Agenda

- Schleifprozess - Übersicht
- Schleifkörnungen
- Bindungstechnik
- Konditionieren von Schleifwerkzeugen
- Einfluss Schleifparameter
- Kühlschmierung

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Einflüsse auf den Schleifprozess

Maschine
- Typ
- Maschinengröße
- Leistung
- Genauigkeit
- Steifigkeit
- Handling
- Steuerung
- Anfunksensorik

Werkstück
- Geometrie
- Profile
- Werkstoffe
- Wärmebe-handlung

Schleif-werkzeug
- Kornart
- Bindung
- Struktur
- Grundkörper
- Abmessungen
- Profile

Konditio-nieren
- Methode
- Werkzeug
- Kinematik
- Zustellung
- Überdeckung
- Schärfen
- Reinigung

KSS Zuführung
- Kühlschmierstoff
- Volumen
- Druck
- Zuführung
- Düsen
- KSS Filtrierung

Parameter
- Umfangsge-schwindigkeit
- Vorschübe
- Geschw. Verh.
- Vorschübe
- Gleich- oder Gegenlauf

Prozessparameter
- Schleifkräfte, Kraftverhältnis
- Zerspanleistung, Scheibenverschleiß
- Bearbeitungszeit, G-Verhältnis
- Thermische Einflüsse auf die Randzone
- Dynamische Einflüsse auf das System

Schleifergebnis
- Toleranzen
- Oberflächengüte
- Thermische Randzonenschädigung
- Produktivität
- Bearbeitungskosten

nach Druminski

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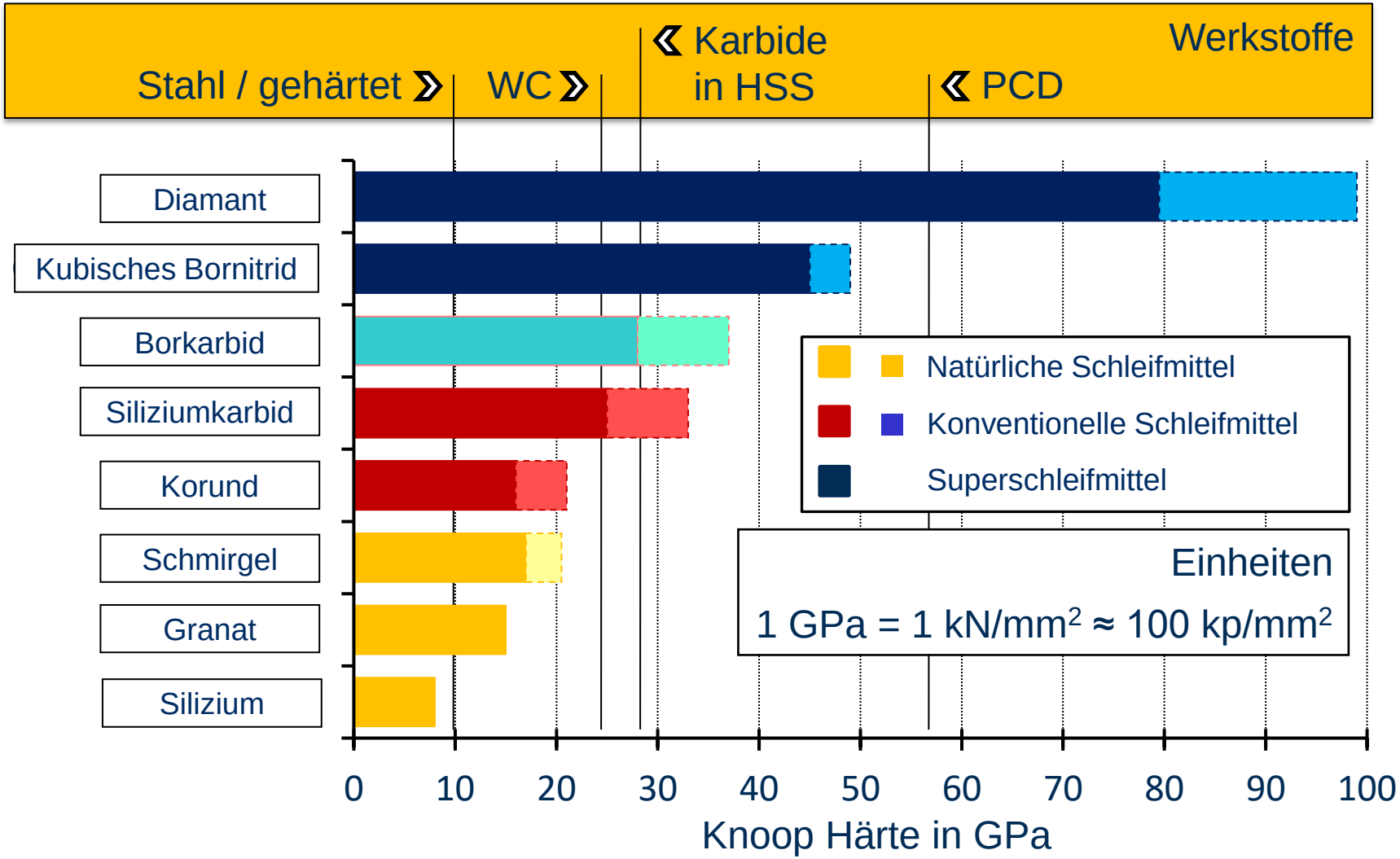


Knoop Härte von Schleifmitteln

Internationaler Standard der Korngrößen für CBN und Diamant

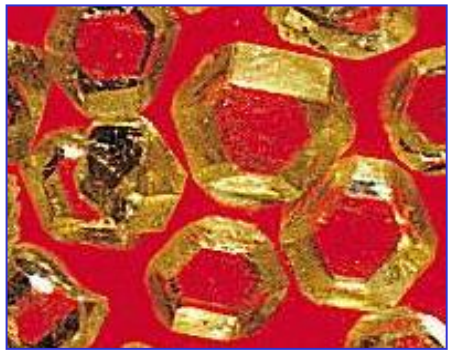
International standardization of grit sizes for diamond and cubic boron nitrid

Nomenclature of sieved grit sizes							fine grit sizes *)		
DIAMOND FEPA - Standard narrow	DIAMOND FEPA - Standard wide	CBN FEPA - Standard narrow	CBN FEPA - Standard wide	DIAMOND + CBN US - Standard narrow	DIAMOND + CBN US - Standard wide	mesh width acc. ISO6106, DIN848-1	diamond marking SGA	CBN marking SGA	grit size µm
D 1181	D 1182	B 1181	B 1182	16/ 18	16/20	1180/1000	D 25		32-52
D 1001		B 1001		18/ 20		1000/ 850	◤ D 20 B	B 30	30-40
D 851	D 852	B 851	B 852	20/ 25	20/30	850/ 710	◤ D 20 A		25-30
D 711		B 711		25/ 30		710/ 600	D 15		10-25
D 601	D 602	B 601	B 602	30/ 35	30/40	600/ 500	D 15 C		20-25
D 501		B 501		35/ 40		500/ 425	◤ D 15 B	B15	15-20
D 426	D 427	B 426	B 427	40/ 45	40/50	425/ 355	D 15 A	B 9	10-15
D 356		B 356		45/ 50		355/ 300	◤ D 7	B 6	5-10
D 301		B 301		50/ 60		300/ 250	D 3	B 3	2- 5
D 251	D 252	B 251	◤ B 252	60/ 70		250/ 212	D 1	B 1	1- 2
D 213		B 213		70/ 80		212/ 180	D 0,7		0,5- 1
D 181		◤ B 181		80/100		180/ 150	D 0,25		< 0,5
◤ D 151		◤ B 151		100/120		150/ 125			
◤ D 126		◤ B 126		120/140		125/ 106			
◤ D 107		◤ B 107		140/170		106/ 90			
◤ D 91		◤ B 91		170/200		90/ 75			
D 76		B 76		200/230		75/ 63			
◤ D 64		◤ B 64		230/270		63/ 53			
D 54		B 54		270/325		53/ 45			
◤ D 46		◤ B 46		325/400		45/ 38			

◤ grit sizes recommended by SGA

*) similar to FEPA Standard

FEPA: Federation Europeenne des Fabricants de Produits Abrasifs



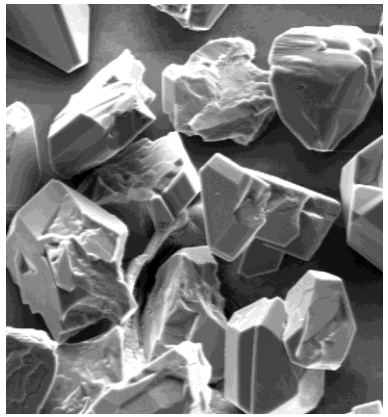
CBN Qualitäten

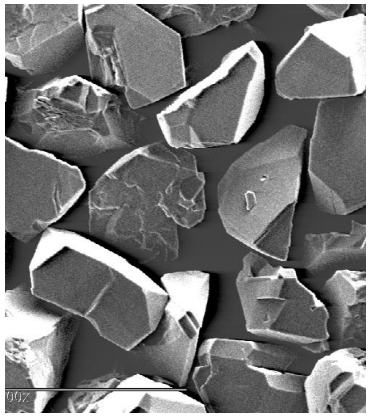
- Selbstschärfen
- Sehr brüchig

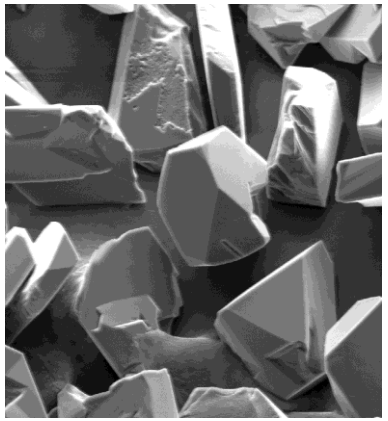
- Mittlere Festigkeit
- Thermisch stabil

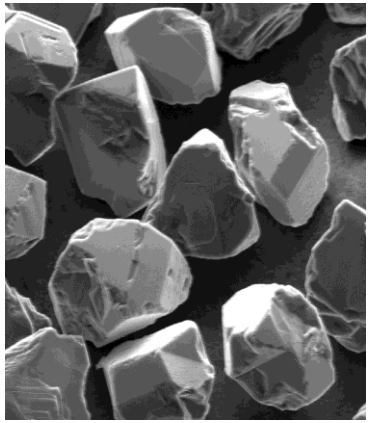
- Sehr scharfe Schneidkanten
- Glatte Oberfläche

- Blockige Körnung
- Hohe Festigkeit



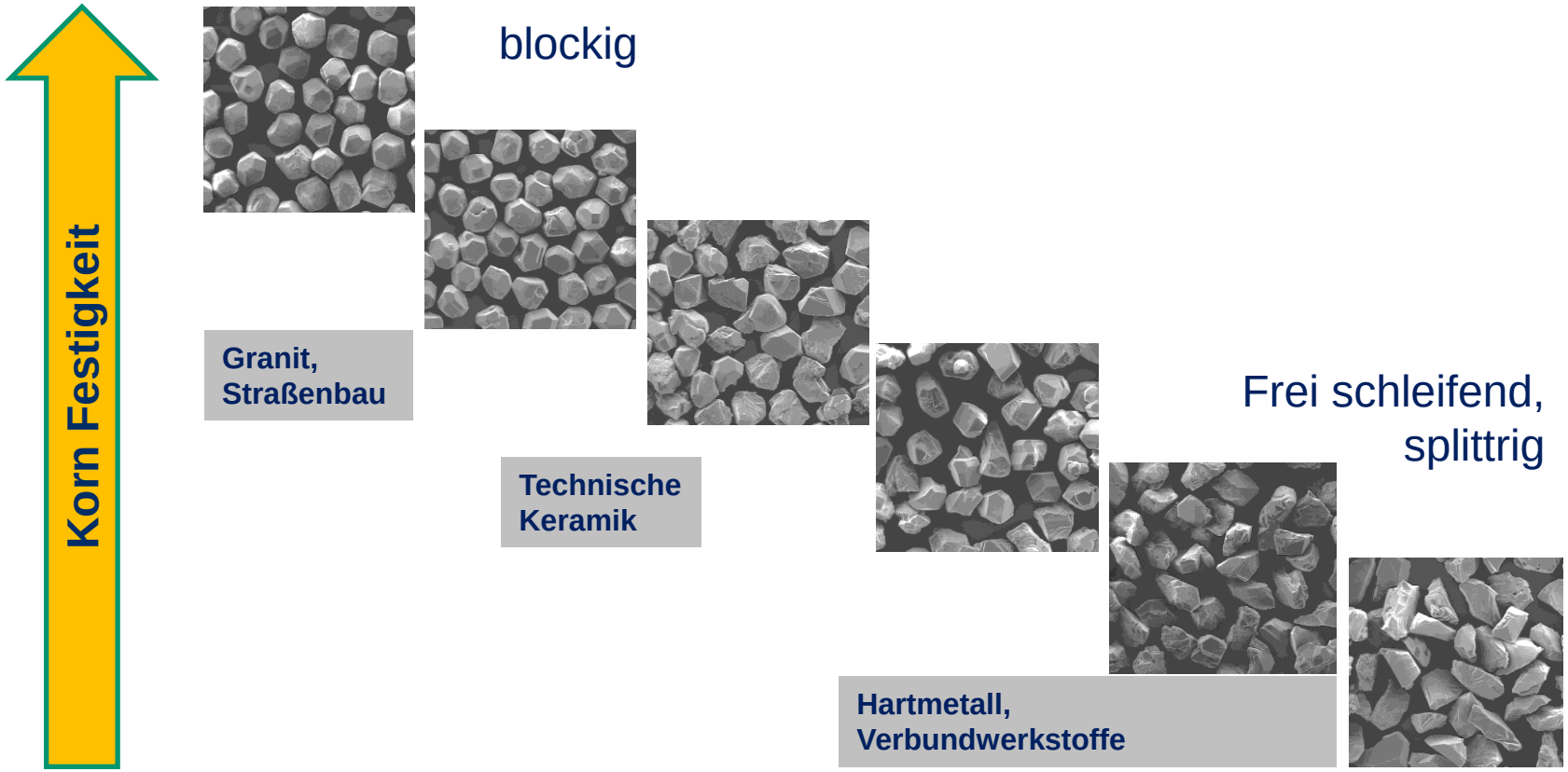




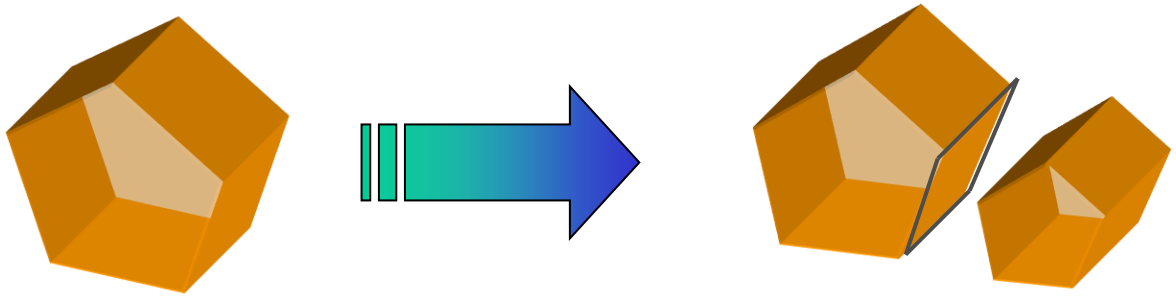


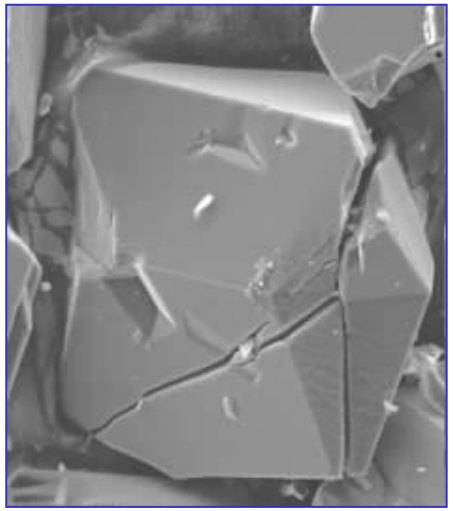
Korn Festigkeit

Diamant Qualitäten

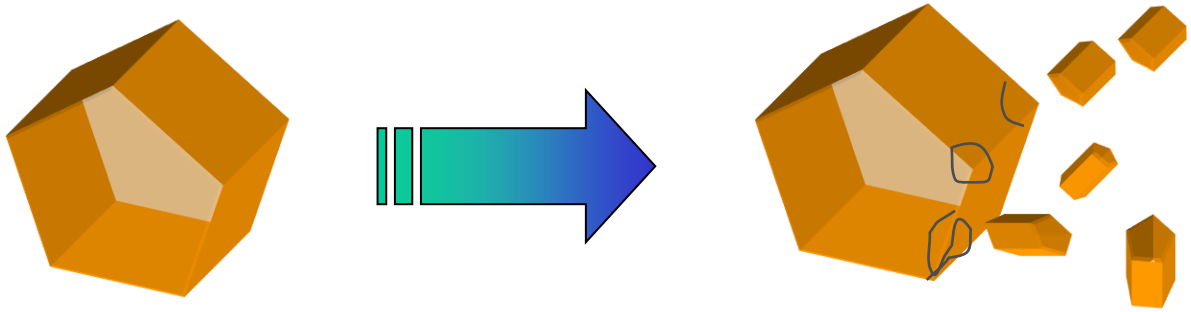


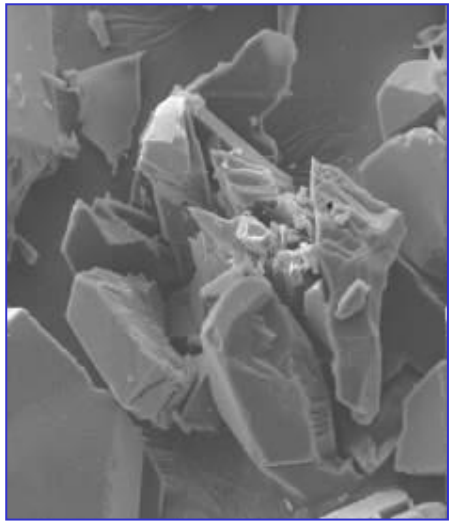
Bruchverhalten von CBN- & Diamantkörnungen





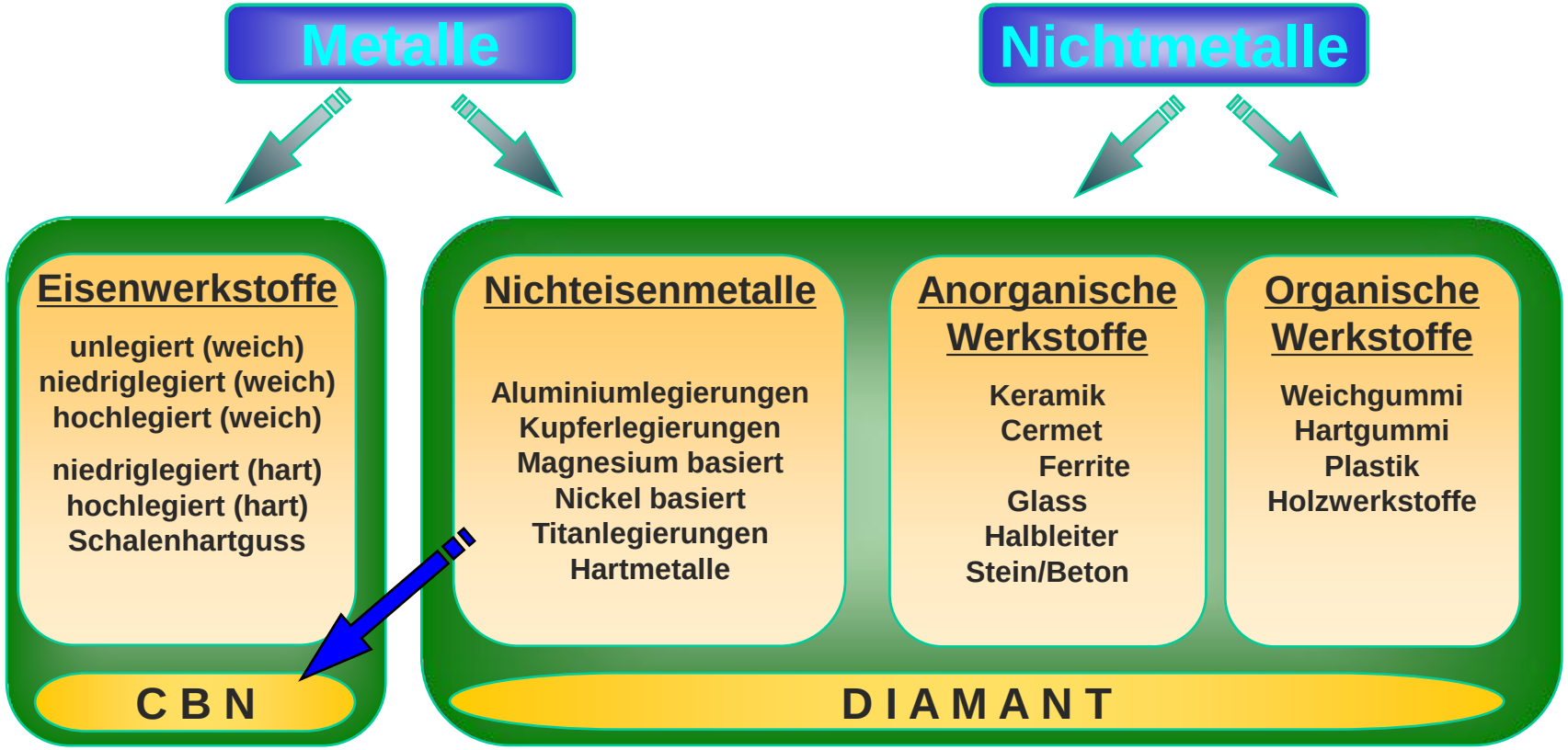
- Monokristallines Bruchverhalten





- Mikrokristallines Bruchverhalten

Einsatz von CBN- & Diamantkörnungen



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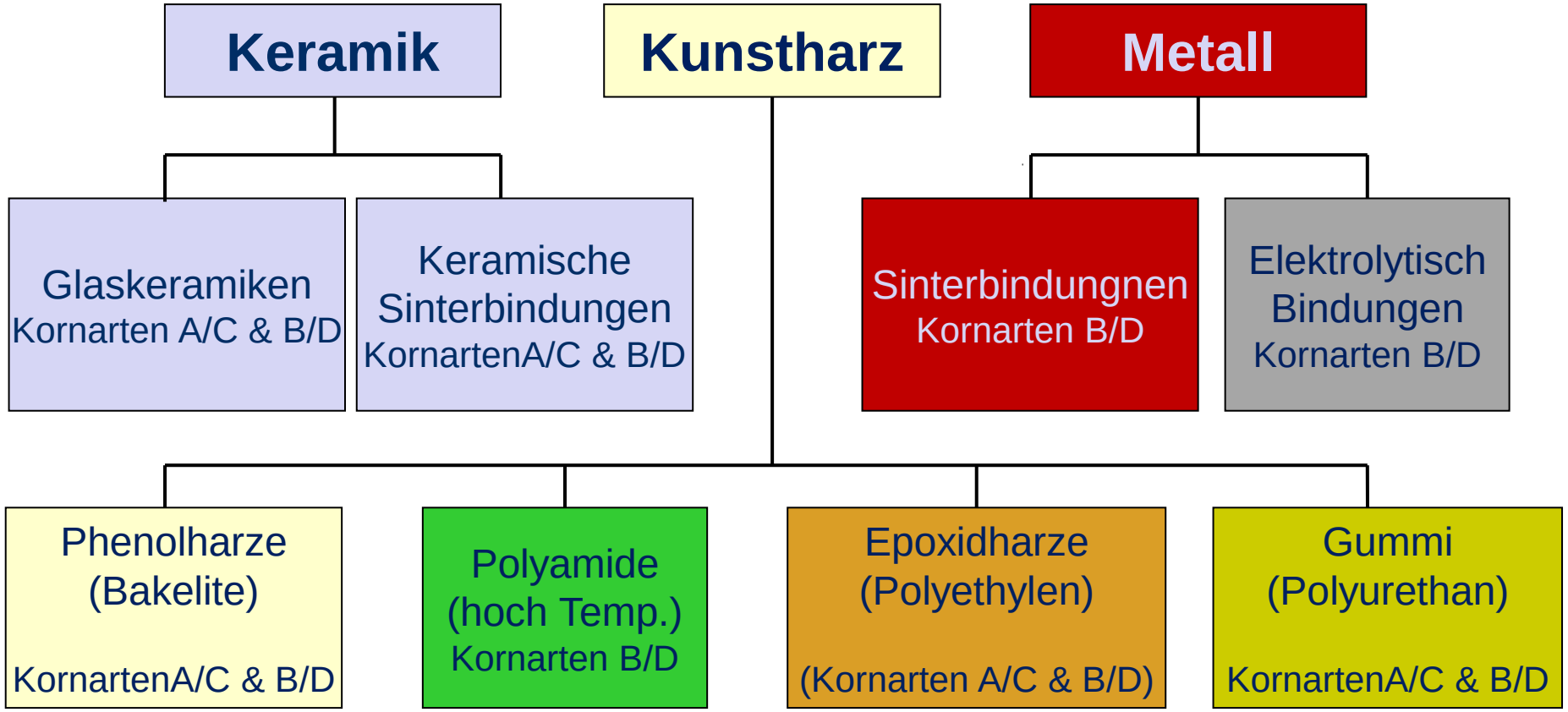
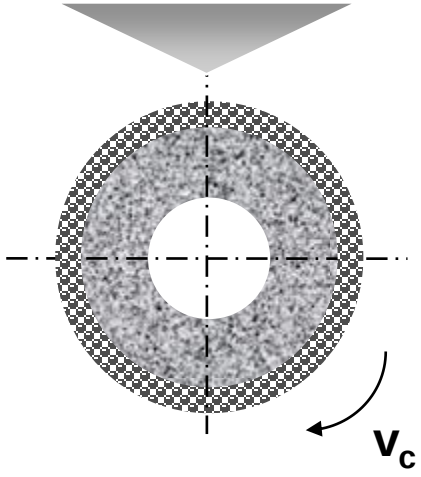


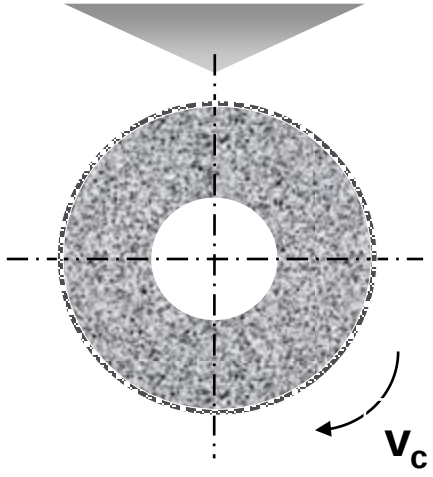
Bindungstechnik – Bindungsarten

Bindungssysteme für Superabrasives-Werkzeuge

Kunstharz	Sinter-Metall	Keramik	Galvanik
• Phenolharz • Polyimid	• Bronze • Messing • Hartmetall	• Basis: Silikat - glasig - kristallin	• chemisch • elektrolytisch

mehrschichtig | **einschichtig**





		Kunstharze			Metall	
Eigenschaften	Keramik	Phenolharz	Polyamid	Gummi	Metall Sinterb.	Galvanik
Härte	++	+/-	+	++/--	++	+++
Sprödigkeit	+++	--	--	---	+/-	---
Zähigkeit	---	++	++	+++	+/-	---
Dämpfung	---	++	++	+++	---	---
Preis	++	-	+	-	++	-
Abrichtbarkeit	+++	+	+/-	+/-	--	---
Vc max	+++	-	-	-	++	+++
Wärmeleitf.	---	++	++	+	++	++
Chem. Best.	+++	--	--	--	+++	+++

Bindungstechnik - Eigenschaften

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Schleifwerkzeug Vorbereitung

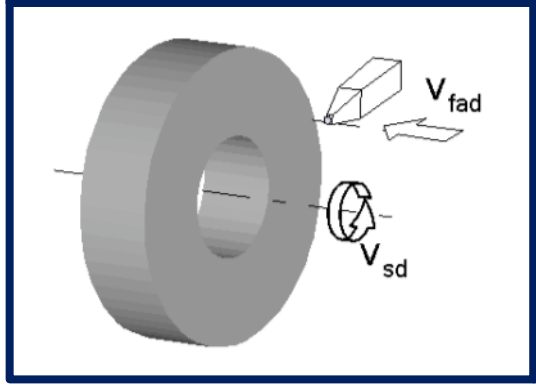
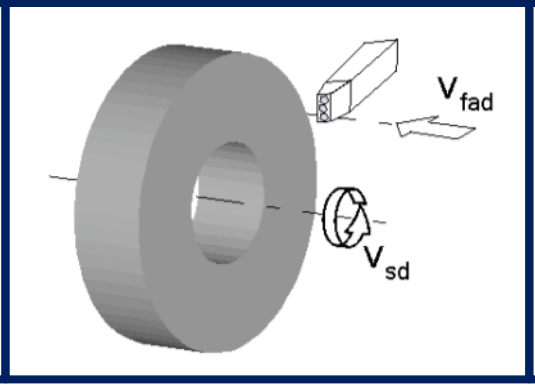
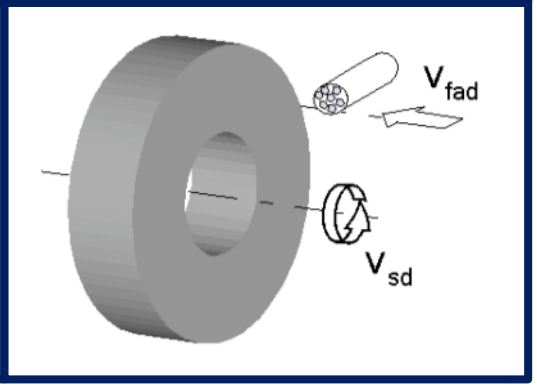
Allgemeine Bezeichnungen

Spannen	Konditionieren	Auswuchten
Montage des Schleifwerkzeuges	Schleifscheibe Erzeugung der Geometrie	Kompensation der Unwucht

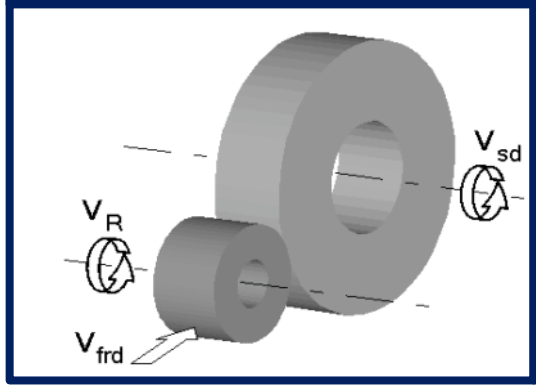
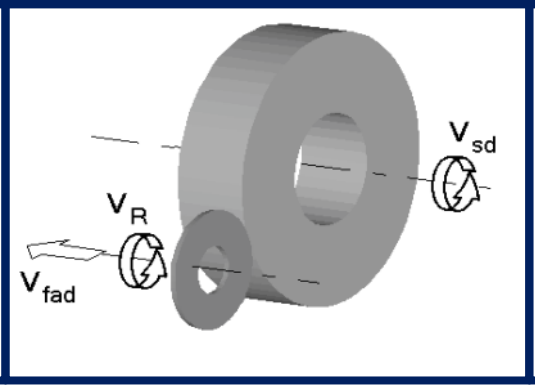
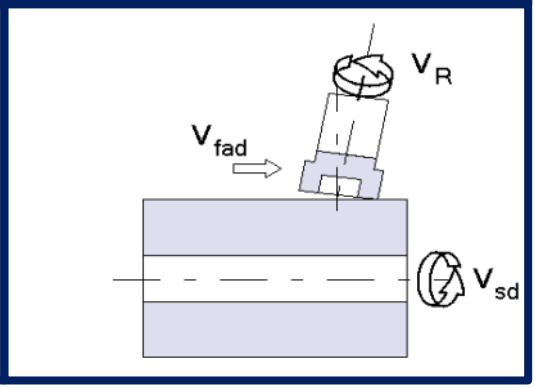
Abrichten	Reinigen
Erzeugung der Schleifscheibengeometrie	Entfernung loser Partikel

Profilieren	Schärfen
Erzeugung der Makrogeometrie	Erzeugung der Oberflächenstruktur
Rundlauf Profil Konzentrizität	Topografie Schärfegrad

Stehende Abrichtwerkzeuge

Einkorn Abrichter	Blattwerkzeuge (Fliese)	Mehrkornabrichter
		

Rotierende Abrichtwerkzeuge

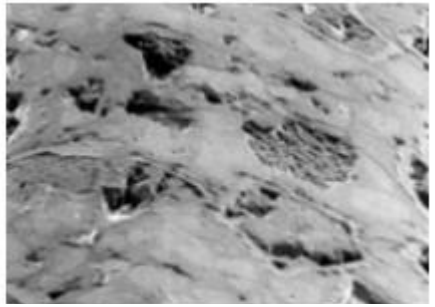
Profil-Abrichtrolle	Form-Abrichtrolle (CNC)	Topf-Abrichter
		

acc. to: F. Klocke

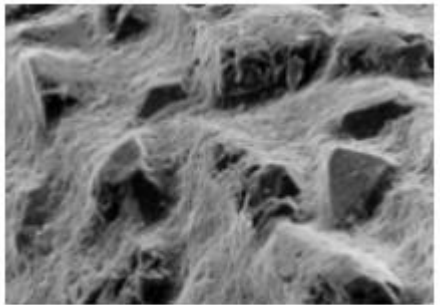
Abrichttechnik – Übersicht Abrichtwerkzeuge

Schärfen

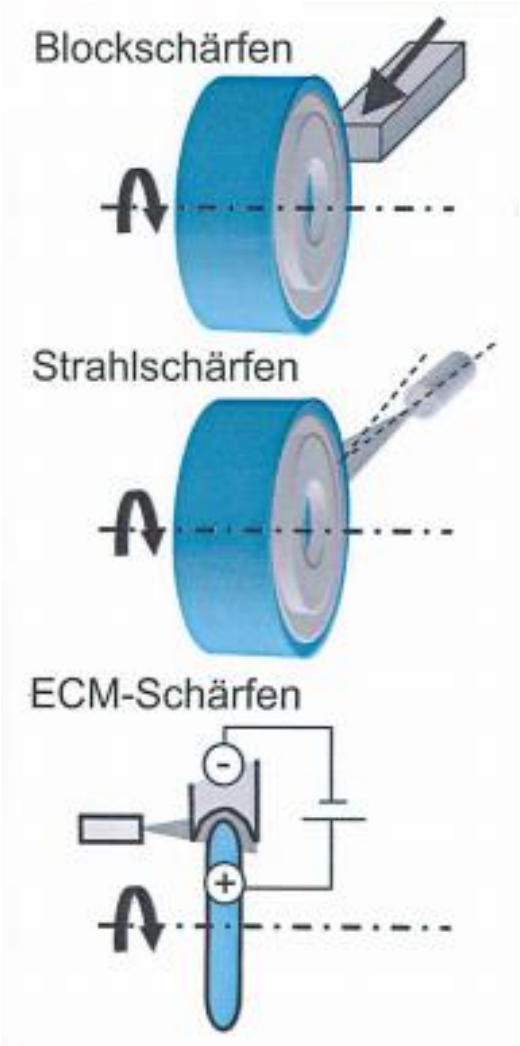
- **Nach dem Abrichten einer Bindung mit geringer Porosität (Kunstharz- & Metallbindungen) besitzt die Oberfläche der Schleifscheibe keine geeignete Topografie für den Schleifprozess**
- **Während des Schärfens wird Bindungsmaterial entfernt**
- **Durch geeignete Schärfparameter kann der Schärfegrad gezielt beeinflusst werden.**



Oberflächenstruktur nach dem Abrichten



Oberflächenstruktur nach dem Schärfen

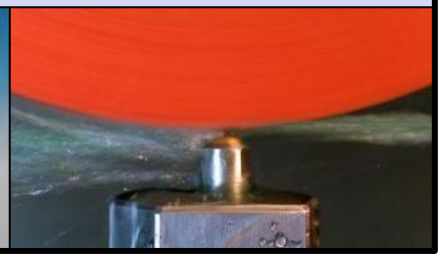


acc. to: F. Klocke, T. Tawakoli

Schleifscheiben-profil	Schleifmittel	Massenproduktion	Kleinserien-fertigung
Einfache Geometrien Einprofilig	Al2O3, SiC	Abricht-Profilrolle	Einkorn Abrichter
	SG	Abricht-Formrolle	Diamantfliese
	CBN	Abricht-Formrolle	Abricht-Formrolle
	Diamond	SiC Abrichtscheibe, Abricht-Formrolle	SiC Abrichtscheibe, Diamantfliese
Komplexe Konturen Mehrprofilig	Al2O3, SiC	Abricht-Profilrolle	Diamantfliese
	SG	Abricht-Formrolle	Diamond Blades
	CBN	Diamant-Formrolle	Diamond Form Roller
	Diamond	Kritisch, hängt von Anwendung ab	Cruschieren, Abricht-Formrolle
Bemerkung	Unabhängig von der Art des Schleifmittels werden kleine Innenrund-Schleifwerkzeuge mittels einer elektrisch oder Luft angetriebenen Turbine mit kleinen Abricht-Formrollen abgerichtet.		

Stationary

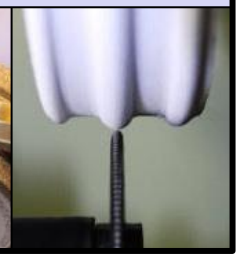
Einkorn, Mehrkorn, Abrichtfliese



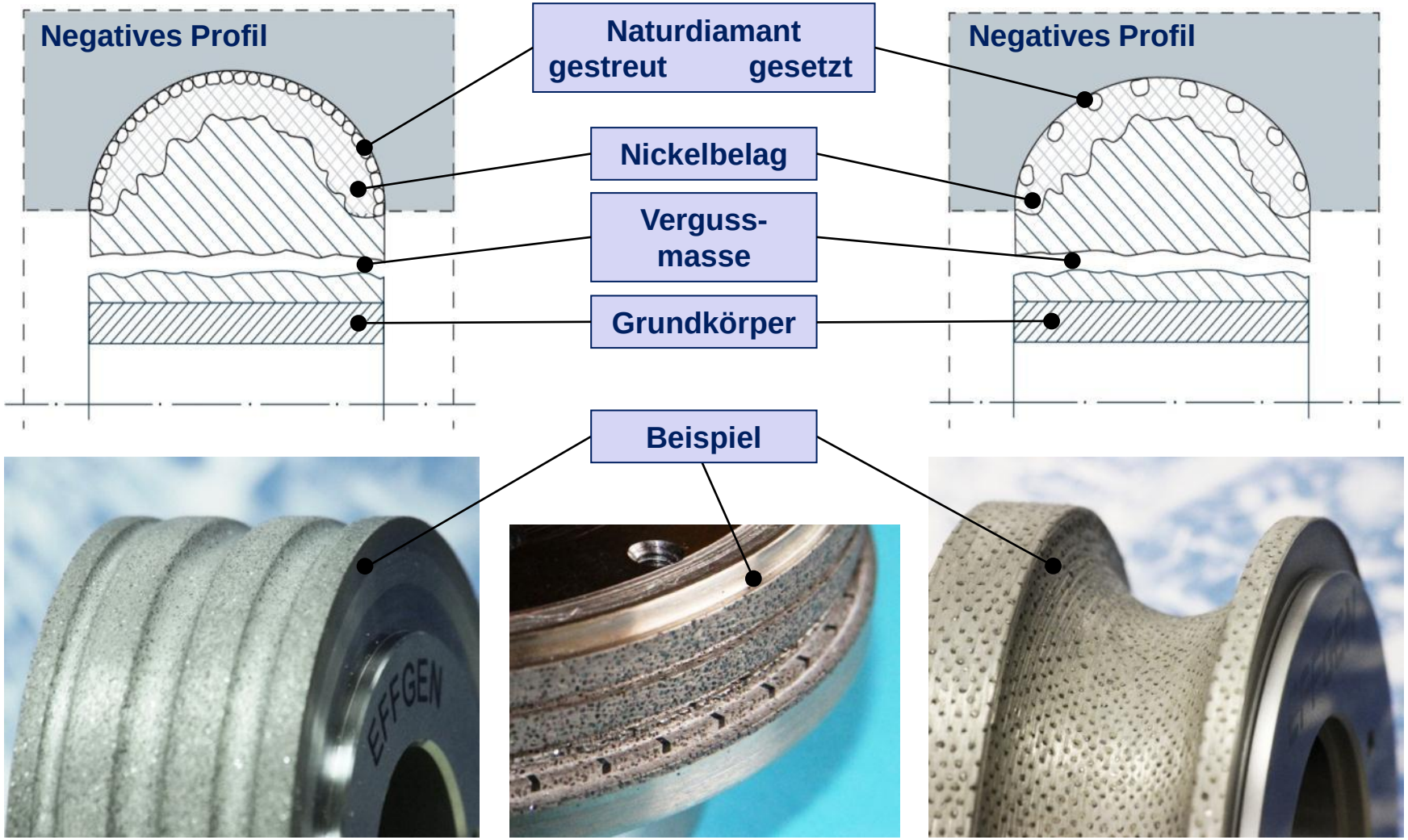
Rotary

Abricht-Profilrolle

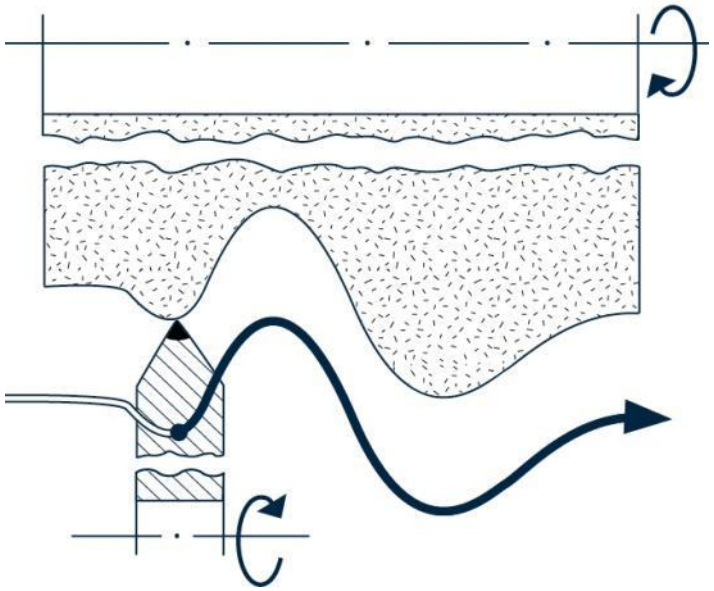
CNC-Formrolle

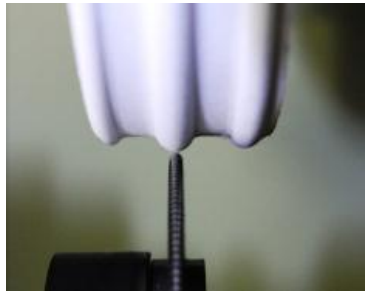


Negativ belegte Abricht-Profilrollen ermöglichen höchste Profil Genauigkeiten



Rotierende Abrichtrollen





Diamant Abricht-Formrolle

CNC gesteuertes Profilieren

Die Scheibentopografie wird bestimmt durch:

- Geometrie der Formrolle und eingesetzte Diamantqualität (CVD)
- Den aktiven Kontaktweg (Gleich-, Gegenlauf)
- Die Abrichtzustellung a_{ed}
- Das Geschwindigkeitsverhältnis q_d
- Die effektive Kontaktbreite der Diamanten b_d,
- Die Abrichtvorschubgeschwindigkeit v_{fad}, v_{frd}
- Der ÜberdeckungsgradU_d

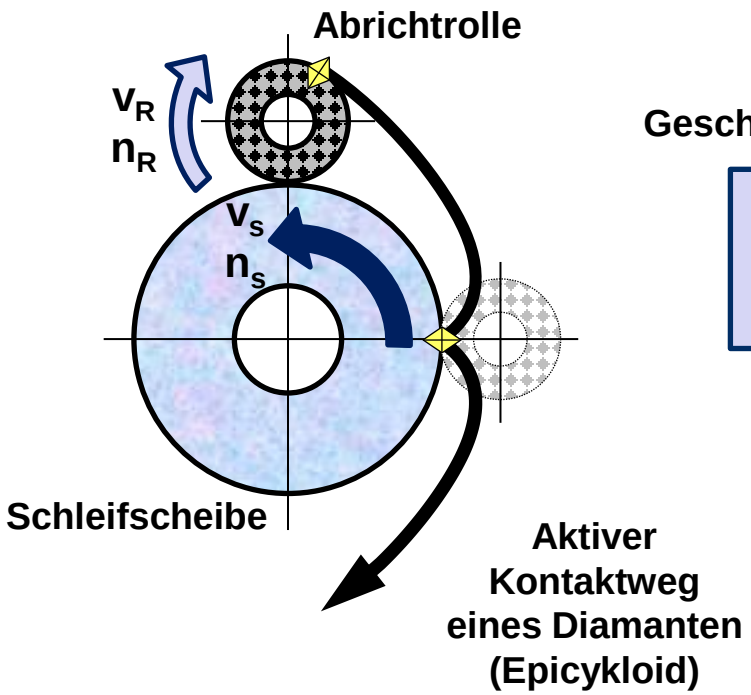
Standard Ausführungen von Abricht-Formrollen

Radial verschleißend
Kein Nachschliff
b_d ~ Dia. Korngröße
Standard für ker. CBN
Kostengünstig

verschleißfest
Kein Nachschliff
b_d einstellbar
Al2O3 / ker. CBN
Mittlere Preiskategotie

Hohe Verschleißfestigkeit
Ca. 5x nachprofilierbar
b_d präzise eingestellt
Al2O3/ ker. CBN
Relativ teuer

Gleichlauf, $q_d > 0$

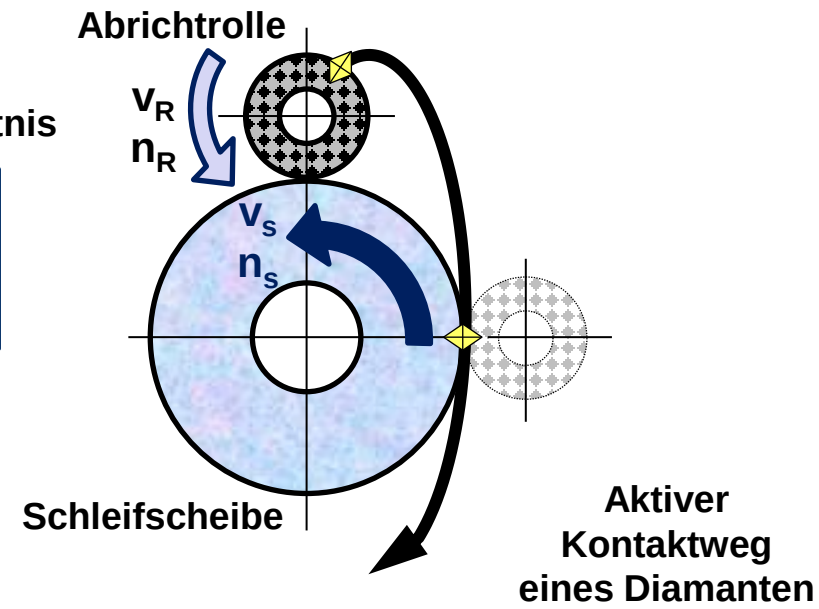


Kontakt fast senkrecht zur Scheibenoberfläche

Geschwindigkeitsverhältnis

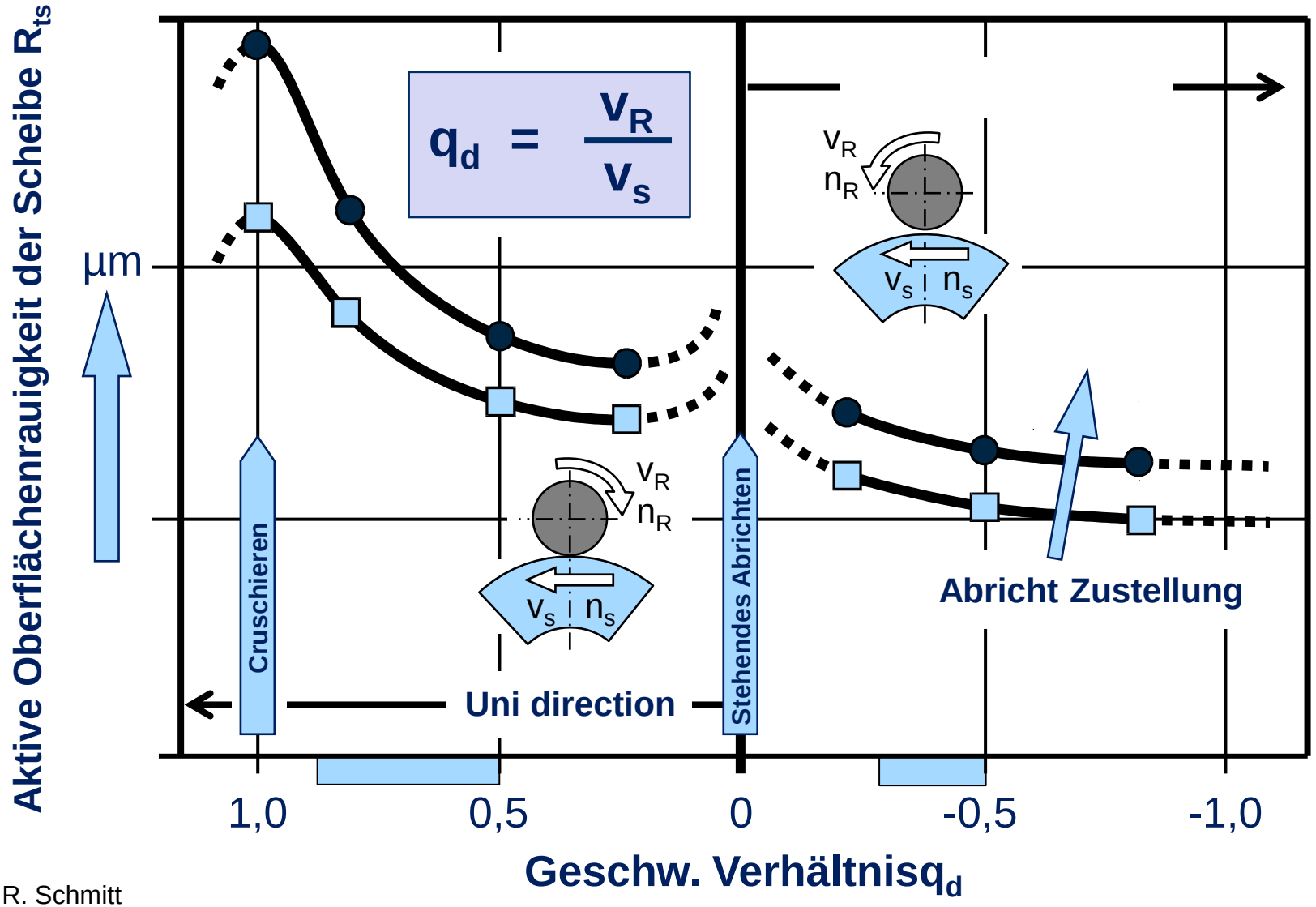
$$q_d = \frac{v_R}{v_s}$$

Gegenlauf, $q_d < 0$

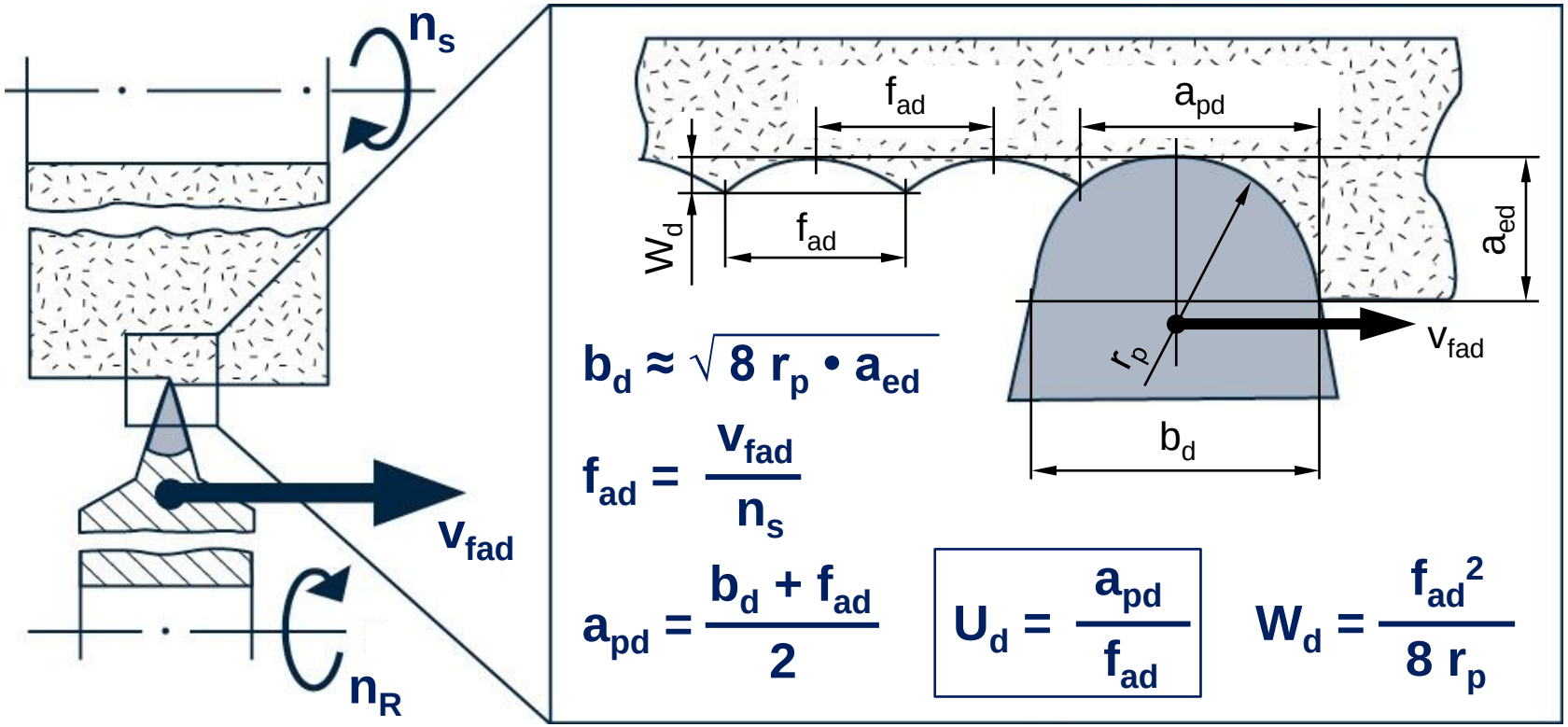


Tangentialer Kontakt zur Scheibenoberfläche

nach U. Harbs



nach R. Schmitt



$$b_d \approx \sqrt{8\, r_p \cdot a_{ed}}$$

$$f_{ad} = \frac{v_{fad}}{n_s}$$

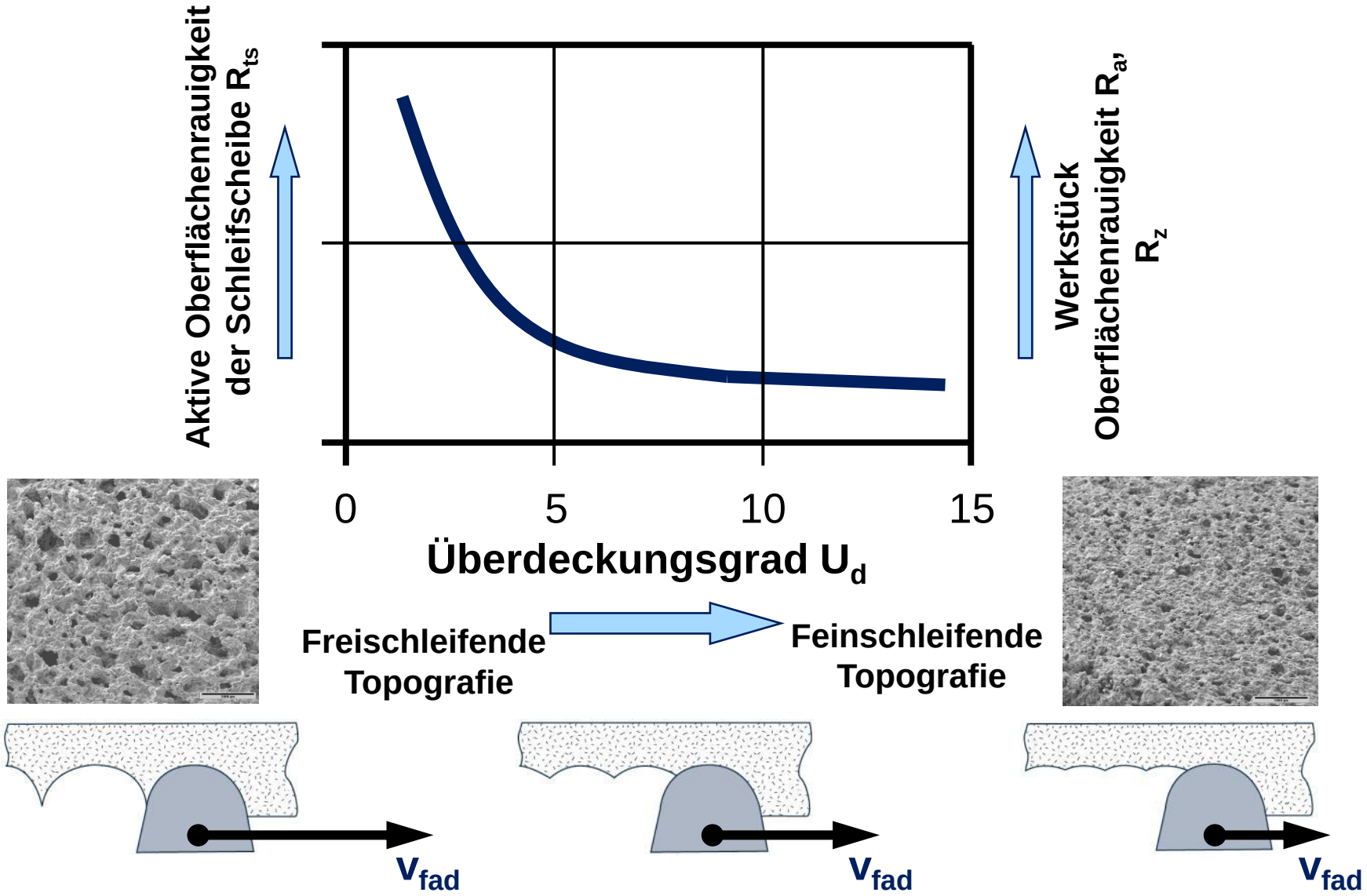
$$a_{pd} = \frac{b_d + f_{ad}}{2}$$

$$U_d = \frac{a_{pd}}{f_{ad}}$$

$$W_d = \frac{f_{ad}^2}{8\, r_p}$$

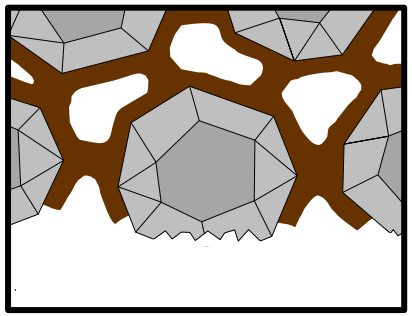
b_d: Effektive Kontaktbreite in mm
r_p: Profilradius in mm
a_{ed}: Abrichtzustellung in mm
f_{ad}: Vorschub pro Scheibenumdrehung in mm
n_s: Drehzahl Schleifscheibein min^{-1}

v_{fad}: axiale Abrichtvorschubgeschw. in mm/min
a_{pd}: Kontaktbreite in mm
U_d: Überdeckungsgrad
W_d: theor. axiale Welligkeit in mm

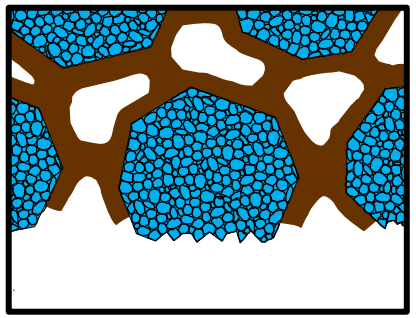


Abrichttechnik – Abrichtparameter Überdeckungsgrad

Typische Abrichtzustellungen
(In Abhängigkeit der Korngröße)

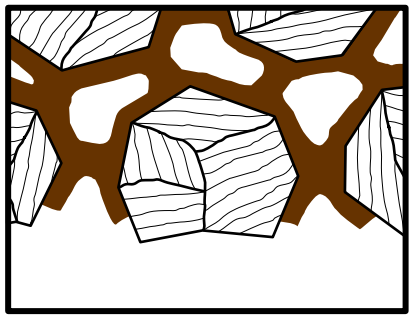


CBN
- Standard 1 µm bis 5 µm per Abrichtzyklus
- Gesamter Abrichtbetrag ca. 10 % der CBN Korngröße

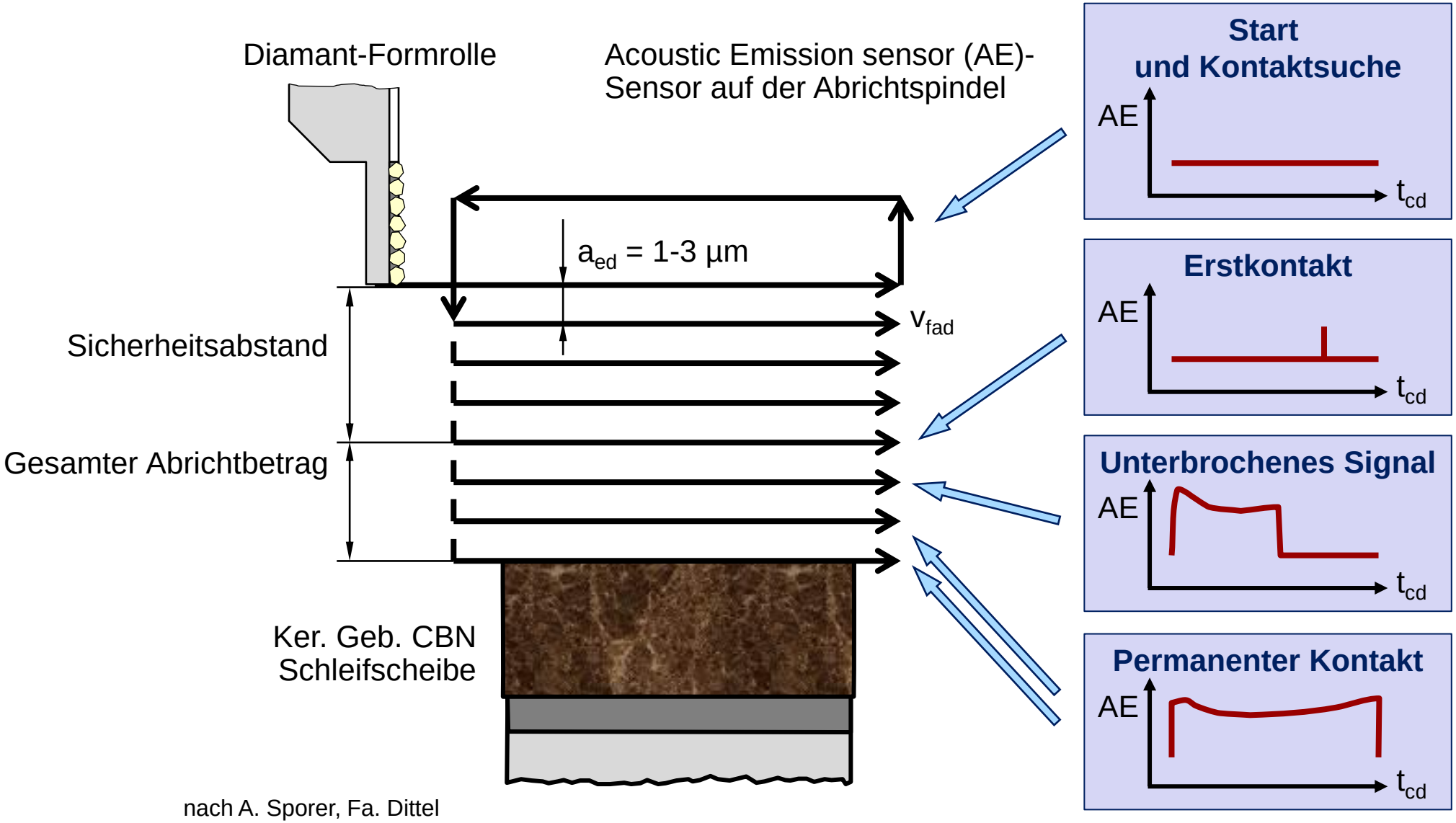


Al2O3 (SG, Cubitron)
- Standard 5 µm bis 20 µm per Abrichtzyklus
- Gesamter Abrichtbetrag ca. 20 - 50 % der Korngröße

Normalkorund
- 10 µm bis 40 µm per Abrichtzyklus
- Gesamter Abrichtbetrag ca. 50 - 120 % der Korngröße



Eine Erhöhung des Abrichtbetrages führt zu...
- Anstieg der Scheiben Oberflächenrauigkeit R_{ts}
- Zunehmender Verschleiß von Schleifscheibe und Abrichtrolle

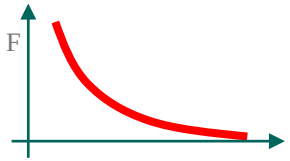
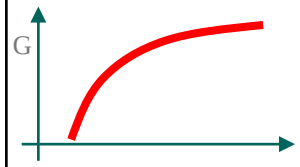
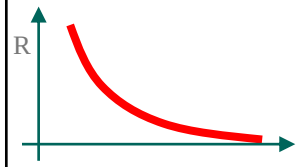
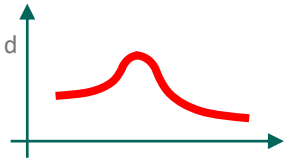
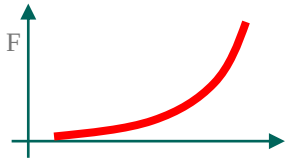
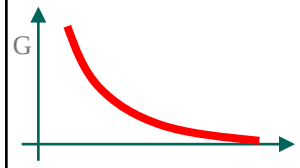
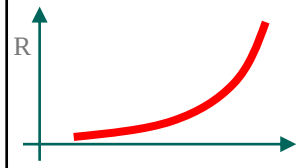
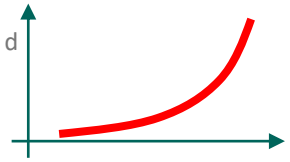
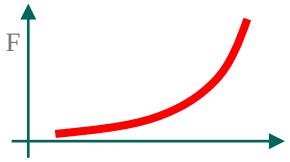
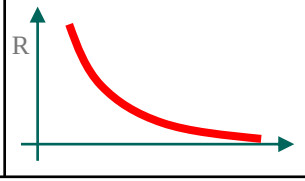
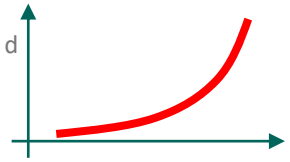


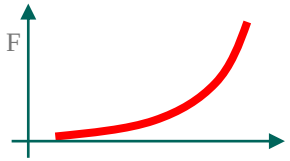
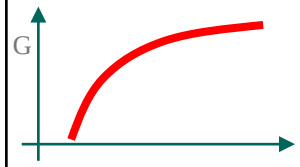
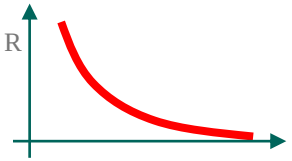
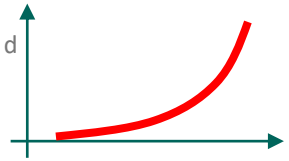
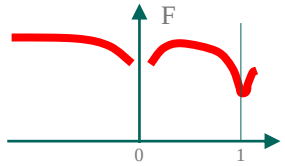
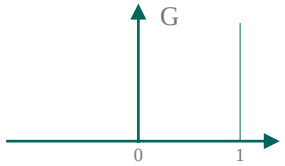
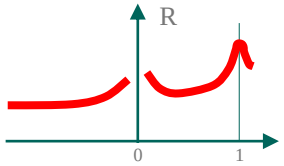
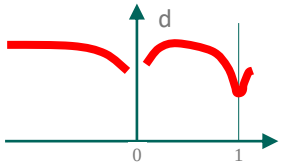
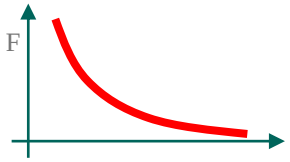
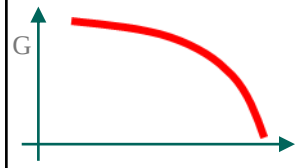
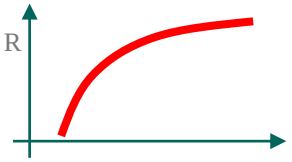
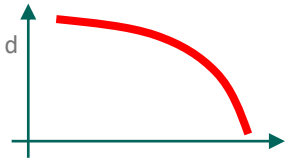
nach A. Sporer, Fa. Dittel

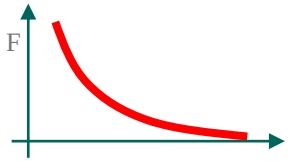
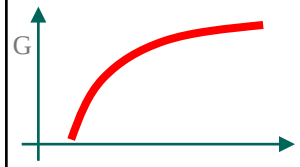
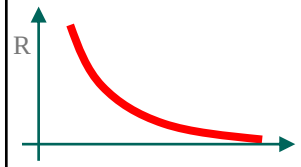
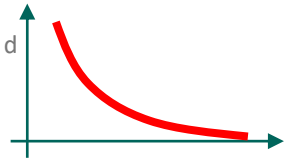
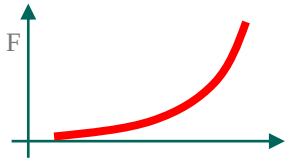
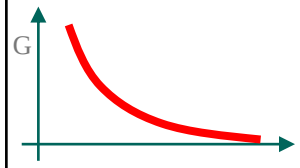
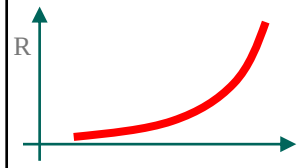
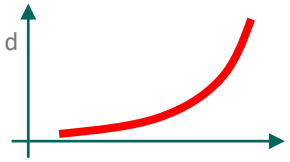
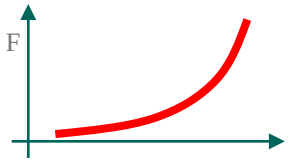
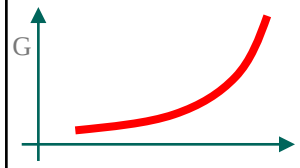
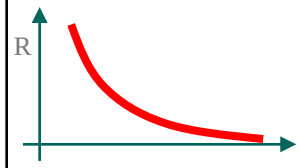
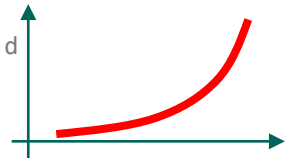
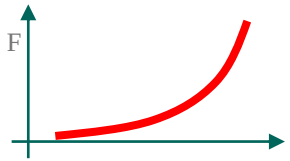
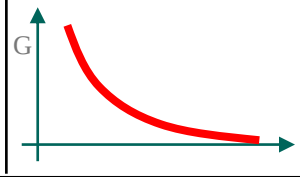
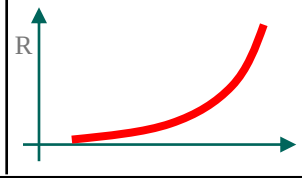
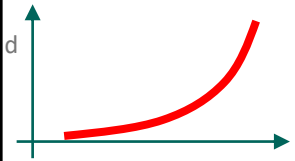
Abrichttechnik - Touch dressing

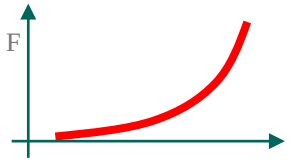
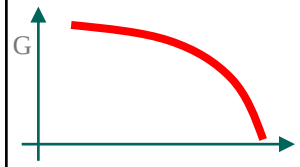
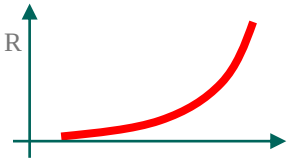
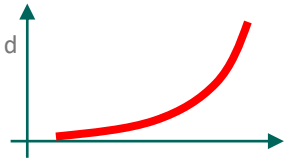
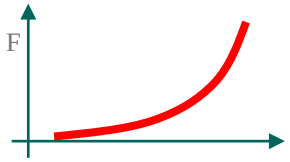
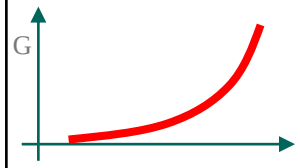
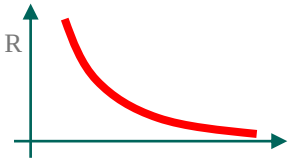
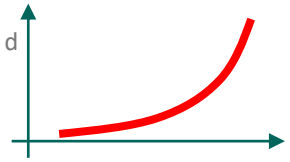
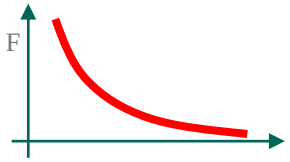
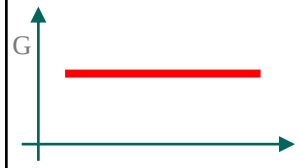
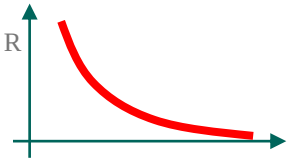
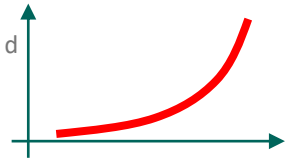
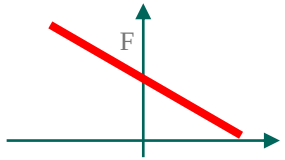
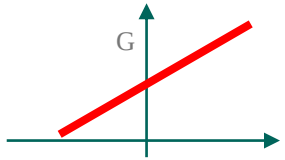
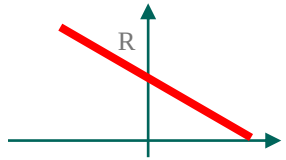
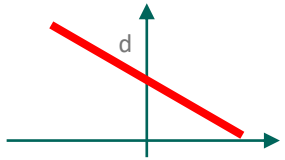
Agenda

- Schleifprozess - Übersicht
- Schleifkörnungen
- Bindungstechnik
- Konditionieren von Schleifwerkzeugen
- **Einfluss Schleifparameter**
- Kühlschmierung

	Dimensions- und Profilgenauigkeit		Oberflächen-Güte	
	Schleif-Kräfte F	**G-Wert**	**Rauheit R**	**Tempe-ratur d**
Schnittgeschwin-digkeit v_c				
bez. Zeitspan-volumen Q_w‘				
Kontakt-Länge l_k				

	Dimensions- und Profilgenauigkeit		Oberflächen-Güte	
	Schleif-Kräfte F	**G-Wert**	**Rauheit R**	**Tempe-ratur d**
Überdeckungs-grad U_d				
Geschwindig-keitsquotient q_d				
Abricht-Zustellung a_{ed}				

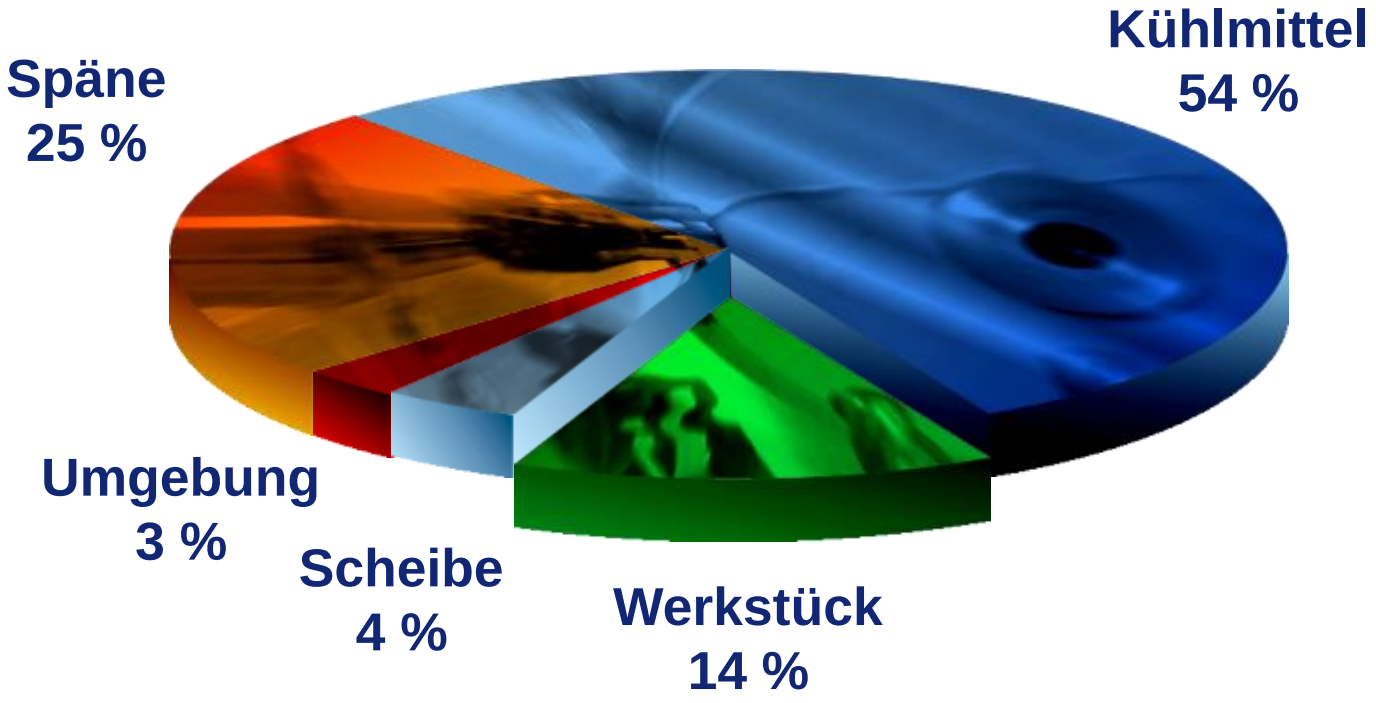
	Dimensions- und Profilgenauigkeit		Oberflächen-Güte	
	Schleif-Kräfte F	**G-Wert**	**Rauheit R**	**Tempe-ratur d**
Zerspanbarkeit				
Aufmaß a_e				
Härte				
Span-Länge l_{Span}				

	Dimensions- und Profilgenauigkeit		Oberflächen-Güte	
	Schleif-Kräfte F	**G-Wert**	**Rauheit R**	**Tempe-ratur d**
Fremdpartikel-Anteil				
Öl-Anteil				
Viskosität				
Strahl-Justage Düsen-Design				

Agenda

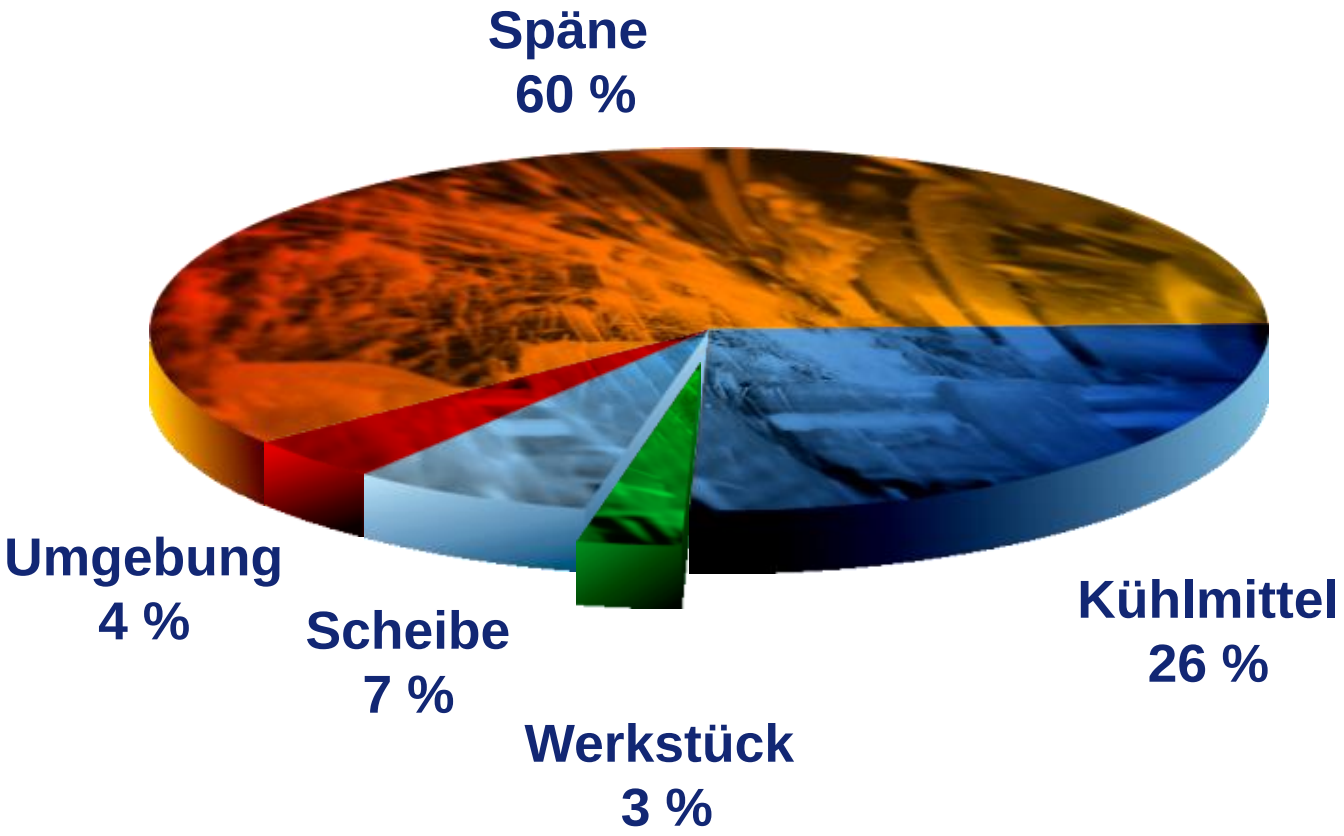
- Schleifprozess - Übersicht
- Schleifkörnungen
- Bindungstechnik
- Konditionieren von Schleifwerkzeugen
- Einfluss Schleifparameter
- **Kühlschmierung**

Auf den Prozeß gut abgestimmte Kühlbedingungen



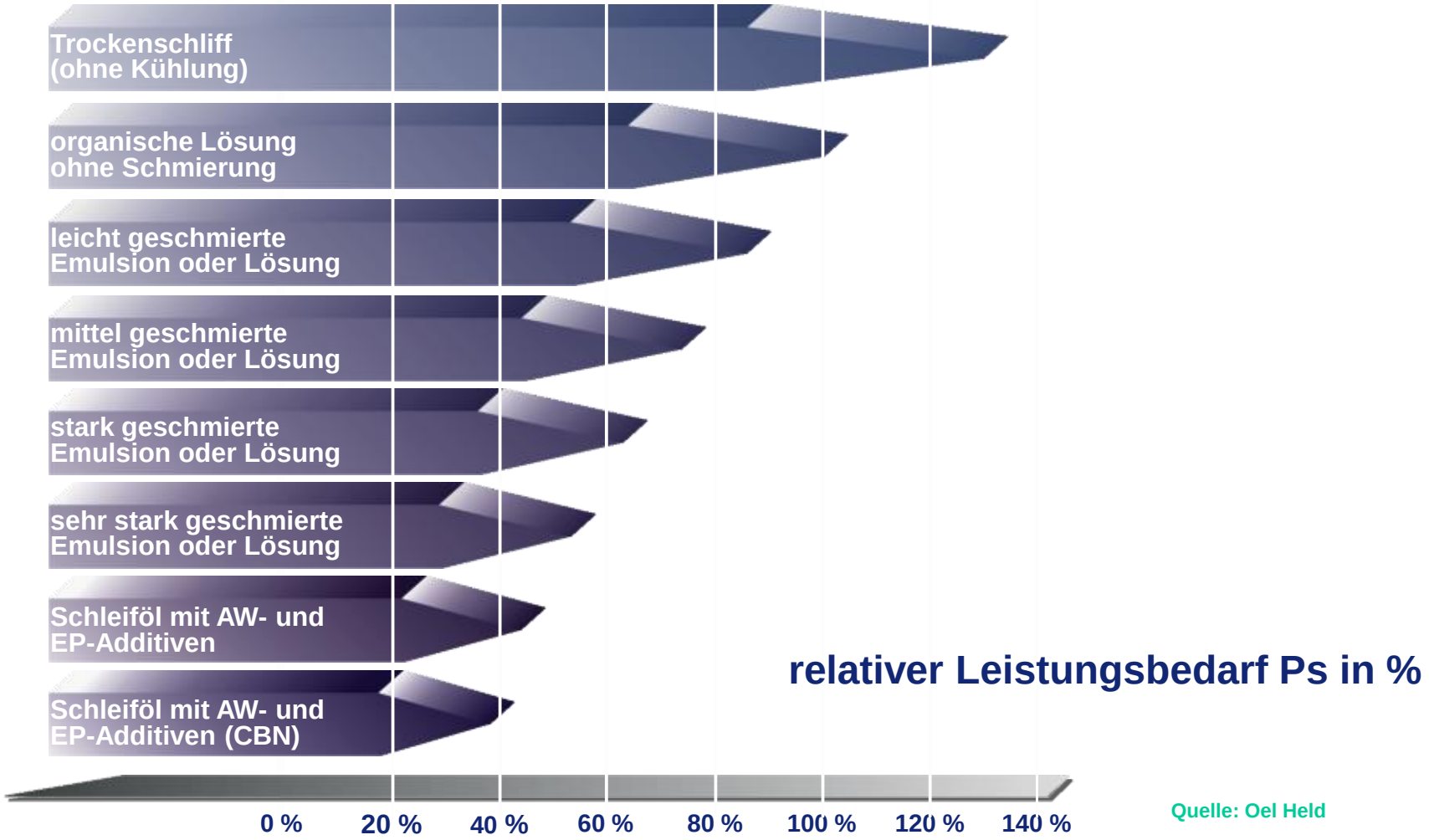
Quelle: Oel Held

Optimale Kühlbedingungen sind hier eine absolute Voraussetzung



Quelle: Oel Held

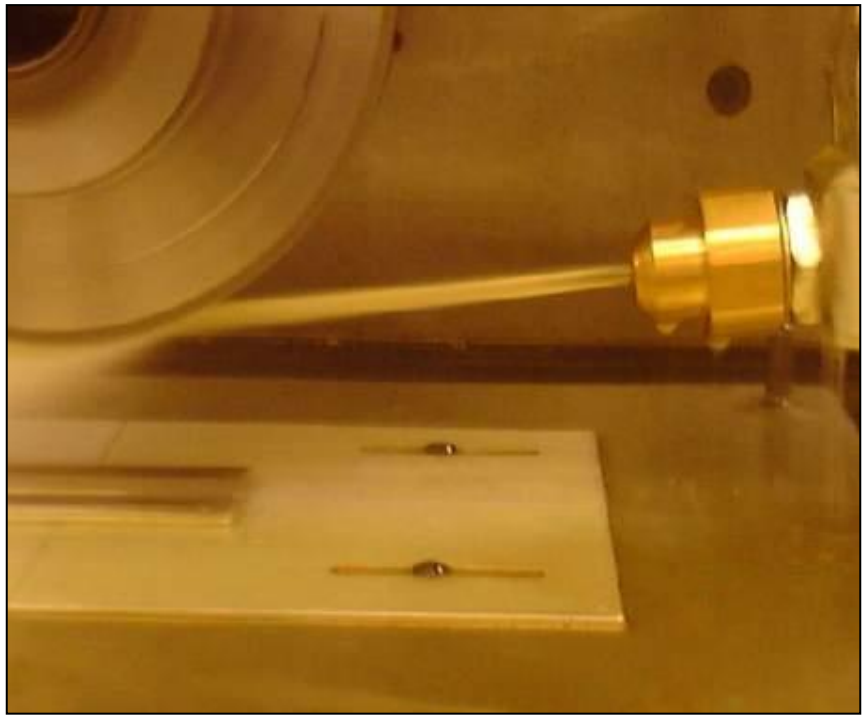
Als Basis (100 %) wird von ungeschmierter organischer Lösung ausgegangen



Quelle: Oel Held

Kühlschmierung - Leistungsbedarf der Kühlschmierstoffe

turbulente Strömung



kohärente Strömung

Kühlschmierung – KSS Zuführung

EFFGEN Schleiftechnik LAPPORT

Vielen Dank für Ihre Aufmerksamkeit