OPERATING MANUAL
KNURLING TOOL RD3/RF3 191 / 192 / 291

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

KNURLING PROFILES AND PRODUCTION PROCESS

191 / 192 series					291 series	
Machining direction	Knurling profiles on the workpiece:				Knurling profiles on the workpiece:	
	RAA	RBL	RBR	RGE	RGE30°	RGE45°
	Selection of knurling wheels:				Selection of knurling wheels:	
	3 x AA	3 x BR	3 x BL	1 x BR / 2 x BL 1 x BL / 2 x BR	3 x AA	1 x BL15° / 2 x BR15°

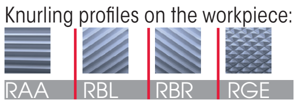
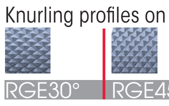



Table 1: Knurling profiles

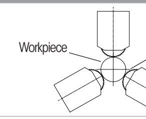
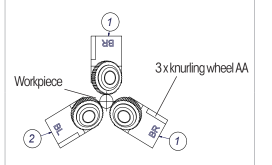
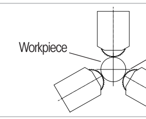
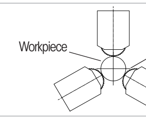
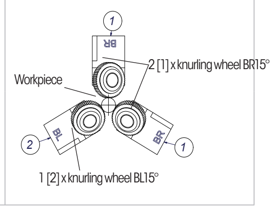
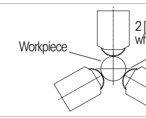
Knurling profile	Forming production process	Knurling profile	Milling production process
RAA knurl with straight pattern	 Workpiece; 3 x knurling wheel AA	RGE left/right-hand knurl, raised points, 30°	 Workpiece; 3 x knurling wheel AA
RBL left-hand knurl	 Workpiece; 3 x knurling wheel BR		
RBR right-hand knurl	 Workpiece; 3 x knurling wheel BL	RGE left/right-hand knurl, raised points, 45°	 Workpiece; 2 [1] x knurling wheel BR15°; 1 [2] x knurling wheel BL15°
RGE left/right-hand knurl, raised points, 30°	 Workpiece; 2 [1] knurling wheel BL; 1 [2] x knurling wheel BR		

Table 2: Manufacturing process

191 series (forming)

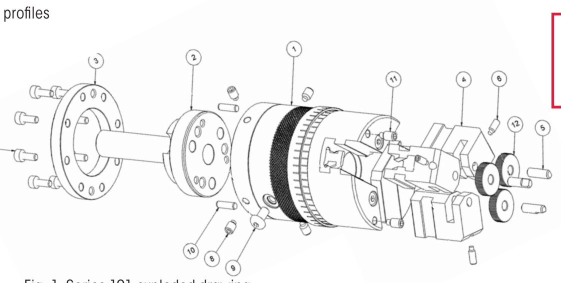


Fig. 1: Series 191 exploded drawing

Ordering spare parts:

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

TOOL SETTING

1. General information

Produce a chamfer (30° – 45°) on the workpiece with a minimum width corresponding to half of the pitch of the knurling wheel on the start of the workpiece. The concentricity of the workpiece must be max. 0.03 mm.

Note: Rotation of the threaded bush CW –> Setting of the profile depth

Rotation of the threaded bush CCW –> Produces a reduction of the profile depth

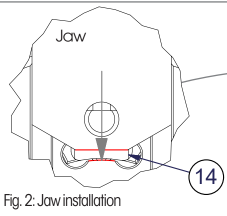


Fig. 2: Jaw installation

2. Tool setting

The following points must be observed for optimal adjustment and use of the tool.

Knurling jaw assembly

Various jaws are pre-assembled depending on the tool type. Conversion between the milling machining process (291 series), forming (191 series) and forming up to a shoulder (192 series) can take place by using different jaw sets. These variants are shown in Figure 3.

Removal:

If the jaw sets must be replaced, first remove the stop screw completely (Fig. 1, Pos. 9) and loosen the three threaded pins (Fig. 3, Pos. 11). Then turn the threaded bush (Fig. 1 + 3, Pos. 1) counterclockwise (CCW) until the knurling jaws (Fig. 1 + 3, Pos. 4) can be removed individually from the guide slot.

Installation:

Vertical positioning of the tool is recommended for easier installation (pull knurling jaws upward, Fig. 3). Now slide the jaws (Fig. 1 + 3, Pos. 4) into the guide slots until the front edge of the jaw is flush with the surface of the recess facing inward (Fig. 2). Then, turn the threaded bush clockwise (CW) until the guide slot of the splined bush (Fig. 2 + 3, Pos. 14) engages in the jaws and pulls them together evenly. Screw in the stop screw again (Fig. 1, Pos. 9).

Note: With use of jaw set 291, a knurling wheel with a left spiral direction must be installed in the left jaw (2). (Example: 1x BL15° & 2 x BR15°), (cf. Table 2, RGE 30°/45°)

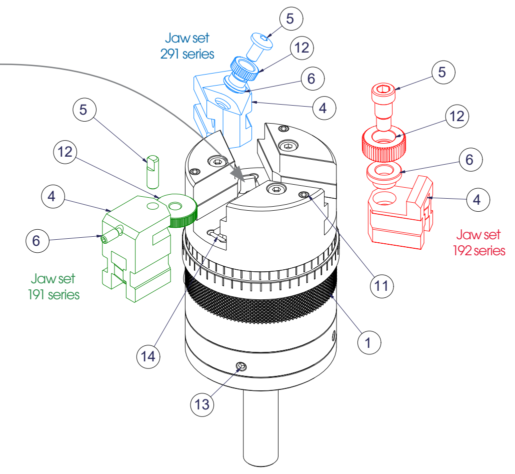


Fig. 3: General view + jaw variants

Knurling wheel assembly

Forming (jaw set 191):

Loosen the threaded pin (Fig. 1 + 3, Pos. 6) and remove the axle pin

(Fig. 1 + 3, Pos. 5). Change the knurling wheel (Fig. 3, Pos. 12) and fix it with the axle pin in the groove.

Note: Align the clamping surface of the axle pin so that it is tensioned after the tightening of the front threaded pin.

Forming up to a shoulder (jaw set 192):

Completely loosen the bearing screw (Fig. 3, Pos. 5) and remove the knurling wheels (Fig. 3, Pos. 12). Fit new knurling wheels on the bearing bush (Fig. 3, Pos. 6) and fix with the bearing screw (cf. Figure 3).

Cutting (jaw set 291):

Completely loosen the Torx screw (Fig. 3, Pos. 5) and remove it with the knurling wheel (Fig. 3, Pos. 12) and the bearing bush (Fig. 3, Pos. 6). Then fit a new knurling wheel on the bearing bush and tighten screw it together with the jaw (Fig. 3, Pos. 4) with the torx screw (cf. Figure 3).

3. Centring of the tool

1. Clamp the tool holder in the machine
2. Unscrew the fastening screw (Fig. 1, Pos. 9) and threaded pins (Fig. 1, Pos. 8; Fig. 3, Pos. 11)
3. Unscrew the threaded bush (Fig. 1, Pos. 1; Fig. 3, Pos. 1) and move over the workpiece in the Z-direction
4. Close the threaded bush until the knurled wheels are in contact with the diameter of the workpiece
5. If all knurling wheels rotate with the workpiece, the tool is centred
6. Tighten the threaded (Fig. 1, Pos. 8) pins evenly
7. Open the jaws one scale mark wide with the threaded bush and move out of the component.

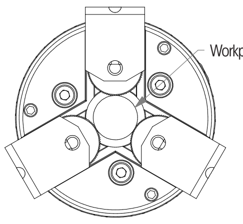


Fig. 4: Centring of the tool (front view)

4. Setting the profile depth

Setting of the profile depths takes place after the centring of the toolholder. This depends on the knurling process, pitch, profile and material displacement to be carried out. For this purpose, loosen the fastening screw (Fig. 1, Pos. 9) and threaded pins (Fig. 1, Pos. 8) and turn the threaded bush (Fig. 1 + 3, Pos. 1) clockwise.

Note: One scale mark corresponds to 0.05 mm, referring to the diameter

Form knurling:

Setting = material displacement – pitch

Example: Profile AA / pitch 1.0 mm / workpiece Ø 15 / free-cutting steel material

Setting = 1.0 mm – 0.4 mm = 0.6 mm

$$\text{Setting on scale} = \frac{\text{Setting}}{\text{1 scale mark}} = \frac{0.6\,\text{mm}}{0.05\,\text{mm}} = 12 \text{ scale marks}$$

Cut knurling:

Setting corresponds to the half pitch $(\frac{p}{2})$

Example: Profile AA / pitch 1.0 mm / workpiece Ø 15 / free-cutting steel material

Setting = 1.0 mm / 2 = 0.5 mm

$$\text{Setting} = \frac{1\,\text{mm}}{2} = 0.5\,\text{mm}$$

$$\text{Setting on scale} = \frac{\text{Setting}}{\text{1 scale mark}} = \frac{0.5\,\text{mm}}{0.05\,\text{mm}} = 10 \text{ scale marks}$$

Then, firmly tighten the fastening screw (Fig. 1, Pos. 9) and threaded pins (Fig. 2, Pos. 8) for fixing the diameter (observe torque table, chapter 6).

Note: In order to compensate for point 3, chapter 7 and possible thread play, adjust one additional scale mark.

APPLICATION

5. Feed rate in Z direction

After adjusting the working area and fixing the tool, the tool can be moved over the component axially in the Z-direction (Fig. 5).

The feed rate according to chapter 8 must be observed during the process.

If the desired length of the knurling is reached, disengage in the opposite Z-direction.

Note: Depending on the profile and pitch which are used, the feed rate in the opposite Z-direction can be 0.5 mm to 1 mm higher than during the knurling.

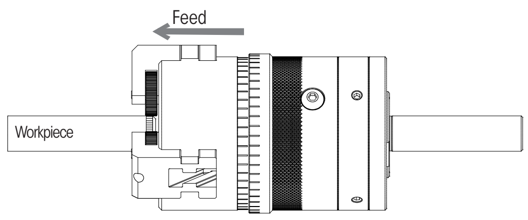


Fig. 5: Feed in Z direction

The correct profile depth has been reached when the profile is knurled completely (Fig. 6, ref. 1). If the profile is not formed (Fig. 6, ref. 2), adjust the threaded bush an additional scale mark and run the workpiece through again. Running into the workpiece again is possible, because the knurling wheels catch in the existing profile.

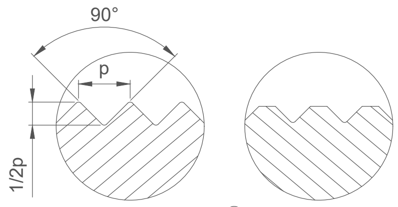


Fig. 6: Different profile pattern

IMPORTANT

6. Manufacturer's recommendation

Replace the bearing bush (Fig. 3, Pos. 6; 192/291 series), knurling wheel (Fig. 3, Pos. 12), bearing screw (Fig. 3, Pos. 5; 192 series) and torx screw (Fig. 3, Pos. 5, 291 series) and axle pin (Fig. 3, Pos. 5) after a reasonable number of cycles, no later than upon appearance of significant wear or deviating process parameters.

Note:

– Always install knurling wheels with the same pitch
– A material displacement of min. 0.03 mm and max. 0.1 mm can arise during the cutting

Designation	Torque	Pos. no.
M3 cylinder head screw	3.5 Nm	Fig. 1, Pos. 7
M3 threaded pin	1.5 Nm	Fig. 1, Pos. 13
M4 set screw	3.5 Nm	Fig. 1, Pos. 8; Pos. 11; Fig. 1, Pos. 11
M4 Allen screw	3.5 Nm	Fig. 1, Pos. 9
M4 torx screw	3.6 Nm	Fig. 3, Pos. 5

Table 3: Torque specifications

7. Troubleshooting

Problem:	Reason / Cause:	Solution:
Profile is not completely knurled	The profile depth setting is not correct	Increase the profile depth setting (see chapter 4, Setting the profile depth)
Spangle collets on the profile (191 / 192 series)	– Residence time in the engagement too long – Tooth pitch does not reach the workpiece	– Observe residence time (3 – 10 rotations of the workpiece) – Adjust rough turn diameter and / or pitch
Finished diameter of the work-piece incorrect	– Incorrect rough turn diameter – Various influential factors not taken into consideration	– Adjust the rough turn diameter of the workpiece – Observe the workpiece deformation according to chapter 9, Table 7 – 9
Heavy material deformation at knurling end (191/192 series)	– Feed rate values not correct – Profile depth is not correct	– Adjust cutting data as specified in chapter 8 – Adjustment of profile depth = pitch (see chapter 4, Setting the profile depth)
Tooth base is knurled unevenly	Centring is not correct	Centre the tool as specified in chapter 3.

Table 4: Troubleshooting

8. 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	50	0.04	0.08	0.14	0.09	0.06	0.05
	10 – 40	15/20	25	55	0.05	0.10	0.20	0.13	0.10	0.07
	40 – 100	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	15	40	0.04	0.08	0.12	0.08	0.05	0.04
	10 – 40	15/20	20	50	0.05	0.10	0.17	0.11	0.09	0.06
	40 – 100	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	30	75	0.04	0.08	0.15	0.09	0.06	0.05
	10 – 40	15/20	40	85	0.05	0.10	0.21	0.14	0.11	0.07
	40 – 100	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	25	60	0.04	0.08	0.18	0.11	0.08	0.06
	10 – 40	15/20	30	65	0.05	0.10	0.25	0.16	0.13	0.09
	40 – 100	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 / forming

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	40	70	0.04	0.08	0.20	0.13	0.08	0.07
	10 – 40	15/25	50	90	0.05	0.10	0.28	0.18	0.14	0.10
	40 – 100	25/32/42	65	110	0.05	0.10	0.35	0.25	0.17	0.11
	100 – 250	25/32/42	65	110	0.05	0.10	0.42	0.28	0.18	0.13
	> 250	32/42	80	100	0.05	0.10	0.45	0.29	0.20	0.14
Stainless steel	< 10	10/15	22	40	0.04	0.08	0.14	0.09	0.06	0.05
	10 – 40	15/25	30	50	0.05	0.10	0.20	0.13	0.10	0.07
	40 – 100	25/32/42	35	60	0.05	0.10	0.25	0.18	0.12	0.08
	100 – 250	25/32/42	35	60	0.05	0.10	0.29	0.20	0.13	0.09
	> 250	32/42	45	55	0.05	0.10	0.31	0.21	0.14	0.10
Brass	< 10	10/15	55	100	0.04	0.08	0.22	0.14	0.09	0.08
	10 – 40	15/25	70	125	0.05	0.10	0.31	0.20	0.15	0.11
	40 – 100	25/32/42	90	155	0.05	0.10	0.39	0.28	0.18	0.12
	100 – 250	25/32/42	90	155	0.05	0.10	0.46	0.31	0.20	0.14
	> 250	32/42	115	140	0.05	0.10	0.49	0.32	0.22	0.15
Aluminium	< 10	10/15	70	120	0.04	0.08	0.12	0.08	0.05	0.04
	10 – 40	15/25	80	150	0.05	0.10	0.17	0.11	0.08	0.06
	40 – 100	25/32/42	110	160	0.05	0.10	0.21	0.15	0.10	0.07
	100 – 250	25/32/42	110	160	0.05	0.10	0.25	0.17	0.11	0.08
	> 250	32/42	130	150	0.05	0.10	0.27	0.18	0.12	0.08

Table 6: Cutting speed and feed rate / cutting

9. 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 7: 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 8: 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 9: Knurling profile acc. to DIN82: RGE30°

Art. no. 09PRO0071/04/2022

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