axis

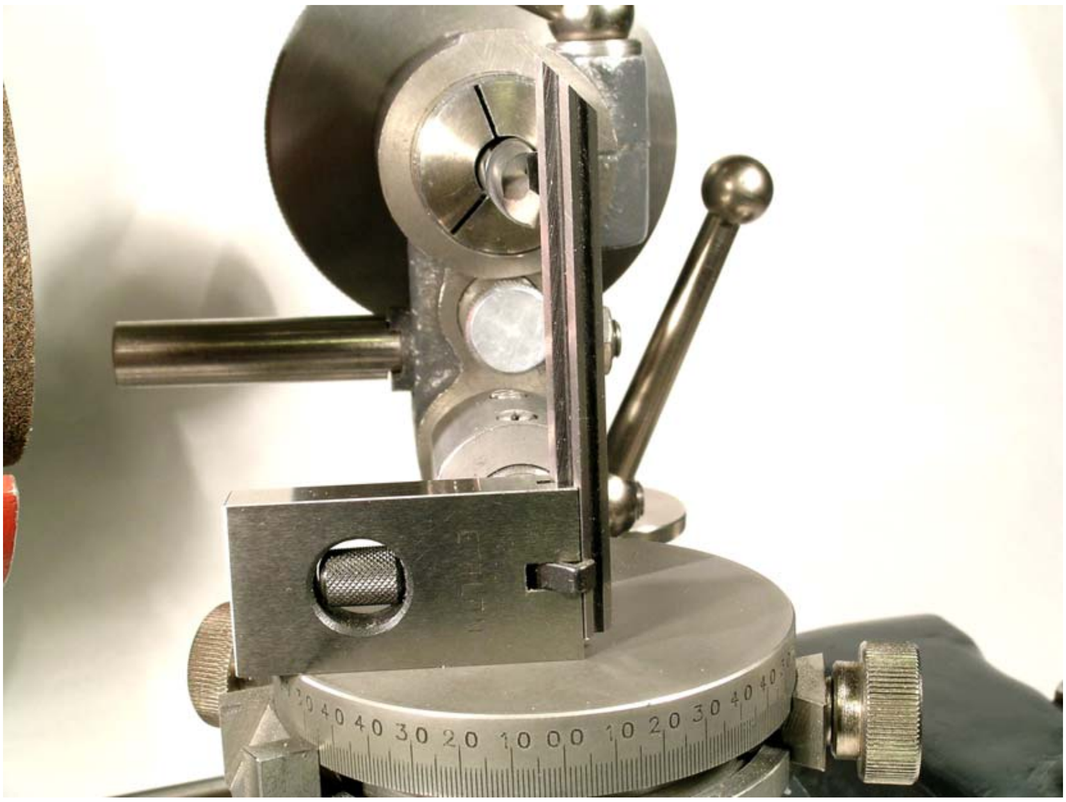

Figure 15: Aligning the drill's azimuth $\tau = 0$

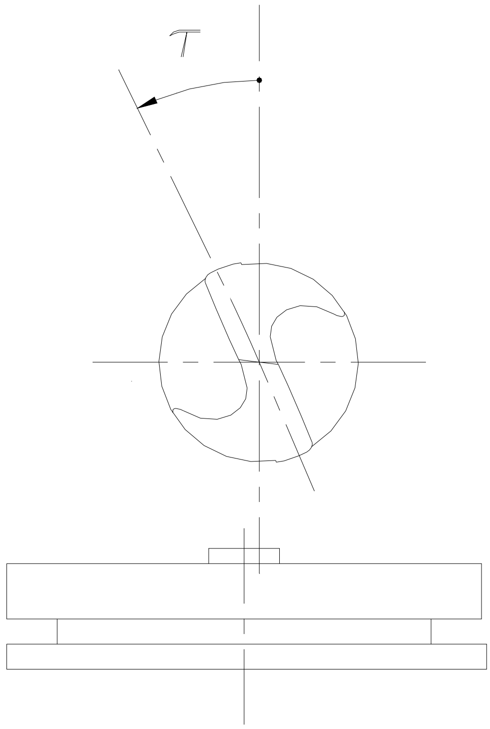

Figure 16: Setting the drill's azimuth τ

Then as seen in Figure 16 the azimuth τ is set. With these adjustments the front faces are ground to identical positions. Steps five and six are measuring the lips' lengths and in case a correction must be performed. The shorter lip is fed X_{TD} closer to the wheel than the longer.

With the QUORN exactly the drills that are characterized by the diagrams Figure 10 and Figure 11 can be ground. The possibility to simulate other drill jigs that generate conical or cylindrical flanks was already mentioned. So special designs can be checked experimentally in advance.

7. Example 2: The V-Clamp Jig

Formelabschnitt (nächster)

In Figure 17 a very simple drill grinding jig is seen and many similar designs are commercially available. The tool is held accurately and securely in a clamp between two V-shaped jaws. At the front two bushings are provided, one for each flank, to be set on a 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: A simple drill grinding jig

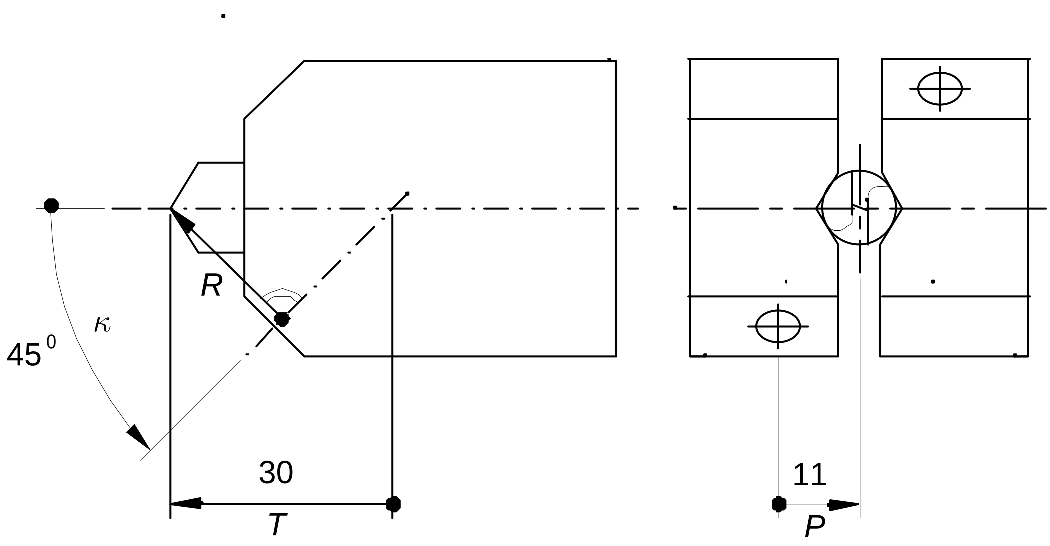

Figure 18: The jig's dimensions

The jigs dimensions with a 10 mm drill are shown in Figure 18 and based on this drawings 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 19 for three different azimuths τ.

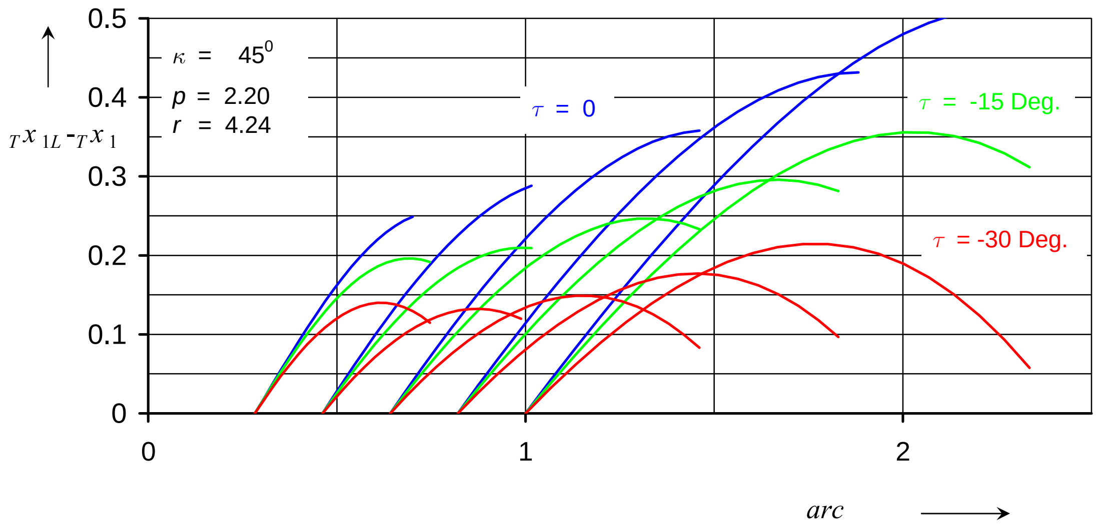

Figure 19: The relieving characteristics of the V-clamp jig

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 20 it becomes clear that no azimuth τ exists that would be really satisfying.

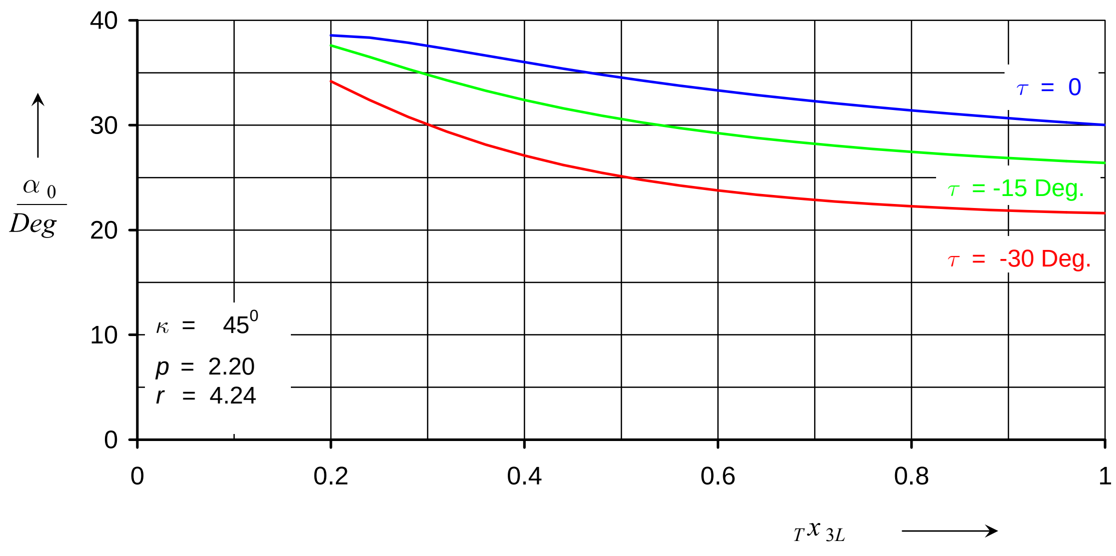

Figure 20: The clearance angle function of the V-clamp jig

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.

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

Formelabschnitt (nächster)

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 21, it belongs to a grinder for engraving tools.

Figure 21: 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 screw slide principle and seen in Figure 22 [5,6].

Figure 22: The POTTS drill grinding attachment

The pivot to swing the drill is mounted on a stage and inclined $\psi = 14$ Deg. 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 rests in a "vee", an angled bar with $\alpha_v = 90^0$; which is combined with the slide and this can be moved $\beta_S = 6^0$ askew to the drill's axis. With a clamp, not shown in Figure 22, the drill is fixed

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[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.

securely to the vee. The slide's movement has two components, one in the drills direction to adapt the radius *R*; the second component is 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 equipped 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 $t_s = 1{,}5$ 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.

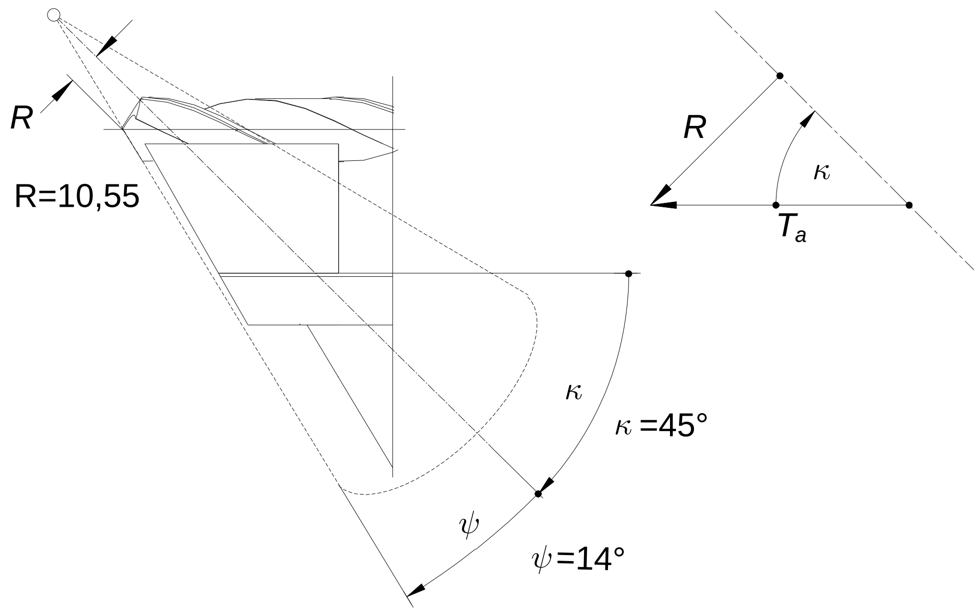

Figure 23: Side view of the jig's front part

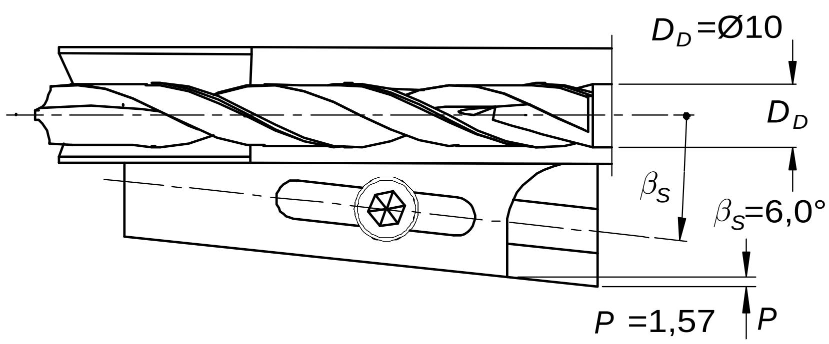

Figure 24: Top view of the jig's front part

From the drawings in Figure 23 the side view and in Figure 24 the top view is seen with all dimensions relevant for judging this jig. The slides position is $T_s = t_s \cdot D_D$, then for the axial and radial shift of the drill we receive

$$T_a = T_s \cdot \cos \beta_S \qquad R = T_a \cdot \sin \kappa \qquad P = T_s \cdot \sin \beta_S \tag{8.1}$$

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With the drill's diameter $D_D = 10$ mm the setting parameters are:

$$\begin{aligned} P &= 1{,}57 \text{ mm} \qquad & p &= \frac{2 \cdot P}{D_D} = 0{,}31 \\ R &= 10{,}55 \text{ mm} \qquad & r &= \frac{2 \cdot R}{D_D} = 2{,}11 \end{aligned} \tag{8.2}$$

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.

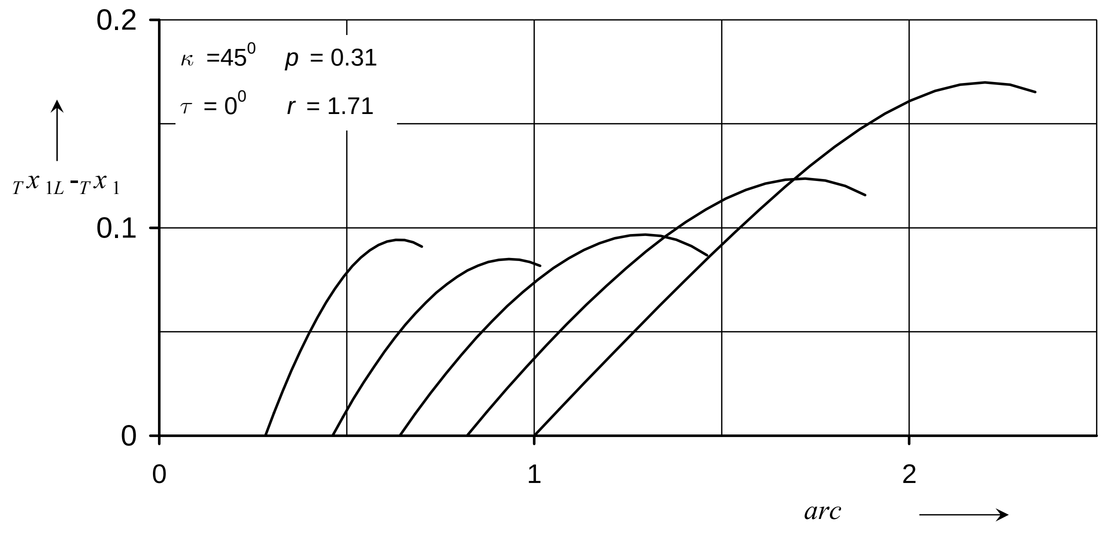


Figure 25: The relieving characteristic of the skew- slide jig

These figures are now introduced into the box {[Input Data]} of the worksheet {Table for Settings} together with $\kappa = 45$ Deg. and $\tau = 0$. From the relieving characteristics in Figure 25 and the clearance angle function in Figure 26 we see at a glance that a perfect drill can be expected. The performance charts are very similar to that of Figure 10 and Figure 11. The chisel edge angle is $\delta = 70.8$ Deg. and higher than usual.

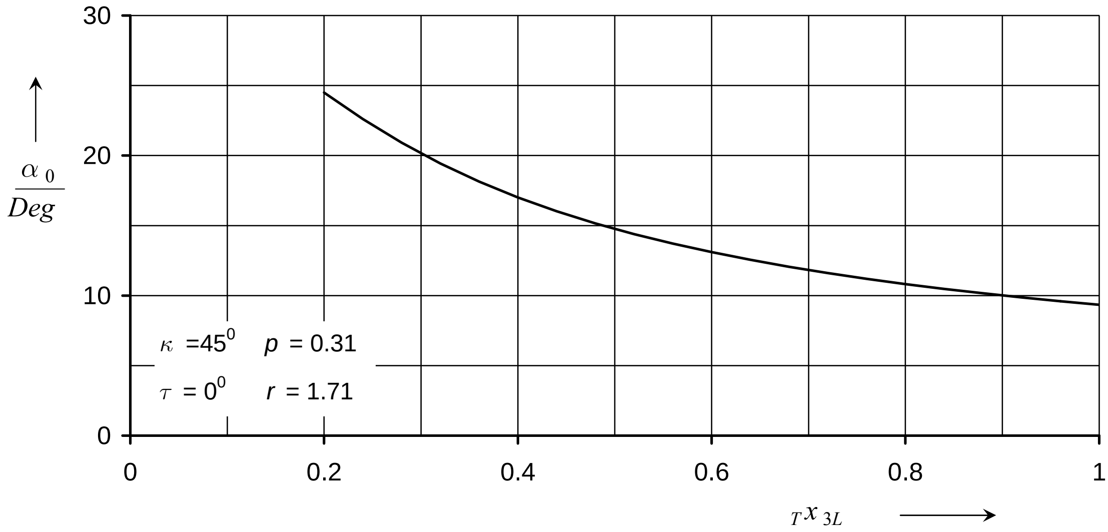


Figure 26: The clearance angle function of the skew-slide jig

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 also with the device completed. Under this aspect a scale would be more flexible than the calliper jaws.

The drill is fed to the wheel in axial direction and then for the lip's length corrections the distance X_{T0D} must be regarded.

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

Formelabschnitt (nächster)

The skew-slide jig belongs to the drill grinding attachments that are based on sound design principles; this is not a matter of course. Also with the vee the drill is turned exactly about its axis. However small drills with diameters less than $3\,\text{mm}$ are 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 27. The half cone angle is given by

$$\psi = \gamma - \kappa \qquad \psi = 14\text{ Deg.} \tag{9.1}$$

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 22, 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 a correction of the lip's length would be necessary.

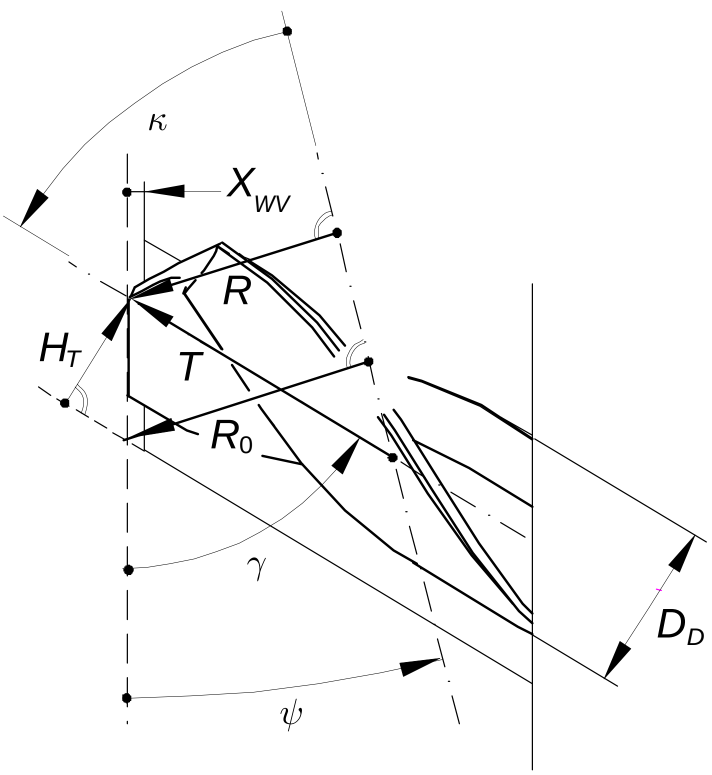


Figure 27: Further denotations for the jig and drill

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

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

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

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

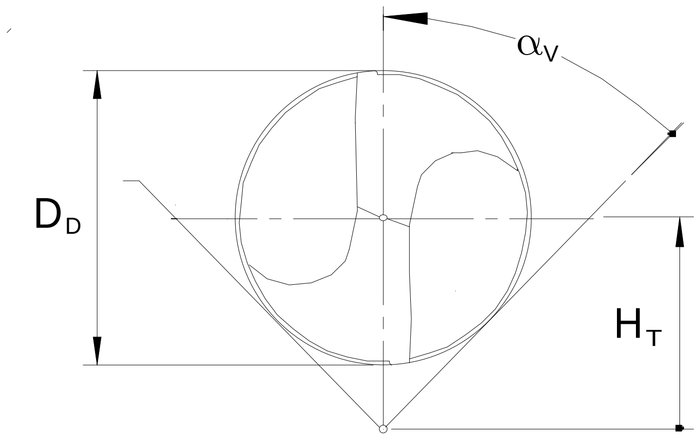


Figure 28: The drill's centre height in a vee

The drill however is raised in the vee the height H_T as seen in Figure 28. 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 27

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

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:

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

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

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

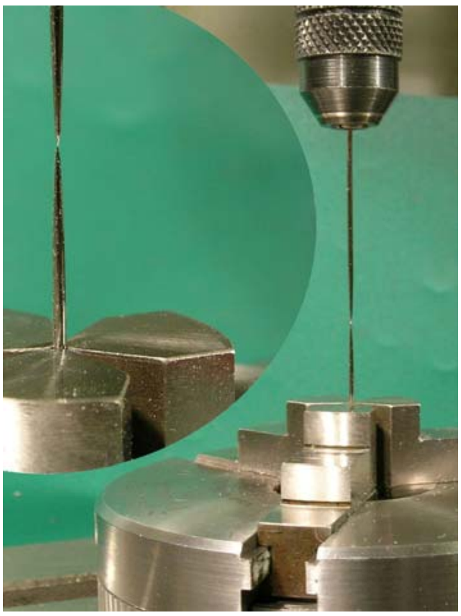
With this correction drills ground with adapters are geometrically similar to those sharpened in the usual way. The distance can be set with suitable spacers or feeler gauges. If the slide has a feed screw with scale on the hand wheel the distance adaption becomes much more comfortable.

10. Example 4: The Poly-Trademark Jig

Formelabschnitt (nächster)

This jig, seen in Figure 29 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. There are notches for five tip 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 available.

Figure 29: The jig with the trademark DRAPER



The jig shall be investigated for $\gamma = 59\,\text{Deg}$ and for the time being the drill diameter is assumed to be $D_D = 10\,\text{mm}$. With a vertical milling machine the measurements are very simple, the pivot pin is held perpendicular to the table with a tree jaw chuck.

Figure 30: The table's zero position at the chucks centre

The zero positions for the table's axes are determined with two needles as seen in Figure 30, one in the chuck and the other fixed in a suitable way to the spindle head.

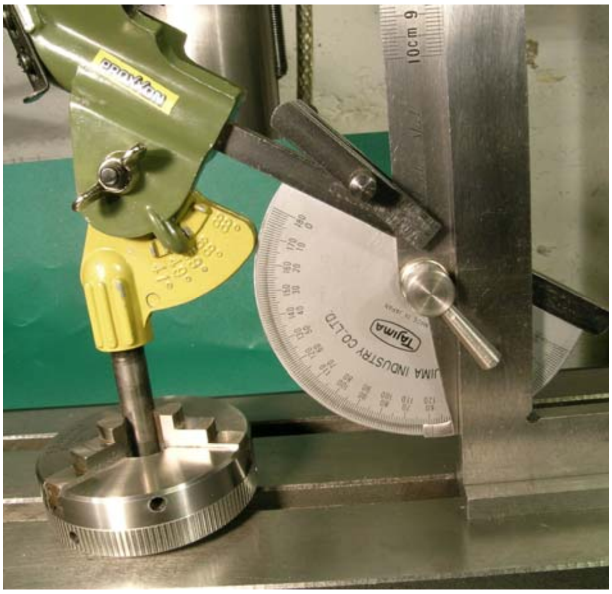


Figure 31: Determination of the angle κ

The pivot pin in the stage would be and is in the chuck perpendicular to the table. Then the angles $\kappa = \gamma = 59^0$ are given. In Figure 31, this is checked again.

The half cone angle ψ is zero; then the flanks' surfaces become cylindrical. This case already was mentioned and if the other parameters are right perfect drills can be received.

Figure 32: Alignment of the jig to the table's X-axis.

Now the jig must be aligned to the tables X-axis which is parallel to the T-slots. In Figure 32 a try square together with a precision ground angle plate was used. In this position the chuck is firmly closed to fix the jig. 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 33. The table's coordinates are the absolute setting parameters, it is $X = R$ and $Y = P$.

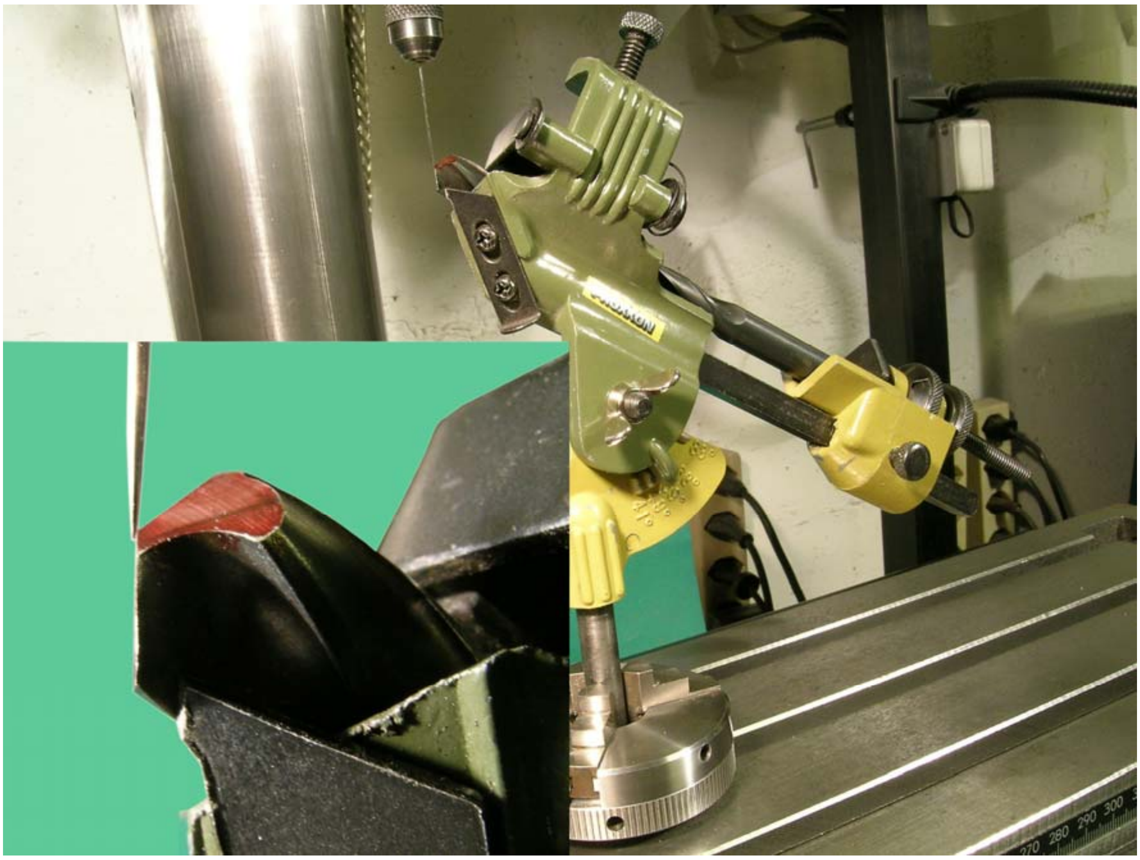


Figure 33: Measuring the drill tip's position

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

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

Identical Example 3 the drill's azimuth is determined by a stop and also here we have $\tau = 0$.

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 but could be easily changed. The distance parameters p and r are seen in Figure 34 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.

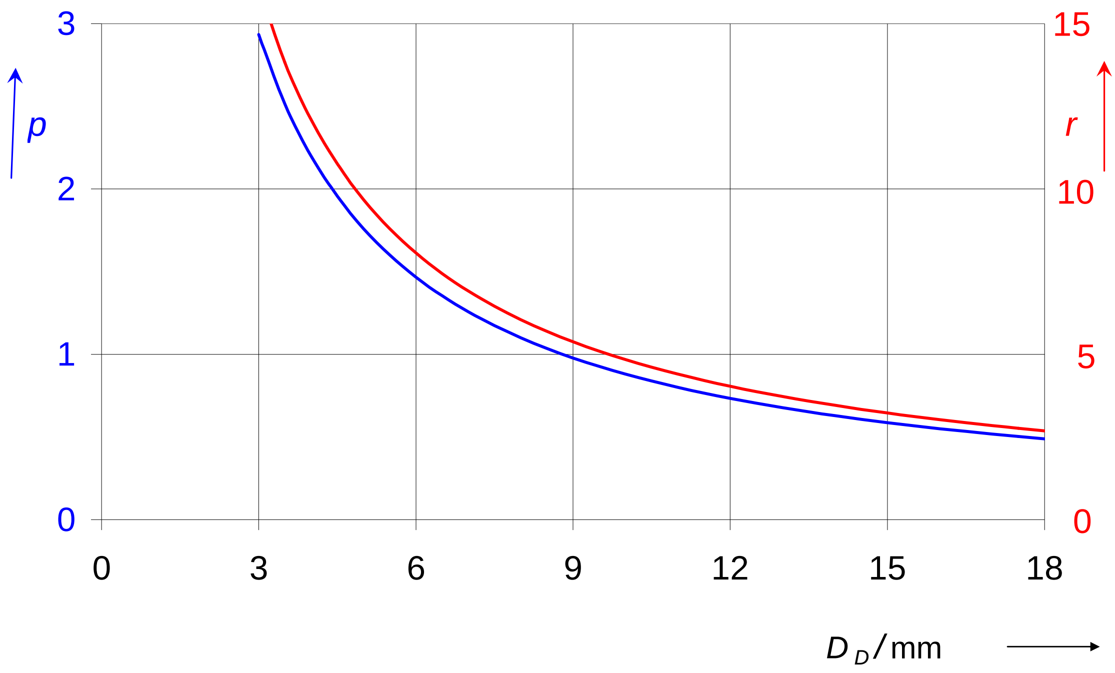


Figure 34: The parameters p and r as functions of D_D