Basics to know about threading

Information & practical advice

Until now the technical term for threading was „thread cutting“. Due to diverse alloys in almost all fields of applications the term “thread forming” has likewise been established. Therefore we chose “threading” for both applications.

What to take care of at threading

Basically essential is the right selection of the tool, and with it the „geometries and coatings of the threading tool“ and the resulting influences on its practical impact concerning the material (from thermoplastics to carbide materials) in process.

Moreover important are depth of thread (e.g. more than 1.5 D), cutting speed and lubrication (formula of lubricant) in order to favorably influence the smoothness of the chip flow and the quality of the thread including accuracy to gauge.

As besides the technique, which ought to ensure optimum production results – also profitability and the documentation of the production play a major role – we are determined to take up the most important issues of this study and expose its complex contexts.

Subsequently we will also cover questions designed to user specifications, e.g. working with thermoplastics and the according lubrication.

This study is constantly updated on our Internet homepage www.microtap.de

For further information’s about our new **TTT Tapping-Torque-Testsystem** incl. the new **“Screening and analysis-software”** WinPCA3 please see our special website www.tapping-torque-test.com

Access to this forum is provided for customers when signing up.

Special thanks to EMUGE GmbH for its support and provision of photographs

1. Topics

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tip

If you are especially interested in particular issues, please let us know and send an email to mailto: http://www.microtap.de
http://www.threadtapping.com

You also may sign up for information-letters which will be sent to you right after release.

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2. Technology

The first perception is: there are no basically or universal valid formulas in order to generally determine the proper tool and / or the optimum cutting speed. Only experience combined with specific research will enable you to determine production parameters and type of tool for optimized production.

3. Types of threads and threading procedures

3.1. Tool technology in detail

3.1.2. Types of threads meant for interior- & exterior threads

- Attachment threads — Seized threads / screw – nut
- Moving threads — Lead spindle / steering gear / adjustment thread
- Transportation threads — Extruder / worm conveyor
    - Construction forms
    - Core hole forms / bolt form
    - Basic forms
    - Geometry
        - Pitch
        - Form and direction of chip flute
        - Tap point [lead] angle
        - Free angle at tap point [lead]
        - Chip angle
        - Gating [chamfered lead] angle
        - Free angle in thread
        - Relief cut of thread
        - Width of web [width of cutting edge]

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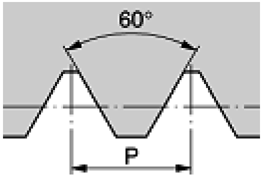
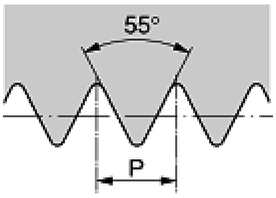
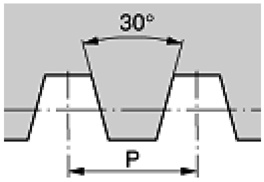
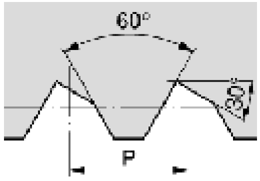
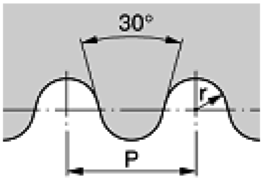
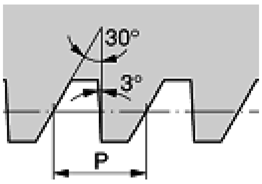
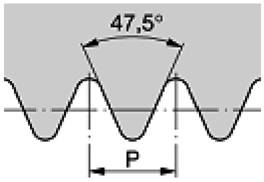
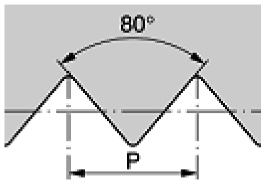
3.2. Types of threads

M, MF, UNF/UNC	Whw-R (G), BSF	Trapeze (DIN 103)	Self-Lock
			
Round (DIN 405)	**Sawing (DIN 513)**	**BA**	**Pg (DIN 40430)**
			

3.3. Thread procedures

- Thread drilling / -cutting
- Thread forming / -grooving / -pressing
- Thread milling
- Thread chasing
- Thread whirling
- Thread rolling

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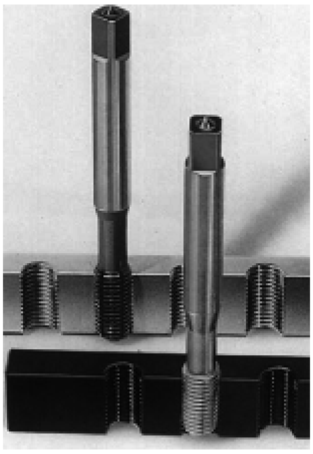
3.4. Interior threads

Thread drilling / cutting	**Proceeding features**
	• Chipping [machining] procedures • Continuous cut • Interior processing • Machining by succession of cutting edges step by step => „rotator chip clearance“ • Suitable for materials of HSS-E up to about 40 HRC, of carbide metal up to about 60 HRC • Cutting material usually HSS-E, but also carbide metal
Thread forming	
	• Chip less procedures • Transformation process step by step • Interior processing • Creation of thread contour by displacement of material • Suitable for materials with a toughness up to about 1200 N/mm^2 and a fracture strain of 8% min. • „Cutting material“ usually HSS-E, but also carbide metal
Thread grooving	
	• Chip producing procedures • Interrupted cut • Interior and exterior processing • Removal of material by „spatial comma chip“ • Suitable for materials of carbide metal up to about 60 HRC • Cutting material usually carbide metal, but also HSS-E

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3.5. Exterior threads

Thread cutting	**Proceeding features**
	• Chip producing process • Continuous cut • Exterior proceeding • Machining by succession of cutting edges step by step => „rotator chip clearance“ • Suitable for materials of HSS-E up to about 40 HRC, of carbide metal up to about 60 HRC • Cutting material usually HSS-E, but also carbide metal
Thread grooving	
	• Chip producing procedures • Interrupted cut • Interior and exterior processing • Removal of material by „spatial Comma chip“ • Suitable for materials of carbide metal up to about 60 HRC • Cutting material usually carbide metal, but also HSS-E
Thread rolling	
	• Chip less procedures • Transformation process step by step • Exterior processing • Creation of thread contour by displacement of material • Suitable for materials with a toughness up to about 1200 N/mm^2 and a fracture strain of 8% min. • Thread rolling material“ made of 1.2379, also HSS possible

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4. Basics of tool geometry

4.1. Topical issues

· Terms of tool geometry, graphical description & terms

· Gating [lead] / Type A

· Types B & C

· Types D & E

· Flanks / teeth of cutting tools

· Relief grinding

· The flute-forms of the tool

4.2. Projected topics

· Preturn gating [chamfered lead]

· The selection of the proper tool

· The difference of the tools in thru- hole (TH) and ground hole (GH)

· Influence of material and geometry of tools

· Influence of resistance & fracture strain of materials
at processing, and the tools to be used

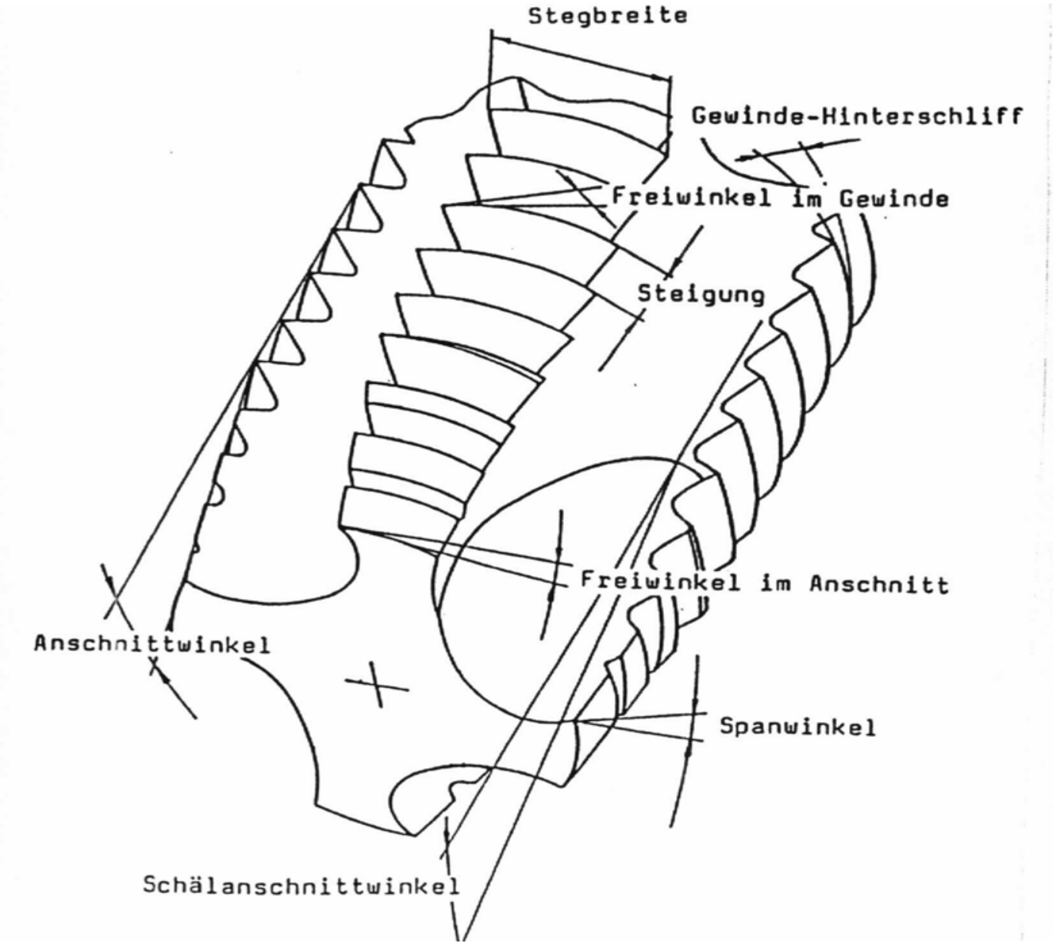
· Diploma dissertations about thread cutting & -forming

· Torque

· Advantages of thread forming

5. Terms of tooth [cutting edge] geometry

5.1. Graphical description and terms



1.Width of cutting edge [web]; 2. Thread-Relief grinding; 3. Free angle in thread; Pitch;
4. Free angle in lead; 5. Lead angle, Chip angle; 6. Chamfered lead angle

Pitch	depending on size of thread
Gating [lead] angle	**Type A - E**

Preturn gating [chamfered lead] angle
Chip angle
Free angle at gating [lead]
Free angle in thread, flank / exterior diameter (=relief grinding)
Width of web [width of cutting edge]

5.2. Gating [The Lead]

The gating [lead] geometry determines for which kind of application the tool is suitable; it also

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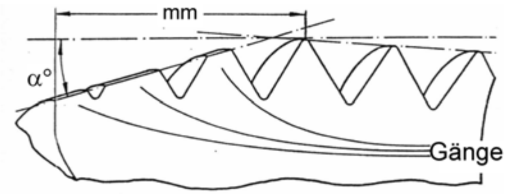
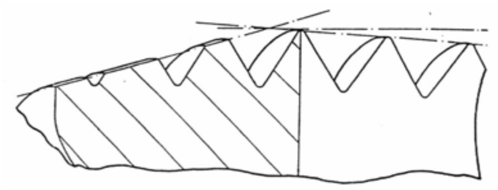
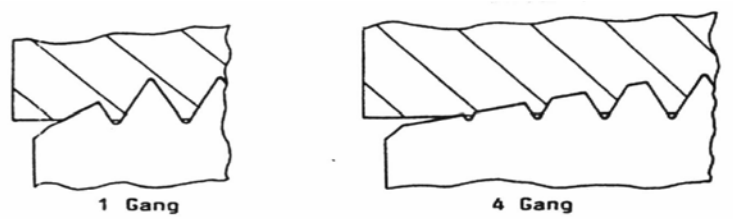
has a significant impact on tool life.



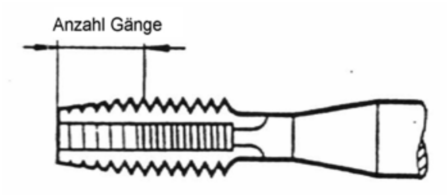


The chips will be removed according to the number of gating [lead] teeth; this impacts the accuracy to gauge and the distribution / workload of torque to the tool and its life. A high torque is equal to higher risk of breakage [fracture].



	1 winding	**4 windings**
Torque	small	high
Quality of thread	low	high
Type of chip	thick / strong	thin / weak
Load to gating [lead]	very heavy	low

The type of gating [lead] and its length are standardized. According to DIN 2187 you distinguish between the types A to E according to the number of gating [lead] windings [teeth]



Type A — 6-8 windings [teeth]

Characteristics: clean flank surface / good quality,
precise concentricity / alignment necessary

Employment: short thru-holes

tip

Do not use for deep thru-holes
Short tool life / risk of breakage [fracture]

5.3. Types B and C

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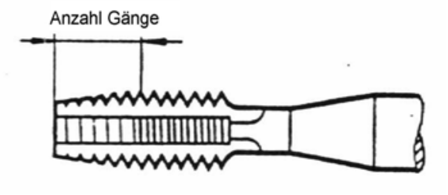


Type B

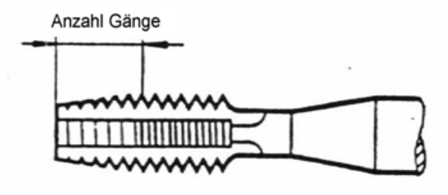
3,5 - 5 windings [teeth]

Characteristics: additionally chamfered lead, effective chip transportation low flute blockage [jamming]

Employment: Standard thru-hole thread tapping tool

tip

For tough materials
Also suitable for deep drilled ground holes



Type C

2 - 3 windings [teeth]

Characteristics: Standard for ground-hole threads with short thread-exit

Employment: Ground-hole thread tapping tool

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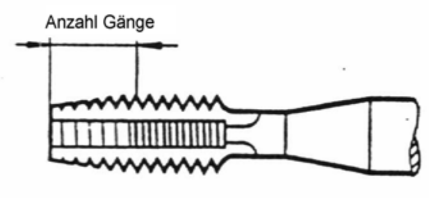
5.4. Types D and E



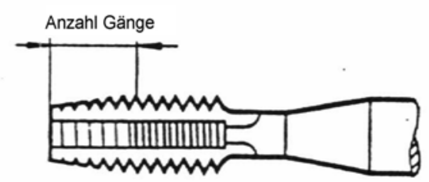
Type **D** 3,5 - 5 windings

Characteristics

Employment: Medium cutter for handheld tapping tools

tip

Don’t use as a machine tool except for
thru-holes, or deep drilled ground-hole threads



Type **E** 1,5 - 2 windings

Characteristics: For short ground-hole threads only
Great machining volume / high torque

Employment: Ground-hole tool for very tough materials

5.5. Summary:

For thru-hole threads usually use Type B

For ground hole threads usually use Type C

For special applications use types A / D and E

tip

With thread tapping machines of **micro**tap you’ll find out yourself – like a specialist – if and when these tools will be of advantage as far as quality, accuracy to gauge and tool life is concerned.

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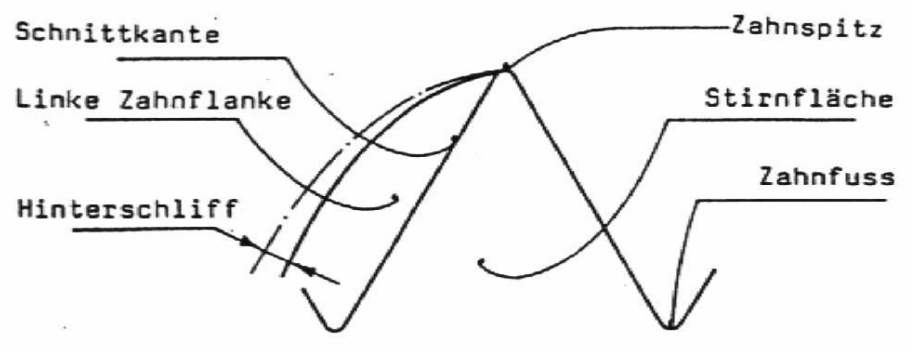
5.6. The tooth

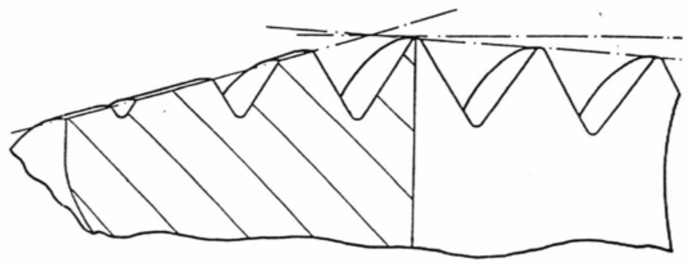
The tooth of a tapping tool is defined by the end face and it’s both tooth flanks.

The width of a tooth is also called “web” [“width of cutting edge”]



Cutting edge; Left tooth flank; Relief grinding; Tooth peak; end face; Tooth bottom

Basically you distinguish between gating [lead] “before” and “behind” the tooth [cutting edge]. While cutting, the tooth located in front of gating [lead] is centering the core drilling while threading. The teeth behind gating [lead] serve solely as guide ways and usually taper toward the shaft in order to avoid friction and jamming chips.



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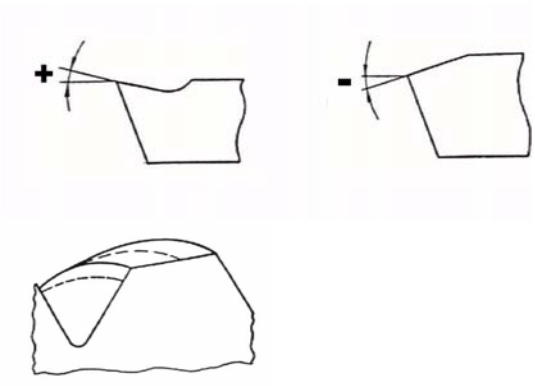
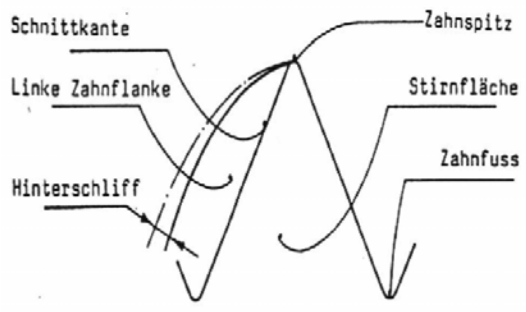
5.7. Relief grinding

The finesse of relief grinding at gating [lead] basically differs from relief grinding of the teeth in the thread, which solely serve for stabilization and guide way.

Relief grinding of tap point [lead] geometry

Spiral fluted tools for ground-hole threads have a strong positive cutting angle on their left flank, as the right flank consequentially provides a negative cutting edge. De facto this ends up with scruffy surfaces and shortened tool life.





Cutting edge; Left tooth flank; Relief grinding;
Tooth peak; End face; Tooth bottom

For ground-hole tools the gating [lead] teeth are relief grinded in order to provide optimal chip removal.
It is the finesse of the tool manufacturers to produce two totally different kinds of relief grindings: either the so-called profile relief grinding or the flank relief grinding, sometimes even a combination of both procedures.

Relief grinding in the thread

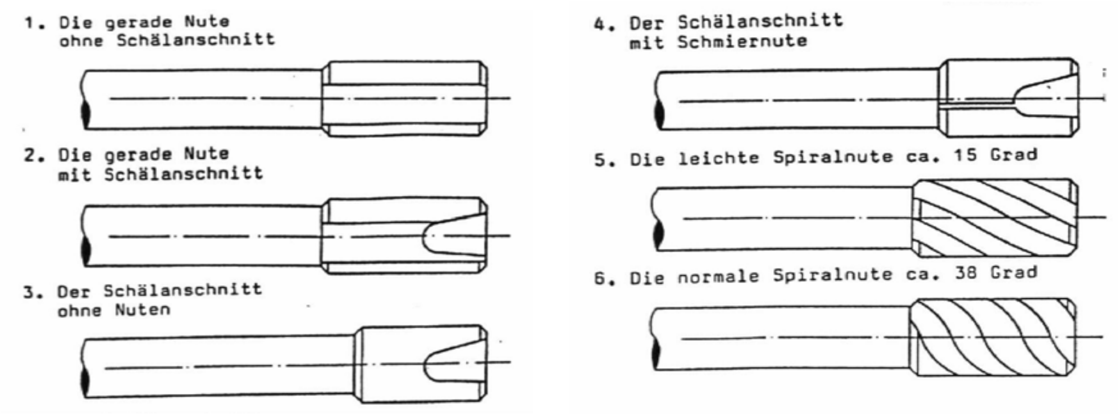
has the very important task to minimize the friction of the guiding teeth. Dependent on relief grinding of tooth, regarding the left as well as the right flank, the specially manufactured tools are crucial for the materials in process, especially regarding their fracture strain and cutting property.

Generally we distinguish between 3 kinds of relief grinding

- Relief grinding, small — Employment: Materials of medium solidity alloy
- Relief grinding, large — Employment: Materials highly-alloyed and of high-strength as well as thin-walled and with high fracture strain
- Relief grinding, cylindrical — Employment: Materials with low fracture strain and good machining property as well as non smearing materials

5.8 Thread flutes

Basically we speak about 6 different <u>forms</u> of flutes



1. Straight flute without chamfered lead; 2. Straight flute with chamfered lead; 3. Chamfered lead without flutes; 4. Chamfered lead with lubrication flute; 5.Light spiral flute (about 15°); 6. Normal spiral flute (about 38°)

Thereby we distinguish between two <u>kinds</u> of flutes

1) **The flute form as chip removal flute**

The chip unrolls in the flute. In order to lessen resistance of chip removal the flutes are chamfered. In deep-ground flutes the chips are removed easily. The smaller core diameter that consequently comes along, significantly weakens the fracture torque of the tool. Many manufacturers produce such tools for thru-hole tools without lead but also for ground-hole tools with spiral flutes for small threads.

tip

Ground-hole tools with deep chip flutes easily remove the chips and generally require less torque at cutting, still producing better thread surface and quality. As the cutting torque is less, the torque of the gear has to be reduced, because the cutting torque of the tools is less than of those with deeper chamfered flutes.

The main application of these tools is best at ground-hole depth < 2 x D

2) **The flute form as lubricant feed at circulation lubrication**

The chamfered lead [gating] of the tool forwards the chips in direction of the cut. The flutes stay without chips and provide good lubrication when using tools with straight flutes plus a lead.

The number of flutes in ground-hole tools has an influence on the quality of the thread. If the thread has to reach the ground, a short lead is to be chosen. When number of teeth is increased, the thickness of chips will decrease and chip flow is eased. With proper cutting speed and lubrication jamming of chips can be avoided..

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6. Basics about thread forming
also called thread grooving or pressing

6.1 Procedures

- Chip less procedure
- Transformation process step by step
- Interior processing
- Production of thread contour by displacement of material
- Material usually HSS-E, but also carbide metal

6.2 Requirements

- Materials with a resistance up to about.1200 N/mm^2
  and a fracture strain of 8% min.
- At processing with feed spindle / enforced in feed normally an
  axial chargeback drill-chuck is required

6.3 Advantages

- No problems with chips
- Appropriate for larger thread depth
- High surface quality
- Appropriate for simple machines, also or multiple in feed machines
- High „circumference speeds“ possible
- Enlarged static and dynamic resistance of thread
- No axial „miss-cut“ of threads
- No loss of material
- High tool breakage security
- High tool life
- According to DIN 13-50 a larger core diameter is tolerated

6.4 To consider

- Burr formation [feathering] at the fold of form
- Larger pilot hole diameter than at cutting is required
- Keep to exact drilling of core-hole
- Torque is higher than at cutting
- Usually a high-class lubricant is required
- Bulging at entry and exit of thread
- No re-sharpening possible

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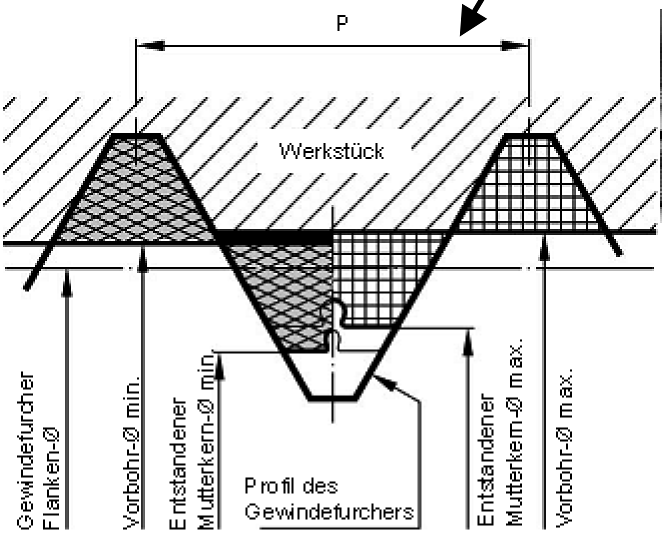
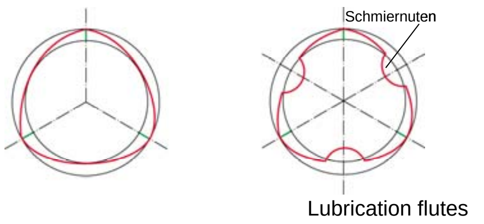
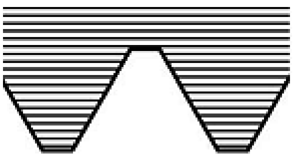
6.5 Principles of thread grooving



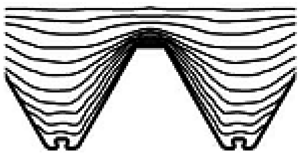


Cross-section profile of a thread groovier

6.6 Comparison / Difference



Fiber flow at thread cutting

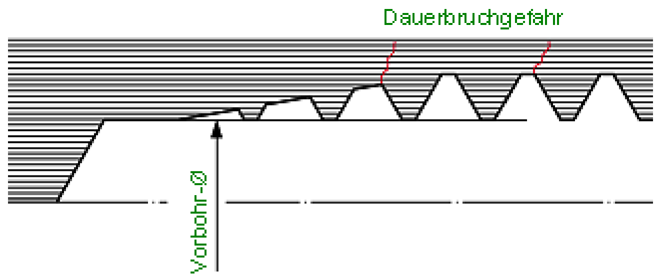


Fiber flow at thread forming

6.6.1 Advantages thread former

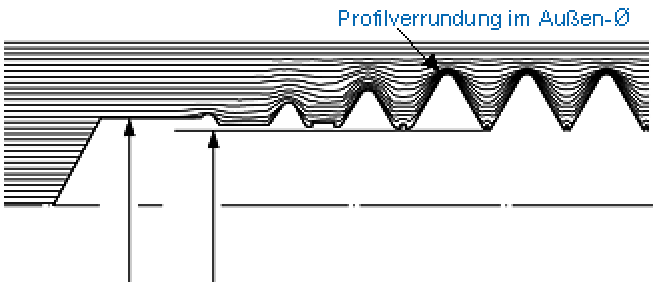
Cut thread profile

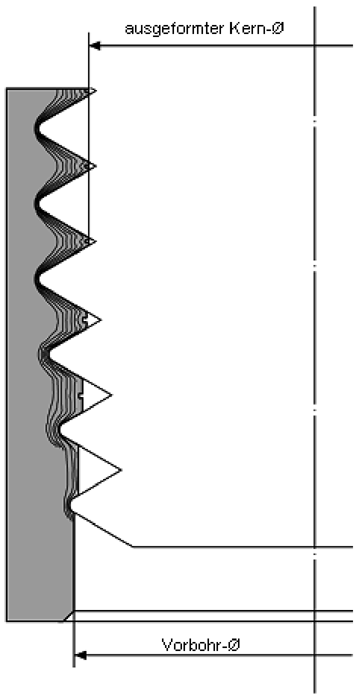
Geschnittenes Gewindeprofil:



Formed thread profile

Gefurchtes Gewindeprofil:





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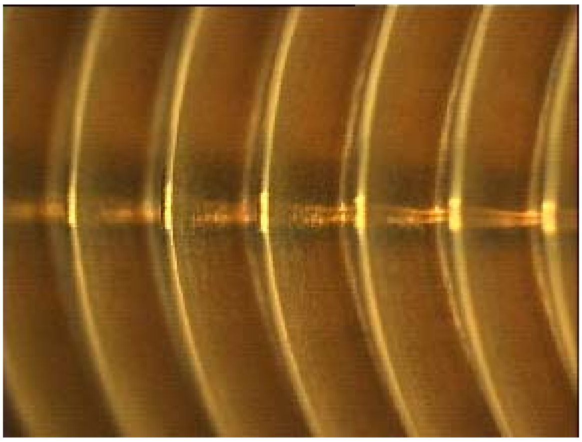
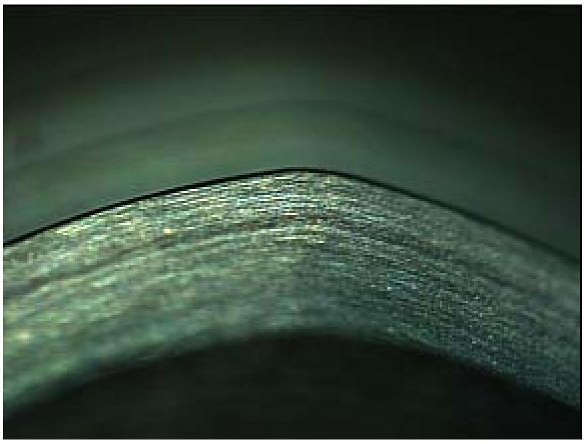
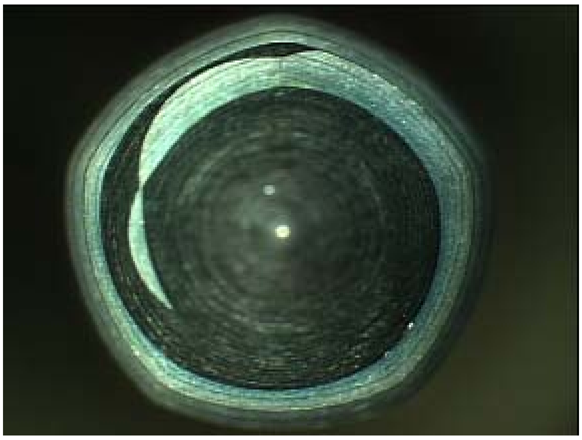
6.7 Polygon form & design of formed thread flanks / webs







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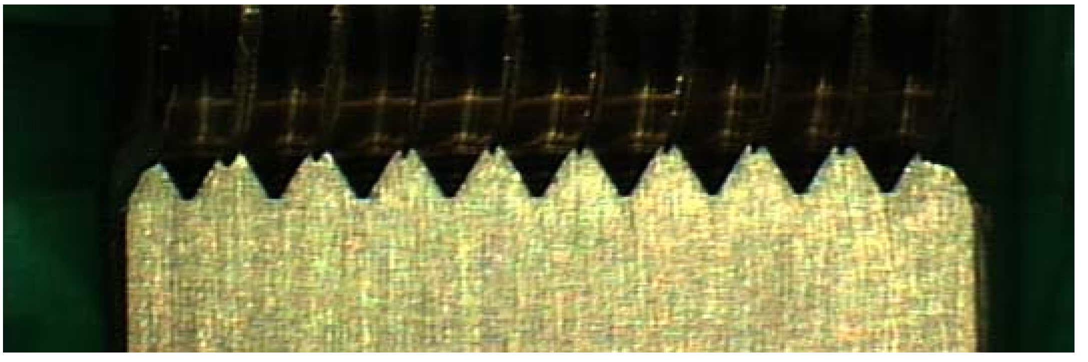
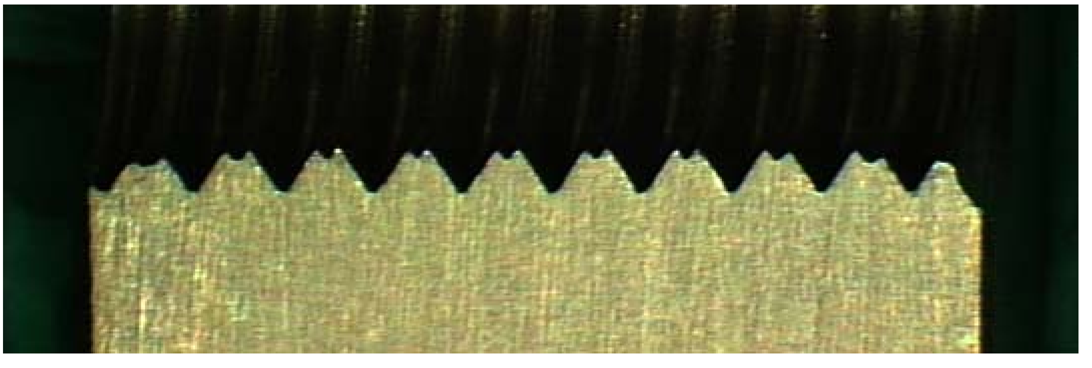
6.8 Effects & influences of tolerances of pilot hole core diameter

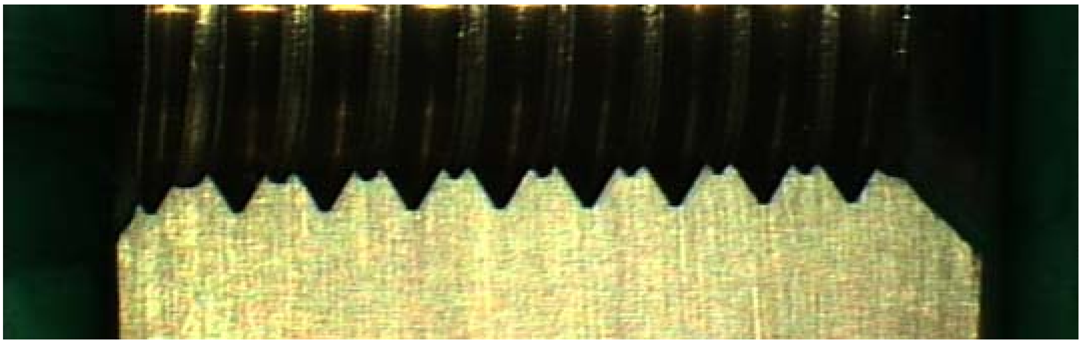
Material	**1.4571**	**Size**	**M10**
Pilot hole ø	9,25	Core-ø after forming	8,42
Identified torque	2670 Ncm	Core-ø-tolerance	8,376 / 8,75



Material	**1.4571**	**Size**	**M10**
Pilot hole-ø	9,30	Core-ø after forming	8,52
Identified torque	2000 Ncm	Core-ø-tolerance	8,376 / 8,75



Material	**1.4571**	**Size**	**M10**
Pilot hole-ø	9,35	Core-ø after forming	8,52
Identified torque	1670 Ncm	Core-ø-tolerance	8,376 / 8,75



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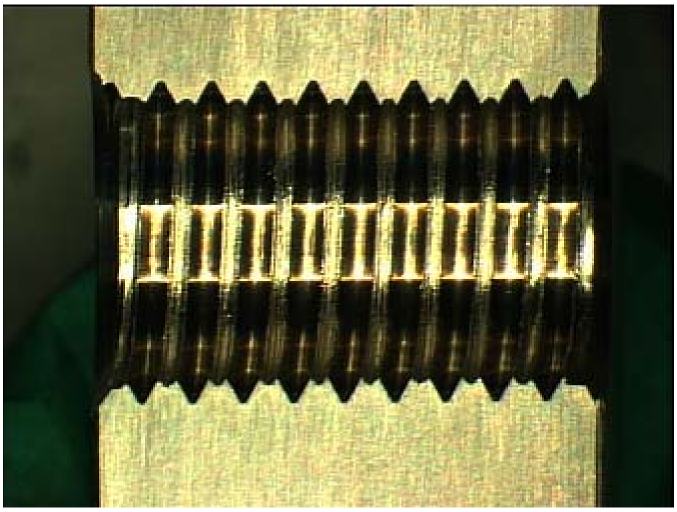
6.9 Effects of pilot hole diameter

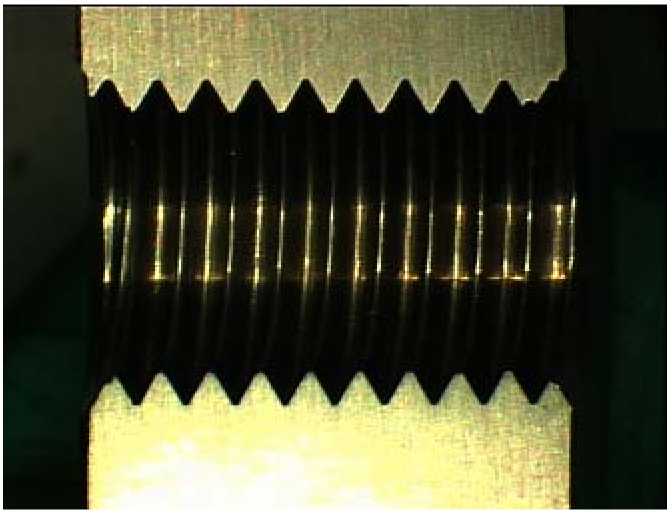
6.9.1 Not fully „formed“ thread profile and „over formed“ profile

Material 1.4571 / M10



Pilot hole ø:	9,40mm
Actual-core ø after forming	8,82mm
Must-core ø (DIN13 T.50)	8,376-8,750

- **Thread profile not fully formed**
- Core-hole-no-go plug-gauge insertable
- Identified torque 1500 Ncm



Pilot hole ø:	9,10mm
Actual-core ø after forming	8,15mm
Must-core ø (DIN13 T.50)	8,376-8,750

- **Thread profile is „over formed“**
- Core ø too small; go-plug-gauge can not be inserted
- Identified torque 4950 Ncm

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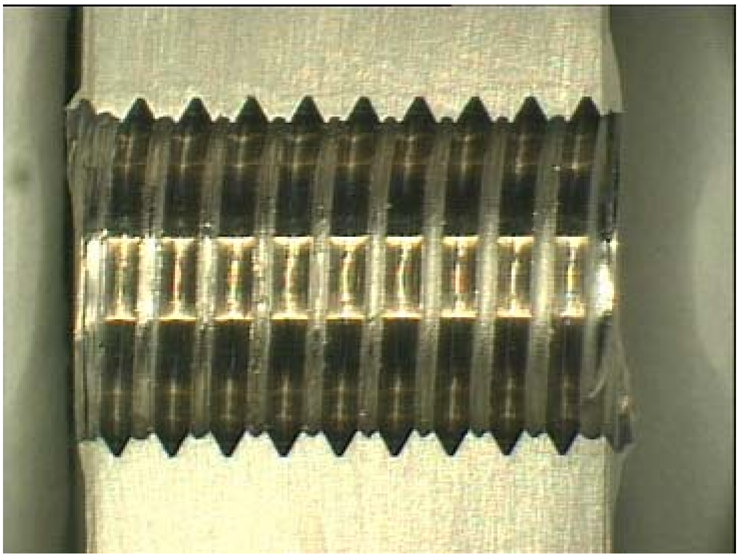
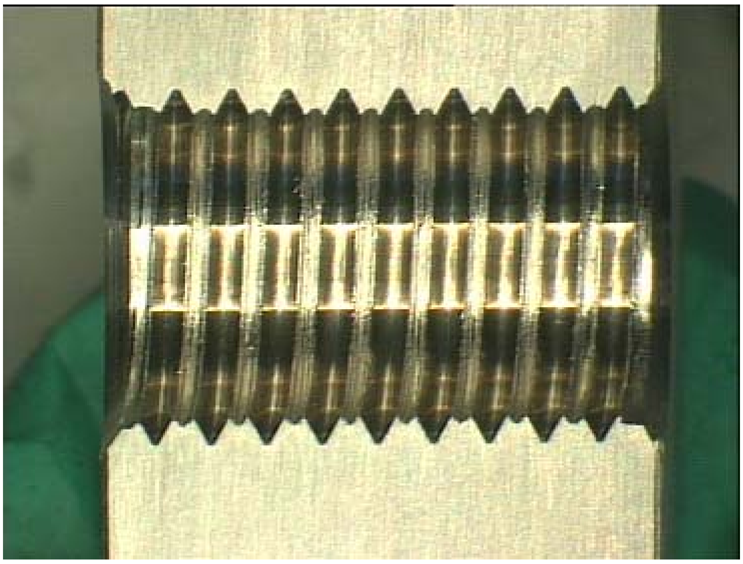
6.10 Spine bulging at thread forming

6.10.1 Impact of thread protection counter bore at thread forming

Not counter bored component with spine bulging at thread entry / exit



Counter bored component – no spine bulging



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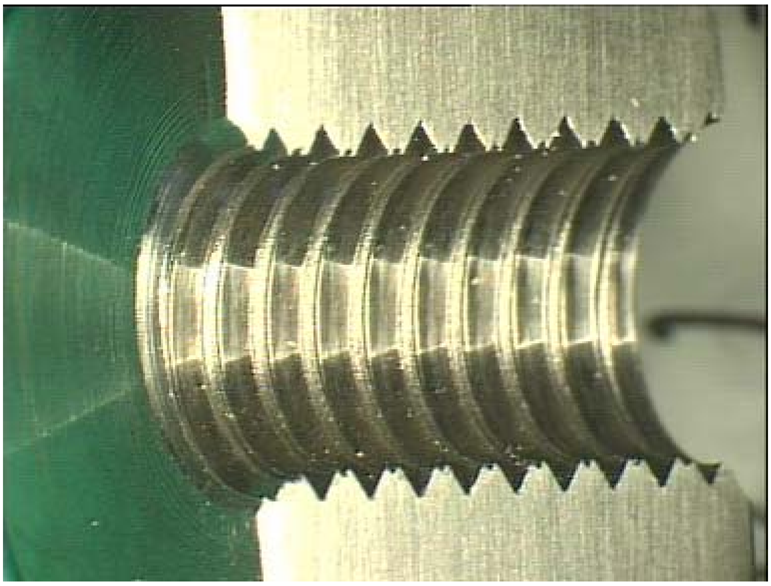
6.11 Thread quality of a formed thread

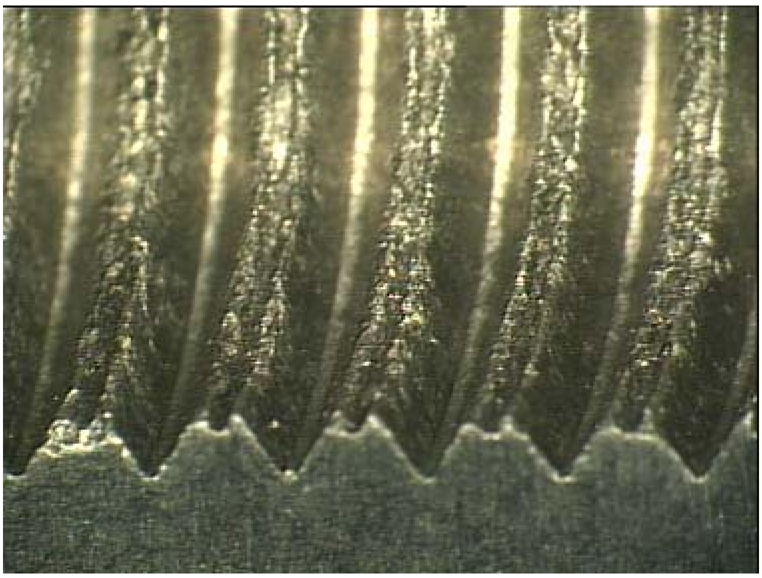
6.11.1 Which materials are suitable for thread forming?

Materials with a resistance up to about 1200 N/mm^2 and a fracture strain of 8% min.

Material 1.4571 - material floatable ➔ suitable for thread forming



Material GG30 – not flowable ➔ not suitable for thread forming



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7. Surface-treatment / Surface-coatings

7.1 Aims of surface-treatment

- Increase of abrasion- / friction resistance
- Decrease of friction in contact zone tool / work piece
- Decrease of heat conductance between tool / work piece material
- high chemical stability of tool teeth

Possibilities achieved

- Longer tool life
- Increase of cutting / forming speed

tip

Advantages include disadvantages

- Minimal infringements of surface cause increased risks of built-up edge
- and therefore significantly downsized tool life and gauge quality.

- Additional costs for coated tools can often be compensated by optimization / adjustment of cutting speed / rpm and the use of a suitable lubricant at constant supply of minimal-amount lubrication.

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7.2 Procedures of surface processing and coating

Ne Neutralization

By neutralization a protection of the surface against cold welding is accomplished. The cutting edges [teeth] are a hardly measurable chamfered.

Ne2 Vaporization / oxidation

In a vaporizer chamber the tool is treated with steam. That’s when an oxidation layer builds up (regular black). This oxide coating protects the surface and is a good carrier of lubricant. Cold weldings, which often occur in low carbon soft steels, are avoided.

NT Nitrify

With nitrogen supply (Tenifer treatment), using adequate salts, the surface develops a resistance of 1000 to 1250 HV-units within the range of 0.03 and 0.05 mm. As the surface becomes very hard and refractory, nitrated tools are good for ground-hole threads, respectively reverse cut, only to a limited extent.
In abrasive materials like gray cast iron, spherulitic graphite iron, aluminum cast as well as thermoset materials the number of threads is significantly increased.

NT2 Nitrify + Vaporisation / oxydation

The surface of the tools first is nitrified and then vaporized (NT + Ne2).

Cr Hard chrome plating

The hard chrome layer reaches a resistance of 1200 to 1400 HV-units. It shows excellent gliding properties. The layer measures about 2 - 4 µm. Especially with non-ferrous heavy metals und thermoset materials longer tool life’s are accomplished. Application in materials made of steel is not recommended. As at machining temperatures of 250°C often are exceeded, an adhesion of the coating is not guaranteed.

CrN Chrome nitride (silver-gray)

At PVD-processing (500°C) layers up to about 6 µm are accomplished. The resistance goes up to about 1750 HV. CrN-layer resists up to 700°C; especially when besides abrasion also corrosion resistance is asked for, CrN-coating is the best option.

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TiN Titanium nitride (gold yellow)

At PVD-processing (500°C) layers of 2 – 4 µm are accomplished. The resistance of about 2300 HV, good gliding properties and coating adhesion provide excellent tool life. This TiN-mono-layer is resistant up to 600°C.

TiN-T1 Titanium nitride (gold yellow)

At PVD-processing (500°C) layers of 2 – 4 µm are accomplished. The resistance of about 3000 HV is accomplished with a multi-layer coating structure.

TiCN Titanium carbonitride (blue-gray)

At PVD-processing (500°C) layers of 2 – 4 µm are accomplished. The resistance counts up to 3000 HV. The TiCN-layer withstands temperatures up to only 400°C.

TiAlN-T3 Titanium aluminum nitride (violet-gray)

At PVD-processing (500°C) layers of 2 – 4 µm are accomplished. The resistance counts up to 3500 HV. The TiAlN-T3-mono-layer resists temperatures up to 800°C. This high resistance and oxidation permanence make TiAlN-T3 applicable for especially „hard“ operation. This coating is appropriate only for hard metal tools.

TiAlN-T4 Titanium aluminum nitride (violet-gray)

At PVD-processing (500°C) layers of 2 – 4 µm are accomplished. The nano-structured TiAlN-T4-layer is resistant up to 800°C und can be applied on HSS-E und HM.

GLT-1 Carbide layer with gliding layer (dark gray)

At PVD-processing (500°C) layers of 2 – 4 µm are accomplished. The combination of a carbide layer and a gliding layer provides significant tool life advantages at dry cutting of ground holes. Also when cutting with lubricants the chip flow can be influenced in a positive way.

7.3 PVD – Physical Vapour Deposition

Lubrication in general is not paid the significance it deserves. In order to get full performance of the tool, the proper lubricant has to be applied.

Normally one differentiates between emulsions and cutting / forming oils. According to legal regulations, lubricants, which contain chlorine, are restricted. Only the use of unchlorinated liquids , „clf“, is admissible.

7.4 Physical properties of hard layers

Features	TiN	TiN-T1	TiCN	TiAlN-T3
Micro hardness – HV 0.05	2300	3000	3000	3500
Friction coefficient	0,4	0,4	0,4	0,4
Temperature – °C	< 600	< 400	< 400	< 800
Type of layer	PVD	PVD	PVD	PVD
Layer structure	mono layer	multi layer	multi layer	mono layer
Thickness – µm	2- 4	2- 4	2- 4	2- 4
Colour	gold-yellow	gold-yellow	blue-gray	violet-gray

Features	TiAlN-T4	CrN	GLT-1
Micro hardness – HV 0.05	3000	1750	3000
Friction coefficient	0,4	0,5	0,2
Temperature – °C	< 800	< 700	< 800
Type of layer	PVD	PVD	PVD
Layer structure	nano structured	mono layer	nano structured
Thickness – µm	2- 4	2- 6	2- 4
Colour	violet-gray	silver-gray	dark-gray

7.5 Employment of lubricants (cutting oils, emulsions, and pastes)

7.6 Overview of lubricants, depending on materials, sorted in 6 groups

Standard lubricants	Materials
A	for not and lowly alloyed steels (as ST 37, machining steels etc.)
B	for cast iron, spherulitic graphite iron, and steels up to 900 N/mm^2 tensile strength
C Water-soluble oils	as emulsion applicable usually at mixing proportion 1:8, and for thread grooving
D	for light metals and non-ferrous metal und its alloys
E	for resistant and taxing materials to cut, usually applicable for thread forming with best results
F Cutting pastes often mixed with graphite	for direct lubrication or with brush for tough und taxing materials, for horizontal processing and large dimensions **Best for thread forming**

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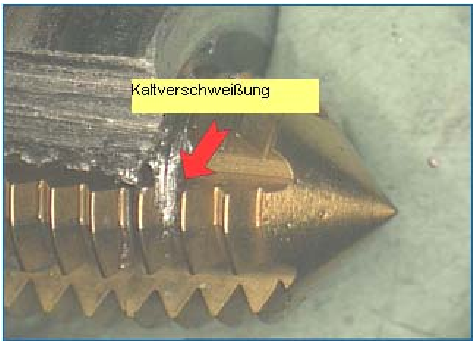
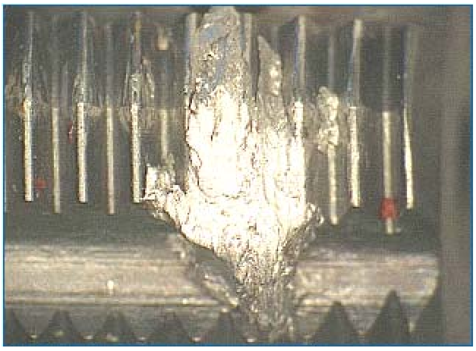
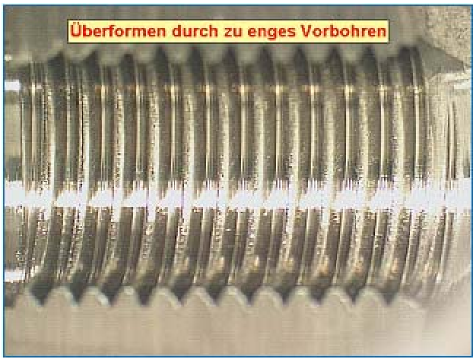
8 Problems with threading

Cold welding	
Cold welding with thread former (Al)	
Over forming	
Cold welding	

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9. Torque

The knowledge about the torque progression of a threading unit, depending on time respectively depth of thread and cutting speed, is crucial for the safe and simultaneously profitable application of a device according to the production assignment demanded.

microtap threading technology GmbH has developed a device, with which the actual torques are measured and “limited” in order to protect the tools from breakage. An internal evaluation system continuously controls and regulates the approach of the gear in real-time.

The customer’s benefit results in the fact that all upcoming procedures are established and controlled at processing, thus producing consistent quality. Besides other parameters, accepted tolerances are targeted with the “minimum & maximum torque window” and enable users to practice the guidelines of fault detection and good-bad selection.´

For further information’s about our new **TTT Tapping-Torque-Testsystem** please see our special website www.tapping-torque-test.com

Find more information in the following documents:

- Competition – Comparison & Advantages.pdf
- Practice-Talks Threading.pdf
- Feature – Advantage – Customer Account.pdf
- Utility Booklet.pdf

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