OPERATING MANUAL
FORM KNURLING TOOL
F711/ F712

Please read this operating manual carefully. Correct assembly of the tool will save you set-up time and allow you to achieve optimal results.

KNURLING PROFILES AND PRODUCTION PROCESS

	F711/ F712 series	
	Machining direction	Knurling profiles on the workpiece: RAA | RBL | RBR | RGE
Single-wheel	radial	Selection of knurling wheels: AA | BR | BL | -
	radial and axial	Selection of knurling wheels: AA | BR | BL | -
Double-wheel	radial/radial and axial	Selection of knurling wheels: 2xAA | 2xBR | 2xBL | 1xBR 1xBL

Table 1: Knurling profiles

Ordering spare parts:

Please specify the tool number and the corresponding position number (see Figure 1).

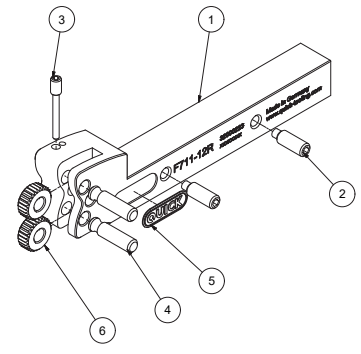


Fig. 1: F711-LD exploded drawing (Swiss-type lathe variant)

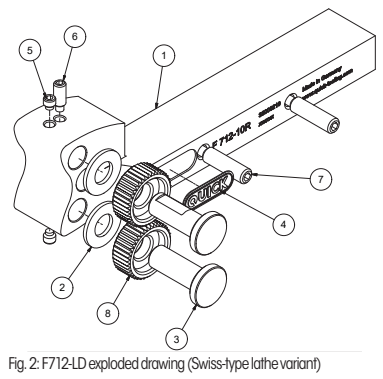


Fig. 2: F712-LD exploded drawing (Swiss-type lathe variant)

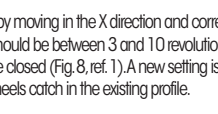
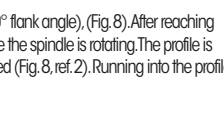
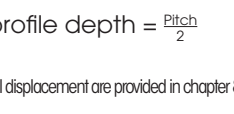
Knurling profile	Manufacturing process	Knurling profile	Manufacturing process
RAA knurl with straight pattern		RBL left-hand knurl 30°/45°	
RGE left-hand/ right-hand knurling, raised points, 30°/45°		RBR right-hand knurl 30°/45°	

Table 2: Manufacturing process

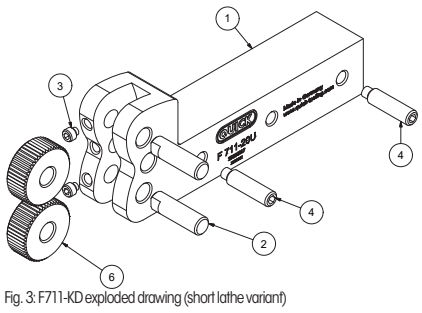


Fig. 3: F711-KD exploded drawing (short lathe variant)

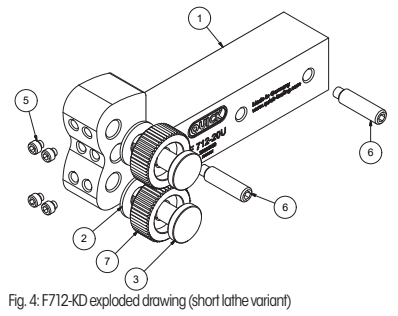


Fig. 4: F712-KD exploded drawing (short lathe variant)

1. General information

The centre height is integrated in the tool holder and corresponds to the upper shank edge.

2. Tool setting

1. Assembly of the knurling wheels

Depending on the required profile, the toolholders can be used with one (centre bore) or two knurling wheels (each in outer bore).

F711:

For installation or replacement of the knurling wheels, loosen the threaded pin (Fig. 1, Pos. 3) completely or loosen the threaded pins (Fig. 3, Pos. 3) slightly. Then, the axle pins (Fig. 1, Pos. 4; Fig. 3, Pos. 2) and knurling wheel can be removed. Mount the new knurling wheel with the axle pins and clamp with the threaded pin. Ensure that the axle pin is clamped with the radius notch (Fig. 1, Pos. 4) or on the planar surface (Fig. 3, Pos. 2).
Note: When using one knurling wheel, the fixed clamping takes place via the rear (Fig. 1, F711-LD) or centre bore (Fig. 3, F711-KD).
In the process, with use of one knurling wheel with Ø 15 mm, the maximum working range can be extended to Ø 50 mm.

F712:

For installation or replacement of knurling wheels, loosen the threaded pins (Fig. 2, Pos. 5; Fig. 4, Pos. 5) slightly and remove the shoulder bolts (Fig. 2, Pos. 3; Fig. 4, Pos. 3) and knurling wheel and washer (Fig. 2, Pos. 2; Fig. 4, Pos. 2). Then mount the new knurling wheels with the shoulder bolt and washer and clamp with the threaded pins. Ensure that the shoulder bolt is clamped on the planar surface.
Note: When using one knurling wheel, the fixed clamping takes place via the rear bore (Fig. 2, F712-LD) or centre bores (Fig. 4, F712-KD).

2. Clamping position of tool

Clamp the tool at an angle of 90° to the workpiece for radial machining (Fig. 5).

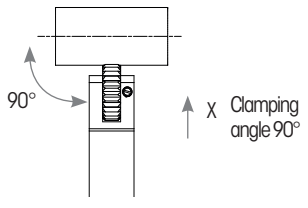


Fig. 5: Radial machining direction

3. Setting the clearance angle

In order to guarantee a better material flow during axial machining, correct the clearance angle of the knurling holder with the threaded pins in the shank (Fig. 1, Pos. 2; Fig. 2, Pos. 7; Fig. 3, Pos. 4; Fig. 4, Pos. 6) by 1°-2° (Fig. 6). This value depends on the materials to be machined.

4. Approach position of the tool

The workpiece can be scratched slightly with the tool in order to determine the approach position (cf. Fig. 7). In the process, when using two knurling wheels, ensure that they engage simultaneously.

Alternatively, the exact approach position can be calculated for CNC programming with the following formula. This value depends on the knurling wheels which are in use, as well as the radius of the workpiece and shows the approach position a, relative to the rotation centre (Fig. 7).
Caution: Calculation only applies with use of two knurling wheels
An additional safety distance must be observed based on workpiece tolerances.

$$a = r_W - \left(\left(r_W * \sin\left(\arcsin\left(\frac{c}{(r_w + r_R) * 2} \right) \right) \right) * \tan\left(\frac{\arcsin\left(\frac{c}{(r_W + r_R) * 2} \right)}{2} \right) \right)$$

Legend:
r_w = Radius of the workpiece
r_R = Radius of the knurling wheel
c = Variable according to Table 3

Knurling wheel Ø	F711 Variable c	F712 Variable c
10	10.5	–
15	–	15.6
20	20.4	20.4

Table 3: Variable c for approach position

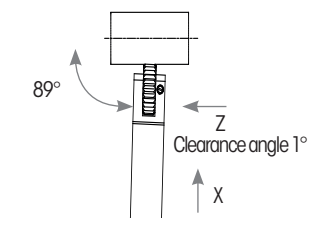


Fig. 6: Radial and axial machining direction

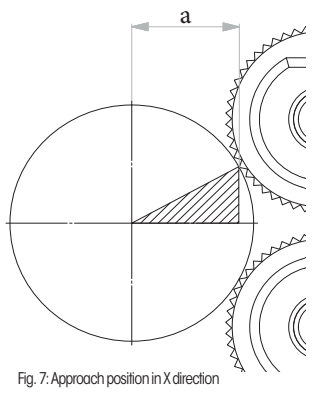


Fig. 7: Approach position in X direction

APPLICATION

3. Setting the profile depth

The profile depth is set in the component by moving in the X direction and corresponds to approximately the half pitch p (with 90° flank angle), (Fig. 8). After reaching the depth, the residence time of the tool should be between 3 and 10 revolutions of the workpiece. Then disengage the tool while the spindle is rotating. The profile is completely knurled when the tooth tips are closed (Fig. 8, ref. 1). A new setting is required when the profile is not completely knurled (Fig. 8, ref. 2). Running into the profile again is possible, because the knurling wheels catch in the existing profile.
Note:

$$\text{Setting of profile depth} = \frac{\text{Pitch}}{2}$$ With 90° flank angle

Guidelines for calculation of the material displacement are provided in chapter 8. This depends on the knurling profile, workpiece diameter and pitch.

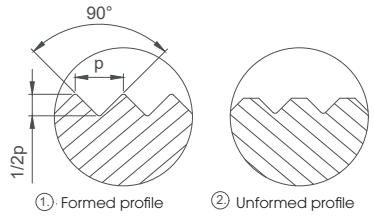


Fig. 8: Different profile pattern

4. Feed rate in Z direction

With axial knurling, adjust in the X-direction first, observing the residence time in the process (see chapter 3). Then move in the Z-direction until the desired knurl width is achieved. After the limit position is reached, the residence time should be approx. 3 to 10 revolutions.
Then disengage the tool while the spindle is rotating.
For guideline values for feed rate and cutting speed, please refer to chapter 7.
Note: Only tool type F712 is designed for machining up to a shoulder.

5. Manufacturer's recommendation

Replace the axle pin (Fig. 1, Pos. 4; Fig. 3 Pos. 2) or washer bolt (Fig. 2, Pos. 3; Fig. 4, Pos. 3), knurling wheels (Fig. 1, Pos. 6; Fig. 2, Pos. 8; Fig. 3, Pos. 6; Fig. 4, Pos. 7) and washer (Fig. 2; Fig. 4, Pos. 2) after a reasonable number of cycles, no later than upon appearance of significant wear or deviating process parameters. Inspect the slot of the knurl holder for wear and widening.
An adequate flow of coolant is recommended.
Note: Always use knurling wheels with the same pitch!

6. Troubleshooting

IMPORTANT

Problem:	Reason / Cause:	Solution:
The profile is not completely formed, surface on the tooth tip	The profile depth setting is not correct	Adjust setting (see chapter 3, Setting the profile depth)
The profile has a double knurling	– Feed rate incorrect – Profile depth too large – Residence time in the engagement too long	– Adjust feed rate as specified in chapter 7 – Setting as specified in chapter 3 – Residence time should be between 3 and 10 revolutions of the workpiece
Irregular profile form	– Deficient concentricity of the workpiece – Warpage of the workpiece due to excessive projection	– Over-turn workpiece diameter – Check extension length and clamping pressure – Correct clearance angle as specified in chapter 2, ref. 3
Spangle collets on the profile	– Residence time of the tool in the engagement too long – Tooth pitch does not reach the workpiece	– Residence time should be between 3 and 10 revolutions of the workpiece – Check cutting data as specified in chapter 7 – Adjust rough turn diameter and / or pitch
Excessive material displacement at knurling end (axial)	– Feed rate value incorrect – Profile depth is not correct – Clearance angle is not correct	– Adjust feed rate as specified in chapter 7 – Setting as specified in chapter 3 – Correct clearance angle as specified in chapter 2, ref. 3
Spirals are formed in the profile	– Workpiece deflects – Clearance angle is not correct – Feed rate value too high – Incorrect centre height	– Check extension length / support workpiece – Correct clearance angle as specified in chapter 2, ref. 3 – Observe cutting data as specified in chapter 7 – Correct centre height
– Overpressure on the profile – Diameter reduction at the beginning of the knurling	– Depth adjustment too high – Incorrect approach position / setting outside of the workpiece	– Setting as specified in chapter 3 – Setting must take place in the component (observe chapter 3)
The finished diameter of the workpiece is too small	– Various material influences – Incorrect rough turn diameter	– Observe guidelines for the material displacement as specified in chapter 8 – Adjust rough turn diameter

Table 4: Troubleshooting

7. Guidelines for cutting speed and feed rates

Material	Workpiece Ø [mm]	Knurling wheel Ø [mm]	Vc [m/min]		f [mm/U]					
					Radial		Axial			
							Pitch [mm]			
			from	to	from	to	> 0.3 < 0.5	> 0.5 < 1.0	> 1.0 < 1.5	> 1.5 < 2.0
Free-cutting steel	< 10	10/15/20	20	50	0.04	0.08	0.14	0.09	0.06	0.05
	10 – 40	10/15/20/25	25	55	0.05	0.10	0.20	0.13	0.10	0.07
	40 – 100	15/20/25	30	60	0.05	0.10	0.25	0.18	0.12	0.08
	100 – 250	20/25	30	60	0.05	0.10	0.30	0.20	0.13	0.09
	> 250	25	30	60	0.05	0.10	0.32	0.21	0.14	0.10
Stainless steel	< 10	10/15/20	15	40	0.04	0.08	0.12	0.08	0.05	0.04
	10 – 40	10/15/20/25	20	50	0.05	0.10	0.17	0.11	0.09	0.06
	40 – 100	15/20/25	25	50	0.05	0.10	0.21	0.15	0.10	0.07
	100 – 250	20/25	25	50	0.05	0.10	0.26	0.17	0.11	0.08
	> 250	25	25	50	0.05	0.10	0.27	0.18	0.12	0.09
Brass	< 10	10/15/20	30	75	0.04	0.08	0.15	0.09	0.06	0.05
	10 – 40	10/15/20/25	40	85	0.05	0.10	0.21	0.14	0.11	0.07
	40 – 100	15/20/25	45	90	0.05	0.10	0.26	0.19	0.13	0.08
	100 – 250	20/25	45	90	0.05	0.10	0.32	0.21	0.14	0.09
	> 250	25	45	90	0.05	0.10	0.34	0.22	0.15	0.11
Aluminium	< 10	10/15/20	25	60	0.04	0.08	0.18	0.11	0.08	0.06
	10 – 40	10/15/20/25	30	65	0.05	0.10	0.25	0.16	0.13	0.09
	40 – 100	10/20/25	35	70	0.05	0.10	0.31	0.23	0.15	0.10
	100 – 250	20/25	35	70	0.05	0.10	0.38	0.25	0.16	0.11
	> 250	25	35	70	0.05	0.10	0.40	0.26	0.18	0.13

Table 5: Cutting speed and feed rate

8. Material displacement

Pitch [mm]		0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.5	1.6	2.0
Material	Workpiece Ø [mm]	Enlargement of workpiece diameter in mm										
Free-cutting steel	5	0.08	0.14	0.18	0.22	0.27	0.29	0.35	0.50	–	–	–
	15	0.08	0.14	0.18	0.23	0.30	0.40	0.44	0.50	0.60	0.65	0.70
	25	0.08	0.15	0.23	0.24	0.28	0.35	0.44	0.53	0.62	0.70	0.98
Stainless steel	5	0.10	0.15	0.20	0.25	0.28	0.30	0.42	0.41	–	–	–
	15	0.10	0.15	0.19	0.25	0.30	0.34	0.45	0.51	0.60	–	–
	25	0.10	0.14	0.20	0.26	0.31	0.33	0.43	0.50	0.62	–	–
Brass	5	0.08	0.12	0.18	0.20	0.21	0.22	0.25	0.28	–	–	–
	15	0.10	0.14	0.20	0.26	0.28	0.29	0.35	0.41	0.44	0.48	0.55
	25	0.10	0.15	0.20	0.25	0.28	0.30	0.36	0.43	0.46	0.50	0.53
Aluminium	5	0.09	0.15	0.19	0.23	0.28	0.30	0.41	0.40	–	–	–
	15	0.10	0.15	0.19	0.26	0.29	0.33	0.45	0.51	0.57	0.65	–
	25	0.09	0.15	0.19	0.26	0.29	0.32	0.45	0.52	0.59	0.65	0.75

Table 6: Knurling profile acc. to DIN82: RAA

Pitch [mm]		0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.5	1.6	2.0
Material	Workpiece Ø [mm]	Enlargement of workpiece diameter in mm										
Free-cutting steel	5	0.11	0.15	0.20	0.24	0.28	0.34	0.45	0.55	–	–	–
	15	0.11	0.15	0.22	0.26	0.30	0.35	0.45	0.52	0.67	0.73	0.85
	25	0.11	0.14	0.23	0.25	0.28	0.36	0.45	0.56	0.70	0.72	0.90
Stainless steel	5	0.09	0.14	0.19	0.25	0.31	0.34	0.45	0.52	–	–	–
	15	0.12	0.20	0.23	0.31	0.35	0.40	0.51	0.62	0.66	0.73	0.97
	25	0.12	0.18	0.24	0.27	0.37	0.39	0.49	0.59	0.80	0.84	0.96
Brass	5	0.10	0.14	0.20	0.23	0.24	0.28	0.33	0.37	–	–	–
	15	0.10	0.15	0.21	0.23	0.24	0.31	0.41	0.47	0.53	0.55	0.63
	25	0.11	0.15	0.22	0.22	0.25	0.30	0.40	0.45	0.55	0.61	0.68
Aluminium	5	0.12	0.14	0.21	0.24	0.29	0.34	0.41	0.51	–	–	–
	15	0.12	0.18	0.23	0.26	0.36	0.40	0.50	0.56	0.56	0.61	0.75
	25	0.12	0.18	0.25	0.28	0.37	0.39	0.50	0.58	0.77	0.82	0.96

Table 7: Knurling profile acc. to DIN82: RBL30° / RBR30°

Pitch [mm]		0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.2	1.5	1.6	2.0
Material	Workpiece Ø [mm]	Enlargement of workpiece diameter in mm										
Free-cutting steel	5	0.12	0.16	0.20	0.25	0.33	0.41	0.55	0.65	–	–	–
	15	0.13	0.22	0.30	0.32	0.35	0.41	0.52	0.62	0.67	0.81	0.95
	25	0.12	0.18	0.28	0.32	0.35	0.38	0.55	0.67	0.77	0.87	0.98
Stainless steel	5	0.11	0.20	0.25	0.30	0.36	0.39	0.55	0.55	–	–	–
	15	0.10	0.14	0.21	0.24	0.29	0.34	0.43	0.53	0.66	0.72	0.88
	25	0.11	0.13	0.20	0.25	0.28	0.32	0.44	0.52	0.67	0.70	0.83
Brass	5	0.12	0.13	0.16	0.20	0.24	0.28	0.32	0.38	–	–	–
	15	0.12	0.16	0.18	0.24	0.28	0.30	0.39	0.40	0.48	0.52	0.63
	25	0.12	0.17	0.22	0.23	0.27	0.30	0.38	0.41	0.48	0.50	0.63
Aluminium	5	0.10	0.15	0.21	0.25	0.33	0.36	0.50	0.57	–	–	–
	15	0.11	0.14	0.20	0.25	0.28	0.33	0.43	0.54	0.67	0.71	0.89
	25	0.11	0.15	0.22	0.25	0.29	0.34	0.44	0.53	0.68	0.69	0.88

Table 8: Knurling profile acc. to DIN82: RGE30°

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