Technical notes

1. History and benefits of multi-point dressers

Up to the end of the fifties, single-point diamond dressers were practically the only type of dressing tool; after that the first multi-point diamond tools were made with small diamonds, and were used with great success for straight dressing of grinding wheels. Thus WINTER produced the Igel® dresser. Later the range was expanded to include pro-dress® with fine grit sizes for dressing fine-grained wheels.

Cylindrical multi-point dressers cannot be used for profile dressing, so the next development step was to sinter a flat plate instead of the cylindrical Igel shape. The was a precursor of the WINTER Fliese. The diamond Fliese® combines the benefits of the multi-point diamond dresser with those of the single-point diamond dresser. It is appropriate for universal dressing, of straight wheels and profiled wheels. The technical and commercial benefits of multi-point dressers:

- Igel®, pro-dress® and diamond Fliese® tools can be used universally for straight dressing.
- Diamond Fliese® tools are also universally capable of use for profile dressing.
- These tools can be used up completely without any requirement for maintenance, and are rugged in operation.
- There is less change in active width b_D compared with single-point diamond dressers, giving more constant dressing results and more constant behaviour of the grinding wheel, i.e. more precision in grinding.
- Multi-point dressers are available in different grit sizes, diamond qualities and concentrations, and as diamond needles; this permits versatile adaptation to the special requirements of a dressing and grinding operation.
- The diamond material used in multi-point tools is much lower-priced and thus more economical compared with the same carat weight in single-point dressers.
- Alongside the single-point dressers, there is also the Rondist programme, with a number of diamonds per tool that are used one after the other.
- Rotary diamond dressers, e.g. diamond profile and copy roller dressers. A separate catalogue is available for these tools. We will be glad to make recommendations for dressing diamond and CBN wheels on request.

2. Dressing with stationary diamond dressers

An optimal grinding process can only be achieved by proper preparation of the wheel by dressing (also known as conditioning). This means not only creating or restoring true running and the correct profile of the wheel, but above all generating the free cutting capability of the wheel which is needed for the grinding process. Thus the term “dressing” covers trueing and/or sharpening of the wheel.

The wheel topography can be controlled over a wide range by varying the dressing parameters. This has considerable effects on the characteristics of the wheel in the grinding process, and on the results of the grinding operation.

Diamond dressing tools may be classified as follows:

- “Stationary diamond dressers”, e.g. single-point and multi-point dressers, and
- “Rotary diamond dressers”, e.g. diamond profile and form dressers.

The dressing techniques used for stationary diamond dressers are considered in this catalogue.

There is a separate catalogue available for WINTER diamond roller dressers. We will be glad to send you this catalogue on request.
We will also be pleased to give you recommendations for dressing diamond and CBN wheels.

The result of dressing is determined by the parameters feed v_{fd}, infeed a_{ed} and the type of dresser used. One important parameter is the active width b_D, i.e. the shape of the diamond as apparent in the surface of the wheel to be dressed. These parameters are summarized in Fig. 1.

All dressing tools are subject to wear, dependent on the parameters set, on cooling, on the wheel volume dressed V_{sd} and on wear resistance. If a single-point diamond dresser is used, the active width b_D increases with increasing duration of operation, i.e. the original point is progressively used up, and the active width b_D changes at the same time, with a corresponding change in the dressing result. Multi-point dressers have much more consistent wear behaviour.

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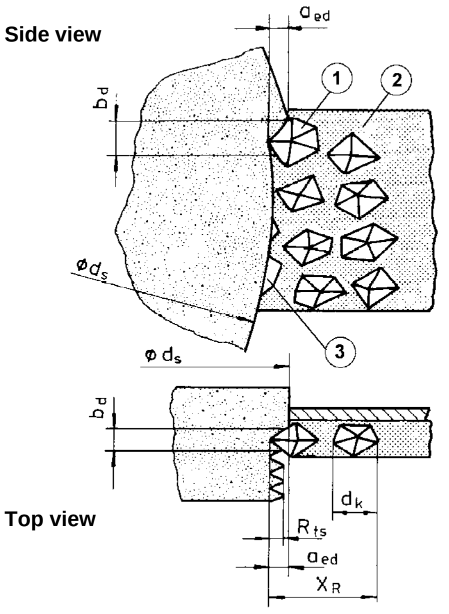

a_{ed}	(mm)	:	Infeed per stroke
b_D	(mm)	:	Active width of diamond
d_s	(mm)	:	Grinding wheel diameter
①		:	Active diamond grit
②		:	Bond T or H
③		:	Pulled out, used grit
d_k	(mm)	:	Diamond grit diameter
R_{ts}	(µm)	:	Active roughness of grinding wheel
X_R	(mm)	:	Residual layer depth of diamond Fliese®
n_{sd}	(rpm)	:	Spindle speed for dressing
v_{fad}	(mm/min)	:	Axial feed rate for dressing
f_{ad}	(mm/rev)	:	Axial feed for dressing
$U_d = \frac{b_d}{f_{ad}} = \frac{b_d \cdot n_{sd}}{v_{fad}}$ (1)		:	Overlap factor for dressing
V'_w	(mm³/mm)	:	Wheel (workpiece) removal volume per mm wheel width in grinding process

Fig. 1: Mode of operation of a diamond Fliese® and formation of active roughness depth R_{ts} as a function of b_D and f_{ad}.

The overlap factor U_d provides a link between the parameters feed v_{fd}, active width b_D and wheel spindle speed n_{sd} during dressing. This overlap factor U_d influences the number of cutting points on the grinding wheel surface. In practice, the overlap factor U_d is between 2 and 8. The figures 2 to 8 characterize the surface topography, i.e. 2 = coarse, 8 = extremely fine. It is important to note that with coarse dressing (e.g. $U_d = 2$), the wheel topography is comparable, regardless of the wheel grain. With finer wheels, there are more cutting points involved in the cutting process, and this means higher cutting forces. However, the finer wheel topography causes greater wear resistance, i.e. higher removal ratios (v_{wd} / v_{sd}) can be achieved at higher overlap factors. U_d factors of more than 8 are uneconomical, as no change can be achieved in process behaviour, and there is no improvement in surface quality.

The following overlap factors U_d are recommended as a function of grinding wheel grain size:

Wheel grain size	**60:**	**$U_{dmax} = 4$**
	80:	**$U_{dmax} = 6$**
	120:	**$U_{dmax} = 8$**
Or simplified:		**U_{dmax} = (US mesh : 15)**

3. Ways of improving results

The possible ways of improving a specific working result are shown in Figs. 2 and 3. The block diagram (Fig. 2) shows the settings that can be adjusted to improve the result. The left-hand block shows symbolically the grinding wheel to be dressed; the middle sections show the parameters that can be adjusted to achieve a specific result, i.e. machine, dressing tool and operating parameters.

These three possibilities can and must be used to achieve the desired topography on the grinding wheel, as shown symbolically in the right-hand block. Fig. 3 supplements Fig. 2 by a systematic overview of the possible ways of influencing the dressing parameters. In individual cases, the decision must be made on the basis of the capabilities of the specific machine with the dressing tool and the setting parameters.

Practical mounting and operating recommendations are given in Section 4. Section 5 shows how to cost an operation, which may permit savings. Section 6 gives a series of test results with true figures, for comparison of results and to help specify operating parameters.

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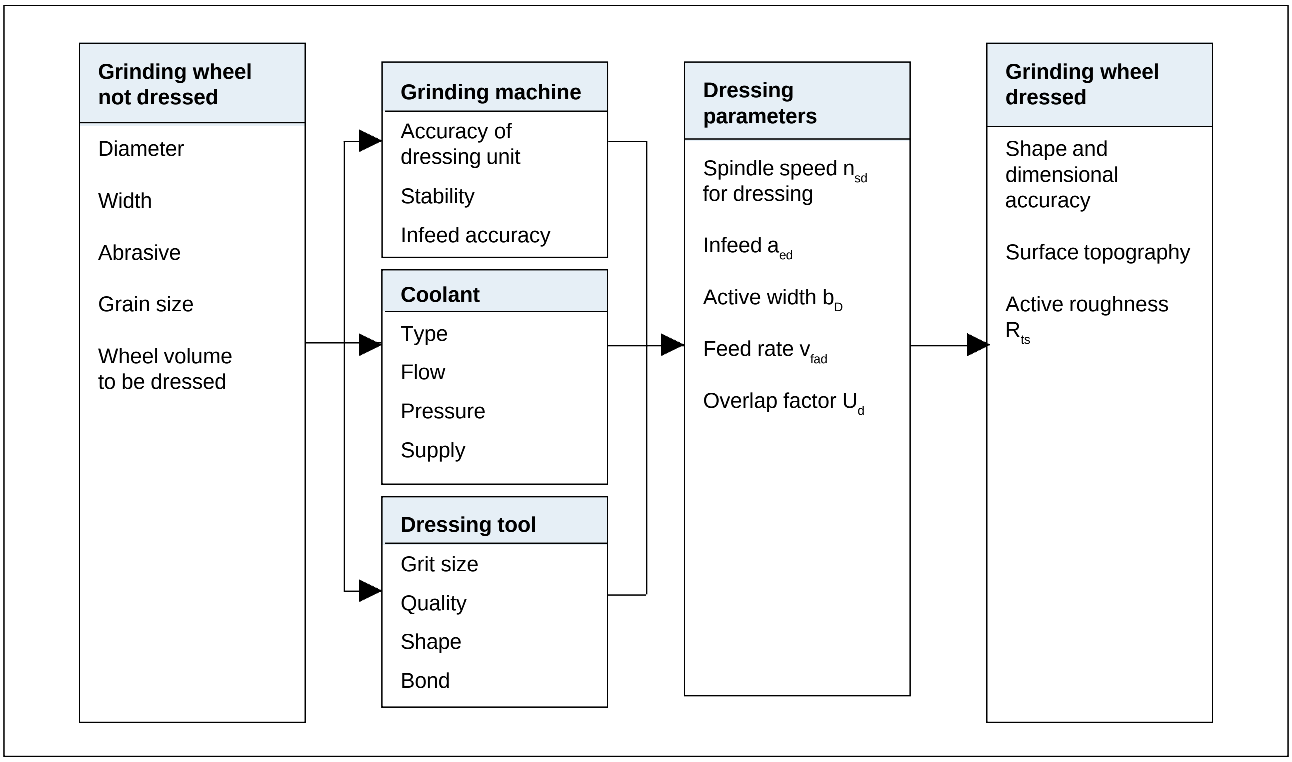

Fig. 2: Block diagram: dressing a grinding wheel with stationary diamond dressers and their variables such as grinding machine, coolant, dresser and operating parameters with the major influencing variables.

Assessment criteria / Influencing variables	Geometrical and dimensional accuracy		Surface roughness
	Cutting forces $F = f(U_d, V'_w)$	Removal ratio $G = f(U_d, V'_w)$	Average roughness $R_z = f(U_d, V'_w)$
Overlap factor $U_d = \frac{b_D \cdot n_{sd}}{v_{fad}} = \frac{b_D}{f_{ad}}$			
Specific material removal rate V'_w (cm³/mm)			

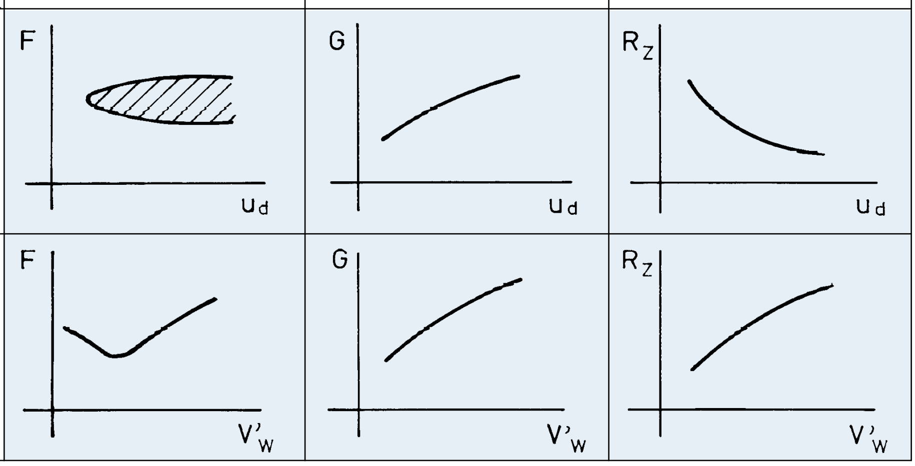

Fig. 3: Systematic diagram showing the influence of technical grinding result as a function of dressing parameters and specific material removal volume V'_w (cm³/mm) of grinding wheel in the grinding process (acc. to Messer)

Technical notes

4. Mounting and operating recommendations (overview see pages 28-29)

5. Cost-effectiveness calculation

For comparison between different dressing tools, it is necessary to look not only at the technical dressing result, but also to make a cost comparison.

Total dressing cost K_{dtot} is calculated from two blocks of cost:

1. Costs related to the service life of the dressing tool, calculated from:

   - Cost of dressing tool K_w
   - Life (no. of dressings) of dressing tool i_d, i.e.

   $$K_{wd} = K_w : i_d \quad \text{(DM : no. of dressings)}$$

2. Costs related to the dressing operation K_{zd}, calculated from:

   - Machine rate K_M (incl. labour and ancillary labour cost)
   - Dressing duration t_d, i.e.

   $$K_{zd} = K_M : t_d \quad \text{(DM : no. of dressings)}$$

Thus the total dressing cost K_{dtot} can be calculated from the two blocks (1 and 2), as follows:

$$K_{dtot} = K_{wd} + K_{zd} \qquad \text{(DM : no. of dressings)}$$

6. Test data and parameters

Practical data and research results are shown graphically on pages 30, 31 and 32 to help specify operating parameters and to enable comparison of results.

7. Recommended literature on dressing technology

I. Appun: Einfluß des Abrichtvorganges und der Kühlverfahren auf Verschleiß und Oberflächengüte beim Rundschleifen. Dissertation TH Braunschweig 1953.

D. M. Busch: Abrichten von Schleifscheiben mit Diamantwerkzeugen. MM Maschinenmarkt, Würzburg, Jahrgang 75 (1969) Nr. 82, Seiten 1807-1810.

H. Frank: Das Abrichten von Schleifscheiben mit Diamanten und der Einfluß auf das Schleifergebnis beim Außenrundeinstechschleifen. Dissertation RWTH Aachen, 1963.

R. Gauger: Diamantwerkzeuge zum Abrichten von Schleifscheiben. IDR 1 (1967) 3, Seiten 141-151.

W. König u. J. Messer: Einstellbedingungen beim Abrichten von Schleifscheiben. Schweizer Maschinenmarkt Nr.49/1991, Seiten 26-29.

W. König u. J. Messer: Abrichten von Korundschleifscheiben mit Stehenden Abrichtwerkzeugen. Jahrbuch Schleifen, Honen, Läppen und Polieren, Vulkan-Verlag Essen, 1982, 51. Ausgabe, Seiten 307-317.

J. Messer: Abrichten konventioneller Schleifscheiben mit Stehenden Werkzeugen. Dissertation RWTH Achen, 1983.

E. Salje: Abrichtverfahren mit unbewegten und rotierenden Abrichtwerkzeugen. Jahrbuch Schleifen, Honen, Läppen und Polieren, Vulkan-Verlag Essen, 1981, 50. Ausgabe, Seiten 284-298.

W. Thöing: Untersuchungen über das Abrichten von Schleifscheiben mit Diamantwerkzeugen. Dissertation TH Braunschweig, 1956.

R. Völler: Feinschleifen - heute und morgen. Trennkompendium, Band 1, 1978, ETF Bergisch-Gladbach, Seite 309.

R. Völler: Abnutzung von Abrichtwerkzeugen. Jahrbuch Schleifen, Honen, Läppen und Polieren. Vulkan-Verlag Essen, 1981, 50. Ausgabe, Seiten 249-266.

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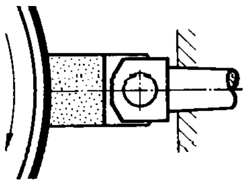
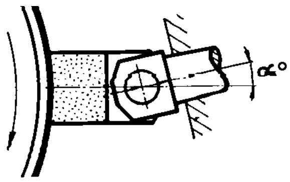
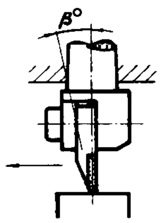
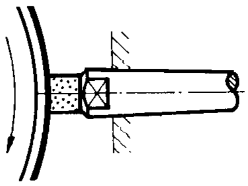
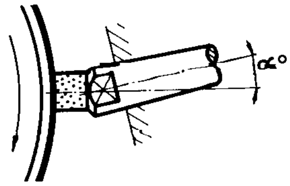
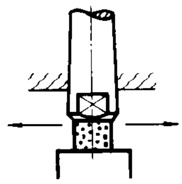
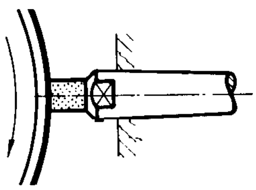
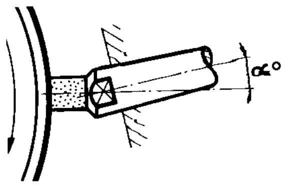
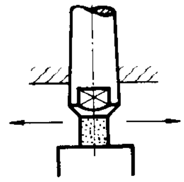
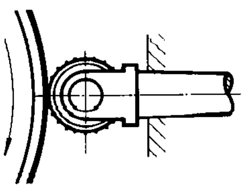
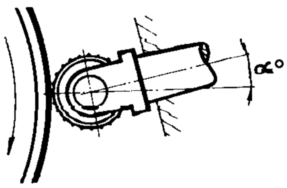
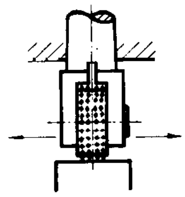
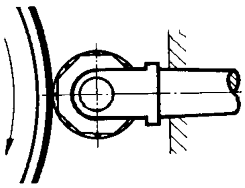
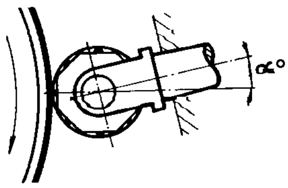
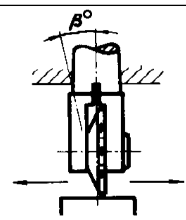
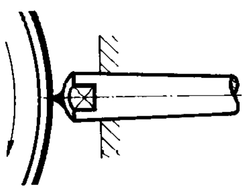
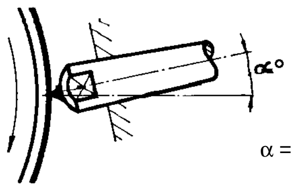
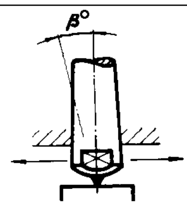
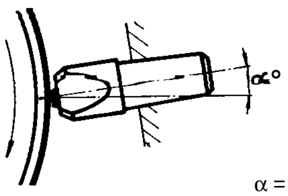
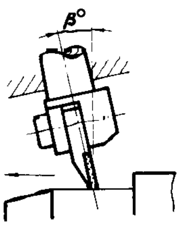
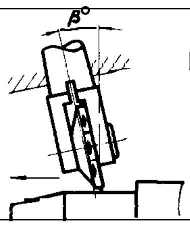
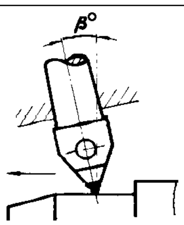
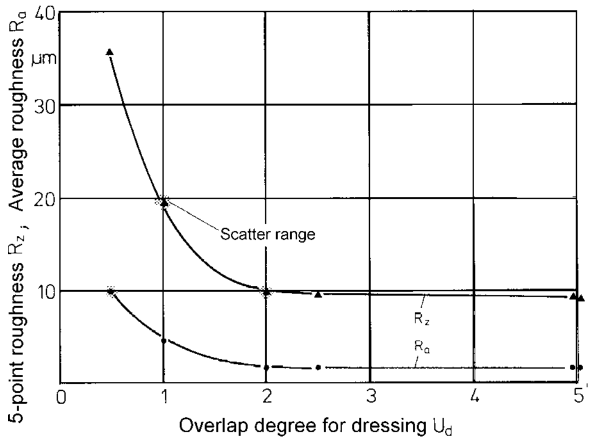
4. Installation and operating recommendations

Diamond dressing tool	Working positions of diamond dressers: for **straight** mount	for **inclined** mount		for **straight** dressing	
Diamond Fliese®			Inclination is compensated by swivelling the Fliese in the swivel holder α = 0...30° or rigid brazed.		Vertical to β = 30°
Igel®			For inclined position of mount, please indicate inclination angle α°		Vertical
pro-dress®					Vertical
Diamond Rondist 2096/5096					Vertical
Diamond Rondist 1008					Vertical or α = 30°
Single-point diamond dresser			α = 5...45°		Vertical or α = 15° to main dressing direction
Profile diamond dresser			α = 5...10°		

Dressing position for **profile** dressing	Active width b_D mm	Overlap factor U_d 1	Dressing infeed a_{ed} mm	Dressing cross feed f_{ad} mm/rev	**Remarks**
 β = 30...45°	~ 0.8 · d_K d_K = theoretical diamond grit diameter	2-8 see page 25	0.01 to 0.03	0.05-0.5	For straight dressing, slight diagonal position possible = drag-cut effekt = finer surface quality For **first operation** of dressing tool, do several dressing strokes with increased infeed if possible, so that the dresser can adjust to the grinding wheel radius.
			0.01 to 0.05	0.3-1.0	Due to large number of active diamonds during dressing, the dressing feed f_{ad} and feed rate v_{fad} must be correspondingly increased.
			0.005 to 0.03	0.05-0.5	
	~ 0.8 · d_K per active grit		0.01 to 0.05	0.3-1.0	Due to four active diamonds, the dressing feed f_{ad} and feed rate v_{fad} must be correspondingly increased.
 β = 30...45°	~ 0.8 · d_k	2-8 see page 25	0.01 to 0.03	0.05-0.5	
	Corresponds to degree of wear	2-8 see page 25	0.01 to 0.03	0.05-0.15	When sharpness decreases, turn diamond insert approx. 60° around its own axis, remount in good time. Do not allow wear flats to become larger than approx. 1 mm². **Stop!** **Too late** 
 β = 30...45°	Corresponds to profile of diamond (angle/ radius)	2-8 see page 25	0.01 to 0.02	0.03-0.10	Please note instructions of equipment and machine manufacturer.

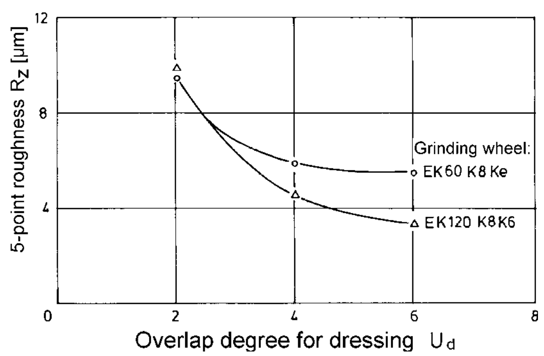


Material: Ck 45N (1.1191)
Grinding wheel: EK60 K8 Ke
Cutting fluid: Emulsion 3%

Grinding parameters:
v_c = 45 m/s
v_w = 0.75 m/s
Q'_w = 3.0 mm³/mm · s
V'_w = 800 mm³/mm

Dressing tool: WINTER needle Fliese FB180
Dressing infeed: a_{ed} = 0.02 mm

Fig. 4: Roughness on ground workpiece is influenced by overlap factor U_d (acc. to Messer).

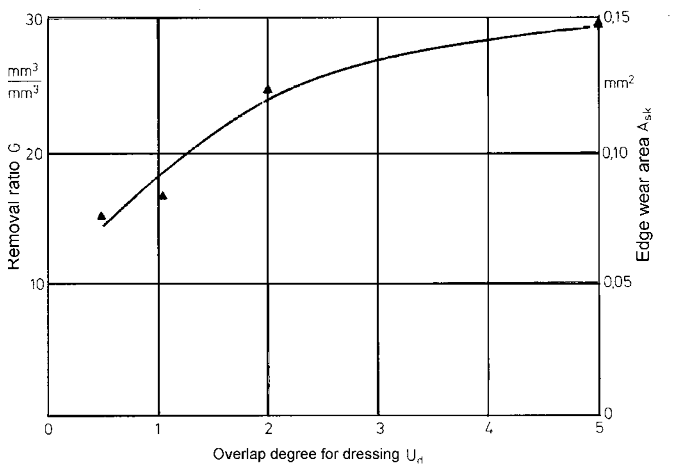


Material: Ck 45N (1.1191)
Grinding wheel: EK60 K8 Ke
EK120 K8 Ke
Cutting fluid: Emulsion 3%

Grinding parameters:
v_c = 45 m/s
v_w = 0.75 m/s
Q'_w = 3.0 mm³/mm · s
V'_w = 200 mm³/mm

Dressing tool: WINTER needle Fliese FB180
Dressing infeed: a_{ed} = 0.03 mm

Fig. 5: Workpiece roughness R_z is influenced by overlap factor U_d and wheel grit (acc. to König, Messer).

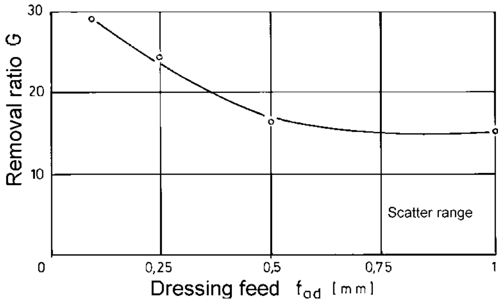


Material: Ck 45N (1.1191)
Grinding wheel: EK60 K8 Ke
Cutting fluid: Emulsion 3%

Grinding parameters:
v_c = 45 m/s
v_w = 0.75 m/s
Q'_w = 3.0 mm³/mm · s
V'_w = 800 mm³/mm

Dressing tool: WINTER needle Fliese FB180
Dressing infeed: a_{ed} = 0.03 mm

Fig. 6: Dressing ratio G of the grinding wheel is influenced by overlap factor U_d (acc. to Messer)

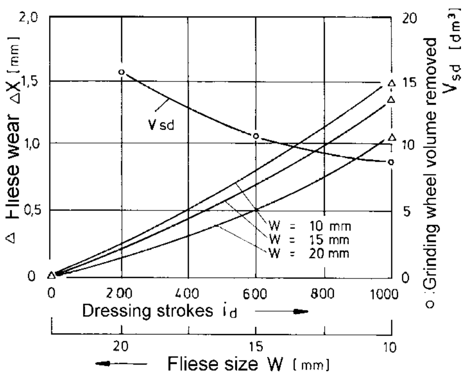


Material: Ck 45N (1.1191)
Grinding wheel: EK60 K8 Ke
Cutting fluid: Emulsion 3%

Grinding parameters:
v_c = 45 m/s
v_w = 0.75 m/s
Q'_w = 3.0 mm³/mm · s
V'_w = 800 mm³/mm

Dressing tool: WINTER needle Fliese FB180
Dressing infeed: a_{ed} = 0.02 mm

Fig. 7: Dressing ratio G (life of grinding wheel) is influenced by dressing feed f_{ad} (acc. to Messer).

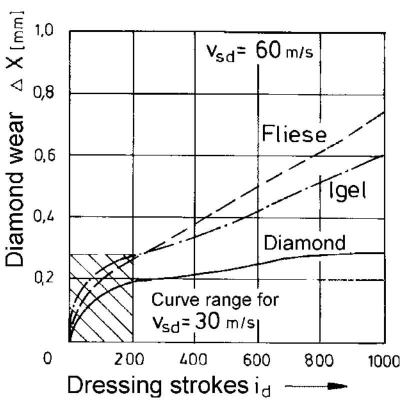


Material: Centerless grinding wheels
Ø 500 x 300 mm,
HK28-80a L6 VXM
Machine: Lidköpping Centerless 4 B
Cutting fluid: Emulsion 2%

Parameters:
Q_l = 4.4 l/min
v_{sd} = 60 m/s
n_{sd} = 2293 rpm
f_{ad} = 0.237 mm
v_{fad} = 540 mm/min
a_{ed} = 0.02 mm
U_d = appr. (0.8 · 2293):540=3.4

Dressing tool: WINTER needle Fliese
W = 20, 15, 10 mm

Fig. 8: Fliese wear is influenced by Fliese width W and number of dressing strokes i_d, grinding wheel volume removed V_{sd} (acc. to Völler).



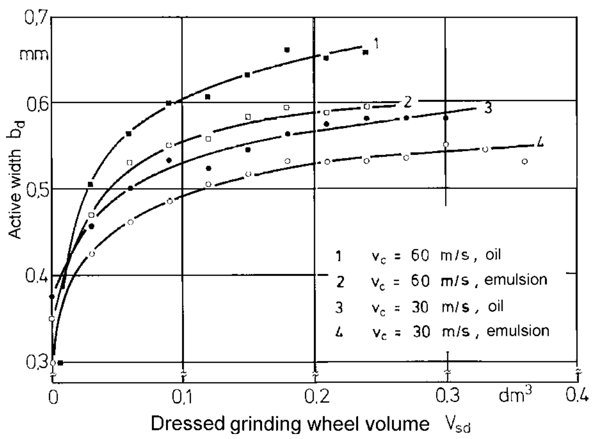
Grinding wheel: Ø 750 x 60 mm
6A2 543 M 6 VAZ
Cutting fluid: Emulsion 2% and oil

Parameters:

2% Emulsion	oil (BP CFL 5171)
Q_l = 4 l/min	Q_l = 4 l/min
v_{sd} = 30 m/s	v_{sd} = 60 m/s
a_{ed} = 0.02 mm	a_{ed} = 0.02 mm

Dressing tool: WINTER needle Fliese
W=10 mm
Igel IG 5
Single-point diamond dresser
EK 1.0 Basram

Fig. 9: Diamond wear Δx of Fliese, Igel and single-point dresser are influenced by operating parameters (acc. to Völler).



Grinding wheel:	EKw 70 Jot 7 Ke		
Cutting fluid:	Emulsion 3%		
	oil (18 mm²/s)		
	Free jet Q_{xss} = 5 l/min		
Dressing parameters:	v_c	=	30 m/s
			60 m/s
	a_{ed}	=	0.03 mm
	f_{ad}	=	0.10 mm
			0.05 mm
Dressing tool:	Single-point diamond		
Basram, 1 carat			
Dressing infeed:	a_{ed}	=	0.03 mm

Fig. 10: Change in active width b_D for dressing with various cutting fluids and at various cutting speeds (acc. to König, Vits)

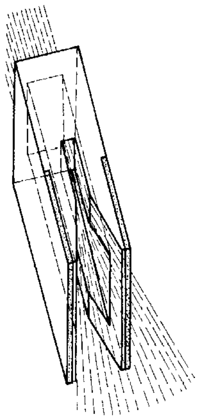
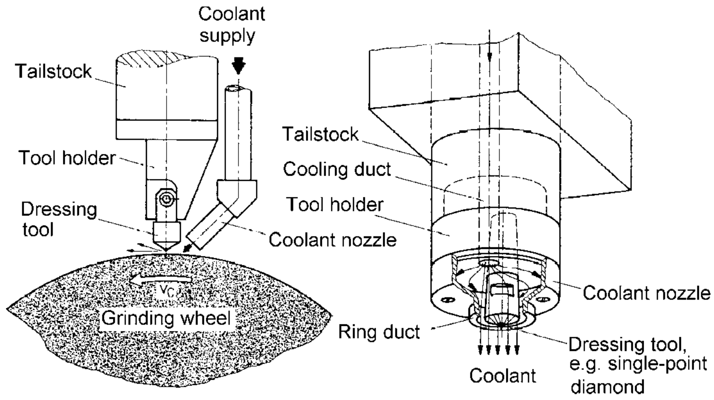


Fig. 11: Twin Fliese with coolant duct

Cutting fluid for dressing

The results of temperature measurements on dressing tools have shown that the cutting fluid nozzles must be large enough and must be directed so as to ensure that even under unfavourable conditions, there is sufficient supply to the contact zone between the dressing tool and the grinding wheel. This is achieved, for example, by WINTER's "Twin Fliese with integrated coolant duct".



Jet nozzle and ring nozzle

The fluid jet of the jet nozzle is supported by the direction of rotation of the grinding wheel and hits the contact zone at an angle of approx. 45°. If the exit velocity of the coolant is not similar to the peripheral speed of the grinding wheel, there is a danger that the coolant jet will be deflected by the air cushion of the grinding wheel.
The ring nozzle is a proven system for controlled supply of coolant to the contact zone.

Fig. 12: Dressing tool cooling by jet nozzle and ring nozzle (acc. to König, Vits)