OPERATING MANUAL
KNURLING TOOL F791 / F792 / C693

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

F791 / F792 series forming		C693 series cutting	
Machining direction	Knurling profiles on the workpiece: RAA | RBL | RBR | RGE	Knurling profiles on the workpiece: RGE30° | RGE45°	
axial	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	Selection of knurling wheels: 3 x AA | 1 x BR15° / 2 x BL15°, 1 x BL15° / 2 x BR15°	

Table 1: Knurling profiles

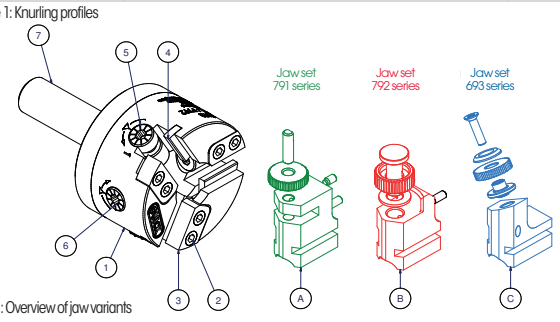


Fig. 1: Overview of jaw variants

Ordering spare parts:

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

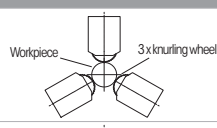
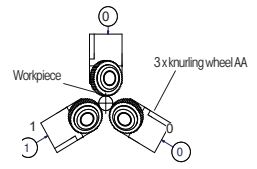
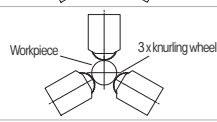
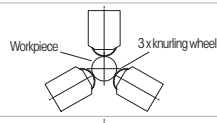
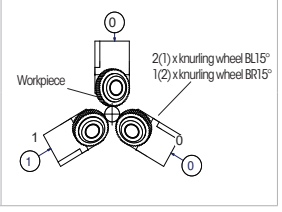
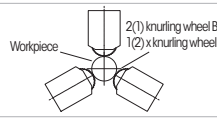
Knurling profile	F791 / F792 series forming production process	Knurling profile	C693 series cutting production process
RAA knurl with straight pattern		RGE left-hand / right-hand knurling, raised points, 30°	
RBL left-hand knurl			
RBR right-hand knurl		RGE left-hand / right-hand knurling, raised points, 45°	
RGE left-hand / right-hand knurling, raised points, 30°			

Table 2: Manufacturing process

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.
Tool shank (Fig. 1, Pos. 7) is not included in the scope of supply.
The concentricity of the workpiece must be max. 0.03 mm.

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 cutting process (C693 series), forming (F791 series) and knurling up to a shoulder (F792 series) can take place by using different jaw sets. These variants are shown in Figure 1 (A – C).

Removal:
If it is necessary to change jaw sets, first loosen the clamping screws (Fig. 1, Pos. 2) of the clamping segment (Fig. 1, Pos. 3). Then turn the spindles (Fig. 1, Pos. 5) clockwise (CW) until the individual knurl holders (Fig. 1, Pos. A – C) can be removed.

Installation:
Slide the knurl holders (Fig. 1, Pos. A – C) individually into the guide slots of the base body (Fig. 1, Pos. 1) and move the jaws together by means of spindles which are turned counterclockwise (CCW).
If all knurl holders are screwed in, tension the clamping segment with the clamping screws.

Note: In the installed state, the spindle aligned to the machine side can be reached through the passage (Fig. 1, Pos. 6).

For production of an RGE45° knurl using jaw set C693, a knurling wheel with a different spiral direction must be installed in the jaw with the negative clamping surface. (Example: 1 x BL15° & 2 x BR15° or 1 x BR15° & 2 x BL15°)

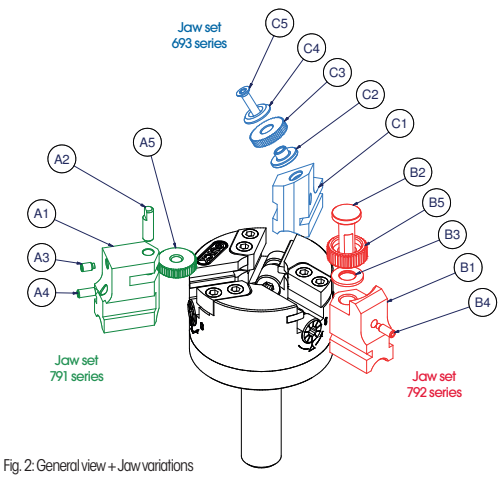


Fig. 2: General view + Jaw variations

Knurling wheel assembly

Forming (jaw set F791):
Loosen the threaded pin (Fig. 2, Pos. A3) and screw in the rear threaded pin (Fig. 2, Pos. A4) so that the axle pin (Fig. 2, Pos. A2) can be removed. Then, change the knurling wheel (Fig. 2, Pos. A5) and fix it with the axle pin in the groove.
Note:
Unscrew the previously screwed-in threaded pin (Pos. A4) the amount of thread screwed in. Align the clamping surface of the axle pin so that it is tensioned after the tightening of the front threaded pin (Pos. A3).

Forming up to the shoulder (jaw set F792):
Loosen the threaded pin (Fig. 2, Pos. B4) and remove the shoulder bolt (Fig. 2, Pos. B2) and knurling wheel (Fig. 2, Pos. B5) and race (Fig. 2, Pos. B3). Fit the new knurling wheel with race on the shoulder bolt and clamp it with the threaded pin in the knurl holder. Align the clamping surface of the shoulder bolt so that it is tensioned by the threaded pin.

Cutting (jaw set C693):
Completely loosen the torx screw (Fig. 2, Pos. C5) and remove the washer (Fig. 2, Pos. C4) and knurling wheel (Fig. 2, Pos. C3) and bearing bush (Fit. 2, Pos. C2). Then fit a new knurling wheel on the bearing bush and tighten screw it together with the jaw (Fig. 2, Pos. C1) with the torx screw.
Note: Torque specifications in Table 3, chapter 7.

TOOL ADJUSTMENT

3. Centring of the tool

The centring must be carried out for each individual knurl holder.
The following points must be observed for this purpose.

1. Clamp the tool holder in the machine
2. Loosen the clamping screws
3. Open the jaws with the spindle and move over the workpiece in the Z-direction
4. Move the jaws together until all knurling wheels come into contact with the workpiece diameter (Carry out for each knurl holder individually!)
5. Open the jaws one scale mark wide with the spindles and move out of the component in the opposite Z-direction.
6. Adjust the profile depth according to chapter 4
7. Then re-tighten the clamping screws and fix the adjusted diameter

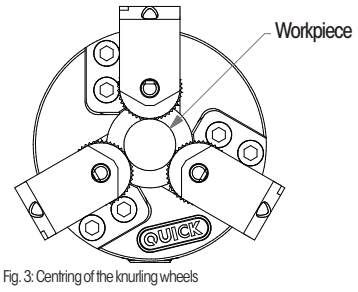


Fig. 3: Centring of the knurling wheels

4. Setting the profile depth

Setting of the profile depth takes place after the centring of the knurl holders. This depends on the knurling process, pitch, profile and material displacement to be carried out.
For this purpose, turn the spindles of the knurl holders (Fig. 1, Pos. 5) clockwise (CW). One spindle mark corresponds to 0.1 mm, referring to the diameter.

Form knurling:
Setting = pitch – material deformation
Example: Profile: RBL30° / RBR30° / pitch: 1.0 mm / Workpiece Ø: 25 mm / Material: Brass
Setting = 1.0 mm – 0.4 mm = 0.6 mm

$$\text{Setting on scale} = \frac{\text{Adjustment}}{\text{1 scale mark}} = \frac{0.6\text{ mm}}{0.1\text{ mm}} = 6 \text{ scale marks}$$

Cut knurling:
Setting corresponds to the half pitch
Example: Profile: RAA / pitch: 1.0 mm / workpiece Ø: 15 mm / Material: Free-cutting steel
Setting = 1.0 mm / 2 = 0.5 mm

$$\text{Setting on scale} = \frac{\text{Adjustment}}{\text{1 scale mark}} = \frac{0.5\text{ mm}}{0.1\text{ mm}} = 5 \text{ scale marks}$$

Note: In order to compensate for point 5, chapter 3 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. 4).
The feed rate according to chapter 9 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. With increasing pitch, a higher feed rate can be selected.

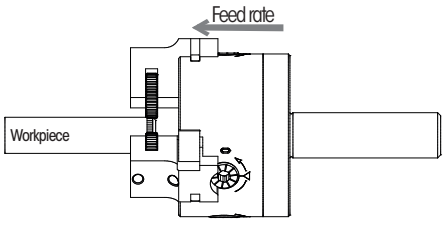


Fig. 4: Feed rate in Z direction

6. Checking the profile depth

The correct profile depth has been reached when the profile is knurled completely (Fig. 5, ref. 1). If the profile is not knurled (Fig. 5, ref. 2), adjust the spindles 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.

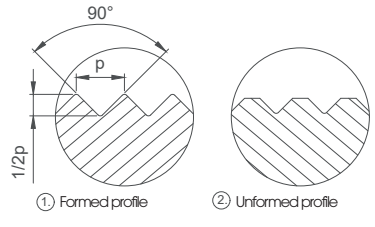


Fig. 5: Different profile pattern

IMPORTANT

7. Manufacturer's recommendation

Replace the axle pin (Fig. 2, Pos. A2), shoulder bolt (Fig. 2, Pos. B2), knurling wheel (Fig. 2, Pos. A5 + Pos. B5 + Pos. C3), bearing bush or race (Fig. 2, Pos. C2 + Pos. B3) and countersunk screws (Fig. 2, Pos. C5) and knurling wheels (Fig. 2, Pos. A5 + B5 + C5) after an appropriate number of cycles – no later than upon appearance of significant wear or deviating process parameters.
An adequate flow of coolant or cutting oil is recommended!
Note:
– Always use knurling wheels with the same pitch
– A material displacement of min. 0.03 mm and max. 0.1 mm can arise during the cut knurling
– If the screws loosen with use of the C693 series (Fig. 2, Pos. C5) during the process, use of Loctite is highly recommended.

Designation	Torque	Pos. no.
M3 threaded pin	1.5 Nm	Fig. 2, Pos. A3 + A4
		Fig. 2, Pos. B4
M3 countersunk screw	1.5 Nm	Fig. 2, C5
M4 clamping screw	3 Nm	Fig. 1, Pos. 2

Table 3: Torque specifications

8. 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 (F791 / F792 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 workpiece 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 10, Table 7 – 9
Heavy material deformation at knurling end (F791 / F792 series)	– Feed rate values not correct – Profile depth is not correct	– Adjust cutting data as specified in chapter 9 – Adjust the profile depth setting (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

9. Guidelines for cutting speed and feed rates

Material	Workpiece Ø [mm]	Knurling wheel Ø [mm]	Vc [m/min] from	Vc [m/min] to	f [mm/U] Radial from	f [mm/U] Radial to	f [mm/U] Axial Pitch [mm] > 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] from	Vc [m/min] to	f [mm/U] Radial from	f [mm/U] Radial to	f [mm/U] Axial Pitch [mm] > 0.3 < 0.5	> 0.5 < 1.0	> 1.0 < 1.5	> 1.5 < 2.0
Free-cutting steel	< 10	8.9/10/15	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	8.9/10/15	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	8.9/10/15	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	8.9/10/15	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

10. 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. 09PRO0105/11/2018

Hommel+Keller Präzsionswerkzeuge GmbH
78554 Aldingen
www.hommel-keller.de