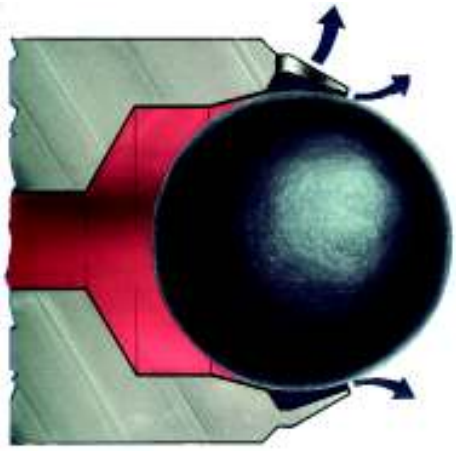
Hydrostatic Tools

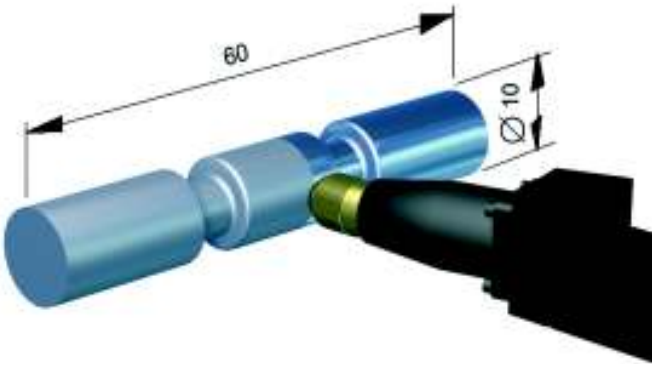
ECOROLL's hydrostatic HG tools can roller burnish even the most complex contours and free-form surfaces. Also designed for hard roller burnishing and deep rolling, the HG tools can be applied with CNC-controlled lathes, drills, milling machines and machining centers as well as with manually controlled machines. HG tools can process materials up to a hardness of 65 HRC.



HG burnishing ball and ball retainer; arrows signify direction of fluid leakage

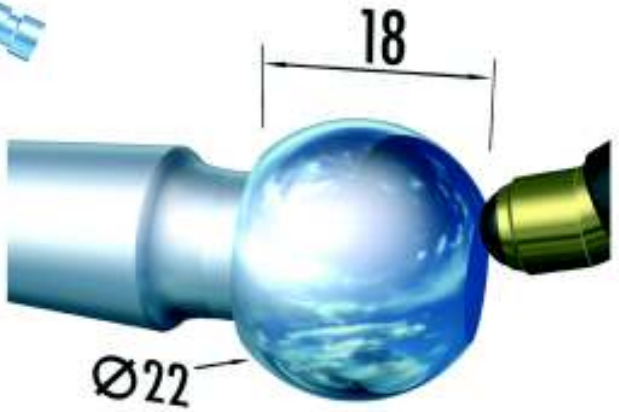
This group of tools includes types HG2 – HG25.

The unique HG tool design is based on a burnishing ball made of an especially hard material. This ball is hydrostatically suspended by pressurized liquid, either water soluble coolant or oil. The ECOROLL HGP line of pumps supply the tools with a consistent, controllable source of operating pressure. This pressure generates the burnishing force that is applied as the ball rotates against the workpiece surface.



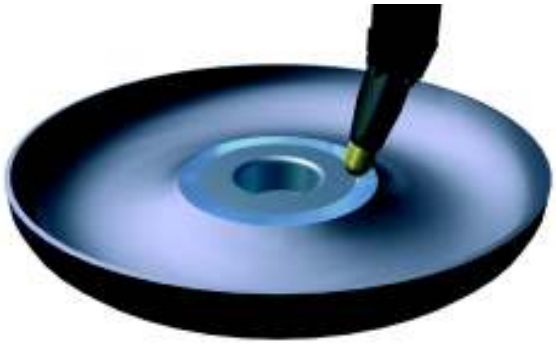
Machining a control valve piston with an HG6 tool to optimize sliding performance.

Deep rolling a valve with an HG6 tool to improve its fatigue strength.



Machining a ball stud with an HG6 tool.

Type HG Tool Applications: Complex contours and deep rolling

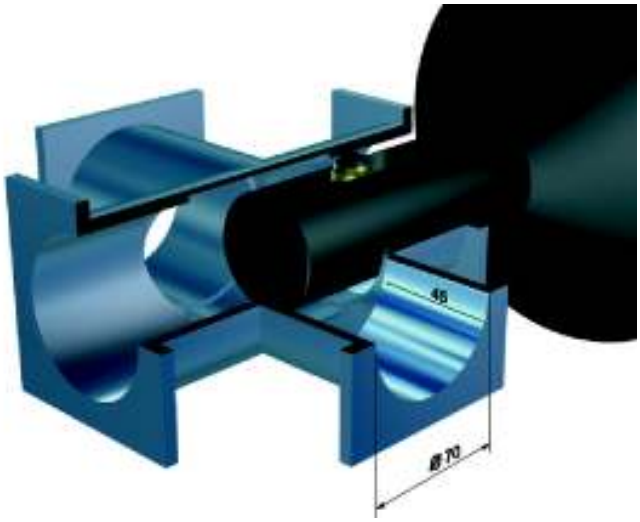


Roller burnishing a torque converter housing with an HG13 tool to improve its sliding properties.

The ECOROLL HG tools can often machine complex shapes that standard roller burnishing tools cannot. The hydrostatically loaded ball can freely rotate in any direction, even at high speed, due to the low friction environment.

The hydrostatic bearing maintains a supporting fluid film between the ball and the ball seat, independent of the distance between the tool and the workpiece.

The HG tool's unique following system enables the burnishing ball to follow the workpiece contour while maintaining a constant burnishing force.



Machining a valve housing with an HG13 tool.

Deep rollling the fillet radius of an axle shaft to increase fatigue strength.

Deep rolling with HG tools dramatically increases the fatigue strength and operating life of dynamically loaded parts and components contstructed of lightweight materials.

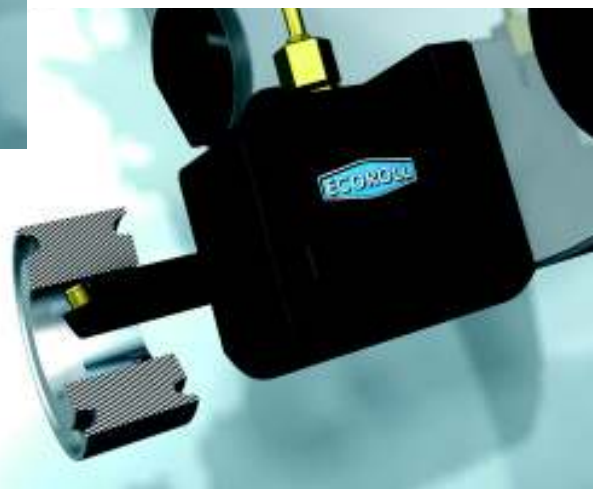
The process induces residual compressive stresses in the component's surface layer and simultaneously improves the material's strength and surface finish through plastic deformation, or cold working.

Type HG Tool Applications: Hard roller burnishing

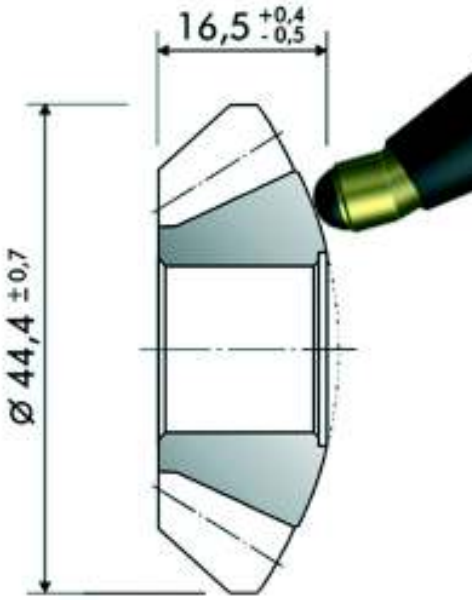
With the exception of HG2 and HG25, the entire HG tool line can burnish hardened steel and other alloys with hardnesses up to 65 HRC.

Machining a hard, contoured mandrel with an HG6 tool eliminates manual polishing.

Using the HG line of tools reduces overall machining costs. One HG tool can be used for multiple applications.



Hard rolling a roller rocker arm with an HG6 tool eliminates an extra lapping operation.



Machining a flywheel with an HG6 tool.

How to order:

HG tools are available in a wide variety of versions. Please refer to the information on page 35 and the naming conventions listed on the following page.

Hydrostatic Tool Design and Specifications

Ball size

The HG line features tools in a wide range of sizes, with burnishing balls from 2 – 25 mm in diameter. The tools are classified according to ball size. For example, an HG6 tool has a ball with a 6 mm diameter. To maximize the level of compressive residual stresses, choose the tool with the largest possible ball diameter.

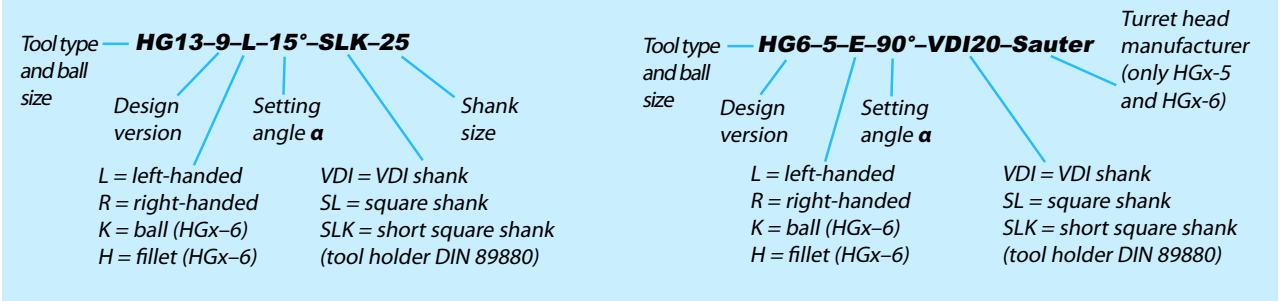
NOTE: *Workpiece contours and finish requirements ultimately determine the burnishing ball size.*

Design version

Because HG tools can be used across a wide spectum of applications, many different design versions are available. HG tools are classified by design version in addition to ball size. For example, an HG6-2 tool has a ball with a 6 mm diameter and is used for burnishing inner diameters. The following table lists the design versions and their related applications.

NOTE: *The tools are listed as follows: HG**x**-**y**, where **x** indicates the ball size and **y** the design version.*

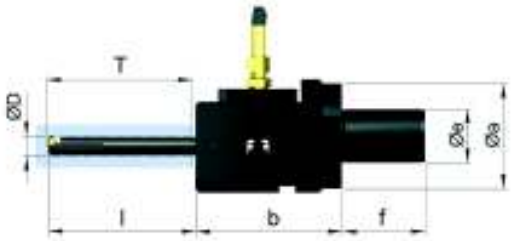
HG design version	Application
HGx-1	internal diameters (cylindrical and tapered bores)
HGx-2	internal diameters (cylindrical bores)
HGx-4	internal diameters (narrow cylindrical bores)
HGx-5	complex contours (cylinders, tapers, faces, fillets, spheres)
HGx-6	complex contours (spheres, rounded surfaces)
HGx-7	faces and free-form surfaces
HGx-9	rotationally symmetrical surfaces (cylinders, tapers, faces, fillets, spheres)
HGx-10	spherical contours and fillets
HGx-11	special tool design versions (e.g. internal diameters – narrow cylindrical bores)
HGx-19	rotationally symmetrical surfaces (cylinders, tapers, faces, radii, slanted faces and other outer and inner contours)
HGx-20	3-point tool (3 burnishing balls), outer diameters of narrow cylinders
HGx-23	outer surfaces of steering knuckles
HGx-29	2-point tool (2 burnishing balls), machines both sides of disc-like and thin-walled components simultaneously (turbine blades)
HG with HFR roller	deep rolling small, hard to reach fillets and hardened workpieces (up to 65 HRC)



Design Versions HGx-1, HGx-2, HGx-4, HGx-11
Application: Internal diameters

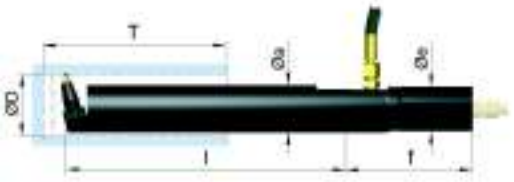
HGx-1

- *For bore sizes ≥ 19 mm*
- *Available with burnishing balls up to 6 mm in diameter*
- *For use with lathes, boring mills and machining centers*
- *Available with rotating union DD for rotating applications (see page 37)*
- *Ball insert, mounted at the end of a lever, operated by the tool body's tracking system*
- *Initial diameter setting: adjust machine slide into approximate radial position*
- *Tracking system automatically fine-tunes diameter setting*



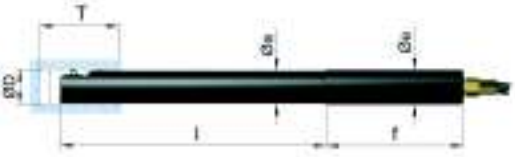
HGx-2P

- *For internal roller burnishing of narrow bores (similar to a boring bar)*
- *Available only with burnishing balls 6 mm in diameter*
- *For bore sizes ≥ 40 mm*
- *For use with boring bar holders on both conventional and CNC-controlled lathes*
- *Shank includes two clamping faces*
- *Maximum rolling length: 350 mm*



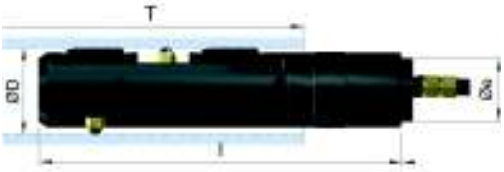
HGx-2

- *For bore sizes ≥ 70 mm (HG6-2) and ≥ 125 mm (HG13-2)*
- *Similar to previous tools, but shank diameter = 50 mm*
- *Rigid shank allows rolling lengths of up to 800 mm*
- *Equipped with standard burnishing elements*

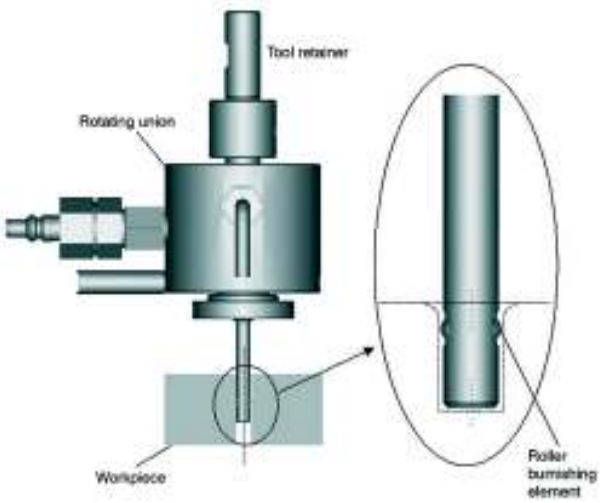


HGx-4

- *For bore sizes 50 - 150 mm*
- *For use with deep hole boring machines*
- *Mounted on boring bar with standard BTA thread connection*
- *Unlimited rolling length*
- *Guide pads centre the tool in the bore (approximate position)*
- *Allowable bore size variation: 2 mm*



HGx-11, *Special version for internal diameters*



HGx-11 (Special version)

- *For the internal machining of small holes*
- *Diameter sizes 6 - 33 mm*
- *Each diameter size requires a customized rolling head*

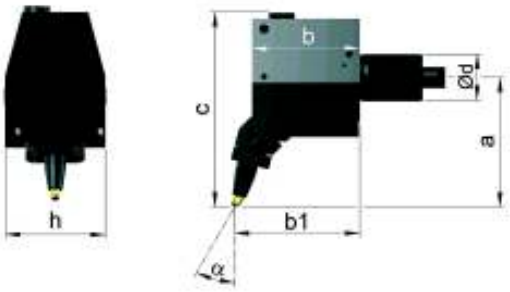
How to order:

HG tools are available in many versions.
Please refer to the the information on page 35 and the following naming conventions.

Tool type and ball size — **HG13–9–L–15°–SLK–25**

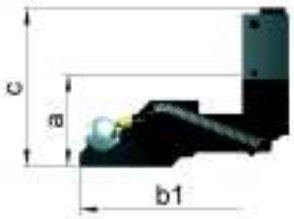
- *Design version*
  - *L = left-handed*
  - *R = right-handed*
  - *K = ball (HGx–6)*
  - *H = fillet (HGx–6)*
- *Setting angle* **α**
- *Shank size*
  - *VDI = VDI shank*
  - *SL = square shank*
  - *SLK = short square shank (tool holder DIN 89880)*

Design Versions HGx-5, HGx-6, HGx-9, HGx-10, HGx-19 Applications: Rotationally symmetrical surfaces and complex contours



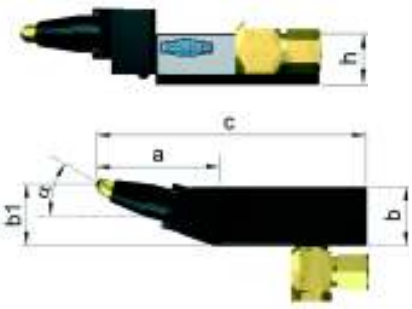
HGx-5

- *Recommended for use with CNC-controlled lathes equipped with tool drive systems*
- *Integrated high pressure pump eliminates the need for external pressure supply*
- *Simply insert the tool into the turret head and it is ready for operation*
- *Can be equipped with VDI-shanks (with diameters of 20 - 80 mm) for all conventional drive systems*
- *Symmetrical design and double-toothed shank allows right- or left-handed use*



HGx-6

- *Similar to HGx-5, but with swiveling burnishing element for burnishing balls and rounded surfaces*
- *Integrated high pressure pump eliminates the need for external pressure supply*
- *HG13-6R roller burnishes fillets*



HGx-9

- *For use with conventional and CNC-controlled lathes*
- *Shank heights from 20 - 32 mm*
- *Both right- and left-handed tools available*
- *Setting angle range: 0 - 90° in 15° increments*
- *Pressure supplied through the shank either from the side or the rear*
- *HG2-9 for deep rolling only, comes with an integrated square shank, but adapters for mounting with standard square shanks are available*

Integrated high pressure pump

- *Standard for HGx-5, HGx-6, HGx-7*
- *For use with CNC-controlled lathes equipped with tool drive systems and standard DIN 69880 tool mounts (VDI shank) with diameters of 20 - 80 mm*
- *Coolant (under low pressure) supplied through the turret head*
- *Tool drive system activates the pump*
- *Clockwise- or counter-clockwise rotation*
- *Maximum speed of 3000 rpm*
- *Built-in pressure relief valve limits the maximum pressure to 400 bar*
- *Available pressure gauge for adjusting rolling force*

HGx-10

- *Recommended for use with conventional and CNC-controlled lathes*
- *Roller burnishing spherical contours and fillets*
- *Swivelling device permits continuous adjustment of the inclination during machining*
- *Both right- and left-handed tools available with standardized square shank heights for standard tool-holding fixtures*

HGx-19

- *For roller burnishing and deep rolling hard materials up to 65 HRC*
- *Can machine all rotationally symmetrical and free-form surfaces*
- *Hydraulically generated burnishing force can be accurately measured and controlled, ensuring consistent, high quality results*
- *Equipped with VDI shank, cylindrical shank, HSK shank or Capto shank*

Design Versions HGx-7, HGx-20, HGx-23, HGx-29 Applications: Faces, free-form surfaces and outer diameters

HGx-7

- *For roller burnishing and deep rolling of plane surfaces and free form surfaces on machining centres and milling machines*
- *For materials up to 65 HRC*
- *Complex shapes that cannot be machined with conventional roller burnishing tools can be treated with hydrostatic tools*
- *Integrated high pressure pump eliminates the need for external pressure supply*

HGx-20

- *For roller burnishing and deep rolling the outer surfaces of thin cylinders (diameters of 0.5 mm) such that the workpiece will not bend during the process*
- *Two fixed burnishing elements prevent the workpiece from bending while a third burnishing element deep rolls the surface*
- *Consistent product quality is ensured: the burnishing force depends on an outside pressure source that can be closely measured and monitored*
- *Equipped with three hydrostatically loaded roller burnishing balls*
- *Normally delivered with a square shank, but other tool shanks are available*

HGx-23 *(not pictured)*

- *Specially designed for machining the outer contours of axles*
- *The workpiece remains static while the burnishing element rotates*
- *For materials up to 65 HRC*
- *Consistent product quality is ensured: the burnishing force depends on an outside pressure source that can be closely measured and monitored*

HGx-29

- *Designed to machine in one pass both sides of disc-like and thin-walled components such as turbine blades*
- *Can be used with both conventional and CNC-controlled machine tools*
- *Processes hardened materials up to a hardness of 65 HRC*
- *Consistent product quality is ensured: the burnishing force depends on an outside pressure source that can be closely measured and monitored*
- *Equipped with a cylindrical shank, but other standard tool shanks are available*

Design Version HG with HFR Roller: Deep rolling fillets

Features

HG tools equipped with the HFR roller enable manufacturers to meet the greater performance demands associated with lightweight, dynamically loaded parts.

- *Deep rolls small fillets that current hydrostatic tools cannot reach*
- *Deep rolls hardened workpieces up to 65 HRC*
- *Used with deep rolling forces up to 15 kN*
- *Deep rolls in a plunge-in process*

Advantages

- *Noticeable increase in fatigue strength*
- *Improved surface quality*
- *Machining can be completed in one setting*
- *Extra hardening process unnecessary*

Parameters

- *Burnishing pressure: 200 - 1500 bar*
- *Machining speed: determined per application*

How to order HG tools

*The tools are listed as follows: HG**x**-**y**, where **x** indicates the ball size and **y** the design version. See also the naming conventions on pages 31 and 32. The lettered dimensions refer to the diagrams pictured with the respective tools.*

Tool	Diameter range D	Rolling length T	a	b	Ø e	f	l
HG6-1	≥ 19	50/80/125	106	131/161/206	40[2)]	136	60/90/135
HG6-2	≥ 70	200/400/600/800	53		50	145	T+40
HG6-2P	≥ 40	200/300	38		40	120	200/350
HG13-2	≥ 125	800	60		63	90	1000
HG13-4	≥ 50	unlimited	49		BTA boring bar thread lead per order		260

NOTES: 1) *With design version DD (rotating union) maximum shank Ø = 32 mm*

Tool	Ball D	Fillet R	a	b[2)]	b_1[2)]	c	d	h	Contact angle α
HG2-9E45°-SL		> 2.5	57	32	61	205		20 25 32	45°
HG2-9V70°-SL			68		72	216			10° or 80°
HG3-9E45°-SL		> 4	69		73	217			45°
HG3-9V70°-SL			80		84	228			10° or 80°
HG6-9._-SL(K)		> 5	66		33	216(148)			30°[3)]
HG13-9._-SL(K)		> 10	80		96	228(160)			
HG6-9E270-SL(K)		> 5			90	276(208)			adjust in 15° increments
HG13-9E270-SL(K)		> 10			111	298(230)			
HG6-5_°-VDI		> 5	100	89	142	130	20 or 30	50	30°[3)]
HG6-5_°-VDI		> 5	109	91	109	164	40 or 50	85 or 100	
HG13-5_°-VDI		> 10	128		162	178	60 or 80	125 or 160	
HG6-6_-VDI		8-25	by request				20 or 30	50	infinitely variable
HG6-6_-VDI40	8-70						40	85	
HG13-6_-VDI	50-250	20-80					40/50/60	by request	

NOTES: 2) *For operation without VDI shank other values apply. Please ask ECOROLL.*
3) *Adapters can be converted to accommodate setting angles of 0°, 60° and 90°. Please request modified dimensions.*

Accessories for Type HG Tools: Type HGP High Pressure Pumps

HGP hydraulic pump units provide pressure to the HG "ballpoint" type hydrostatic tools or to other tools without integrated pumps.

Using the pump unit can prevent rounded workpiece edges in the areas where burnishing begins or ends. The unit gradually increases then decreases the rolling pressure. During deep rolling the unit can be used to create smooth transitions to unburnished areas.

- *Can be used with conventional lathes, machining centers, and CNC-controlled lathes without tool drives*
- *Portable or fixed versions available*
- *The pump runs with a standard three-phase motor; single phase motors available by request*
- *On CNC-controlled lathes the M-function can activate the pump and control pressure supplied to the tool*

Pressure gauge unit

- *Optional HGM measuring device consists of a heavy duty, shock resistant, dampened pressure gauge with a hose unit and a tool specific connector fitting*

How to order:

Pump type: see parameters on this page

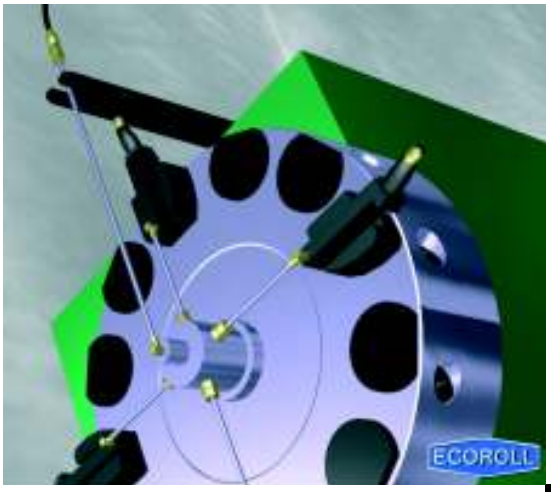
HGP3.0

Pump design: see descriptions on the following page

Pump type	Maximum Pressure (bar)	Maximum burnishing elements (HG tool)				
		HG2	HG3	HG6	HG13	HG25
HGP3	200	12	10	8	6	6
HGP4	400	5	4	3	2	2

Accessories for Type HG Tools: Type DS/DE Rotating Unions

On a CNC-controlled lathe without a tool drive system, the DS rotating union can supply up to four tools with high pressure emulsion.



The DS rotating union is centrally mounted on the face side of the turret. Fixed pressure lines run from the coupling's rotor to the tool(s). The coolant supply is connected to the rotating union's stator and to an external hydraulic pump unit (via a high pressure hose).

The DE rotating union supplies high pressure emulsion to just one tool.

Pump Design	Description
.0	Portable (by hand), direct start/stop controls, pressure build-up without delay, no switch box
.2	Portable (on a cart), roller burnishing and deep rolling with pressure accumulator(s) and solenoid valve, CNC control with M-function or with manual control cable, includes switch box
.3	Integrated into the machine's coolant tank, roller burnishing and deep rolling without pressure accumulator, CNC control with M-function , no switch box
.4	Integrated into the machine's coolant tank, roller burnishing and deep rolling with pressure accumulator(s) and solenoid valve, CNC control with M-function, no switch box
.5	Portable (on a cart), roller burnishing and deep rolling with pressure accumulators and solenoid valve, CNC control with M-function or with manual control cable, includes switch box
.7	Portable (on a cart), roller burnishing and deep rolling without pressure accumulator, CNC control with M-function or with manual control cable, no switch box

Deep Rolling Tooling Technology

Advantages of deep rolling

Deep rolling with mechanical or hydrostatic tools increases the fatigue strength of metal components. Both low and high cycle fatigue resistance is increased and stress corrosion cracking is prevented or reduced. This process is well suited for treating both rotationally symmetrical parts and free-form surfaces.

Deep rolling tools (including the hydrostatic HG tools) can be used with both conventional and numerically controlled turning and milling machines. The versatile tools can also be applied in mass production settings on special machines (for example, to machine crankshafts for combustion engines). Deep rolling can be performed in one setting right after an initial cutting process.

In deep rolling, one or more rollers or balls are pressed against the workpiece surface, plasticizing the material's top layer and changing the surface's micro-structure. At the contact point, the deep rolling force generates Hertzian contact stresses in the material's rim zone. If this stress is higher than the material's yield strength, the material near the surface starts to flow. After the process, residual compressive stresses remain in this zone, increasing the material's fatigue strength.

When the plastic deformation takes place at room temperature or below recrystallization temperature, it is called "cold working." The amount of cold work produced depends on the rolling force, the distance between the rolling traces (or the feed rate), the shape of the roller and the workpiece, and the material's properties. Rolling force and feed rate are the variable parameters. For example, a low rolling force induces a low amount of cold work.

The characteristics achieved depend on both the amount of cold work and the material's properties. The penetration depth of the compressive stresses can vary; for example, lower values occur when using lower force and/or smaller rollers (or balls). Likewise, penetration depth increases with higher force and/or larger rollers (or balls).

Deep rolling is the only metal improvement process that induces residual compressive stresses and cold work while burnishing the workpiece's surface to a high quality finish. The cold work induced by deep rolling increases surface hardness, and the burnishing inherent to deep rolling eliminates all micro-notches. With other processes, micro-notches (such as machining marks) remain in the workpiece, creating the possibility of stress corrosion cracking. Moreover, processes such as shot peening create even more notches and actually increase surface roughness. Deep rolling eliminates the need to remove these micro-notches in a separate time-consuming process.

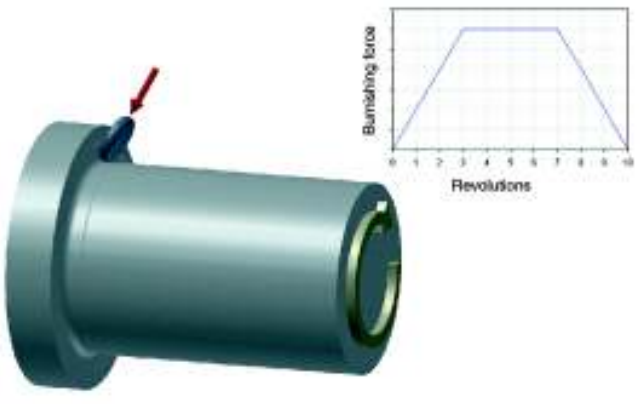
Deep rolling process

The specific process used for deep rolling depends on the workpiece and the desired result. Deep rolling tools are designed for either plunge-in or feed operation.

Plunge-in process

In this process the profile roller(s) engage the fillet radius such that rolling force is concentrated on the area that experiences the highest tension or material fatigue under operating load.

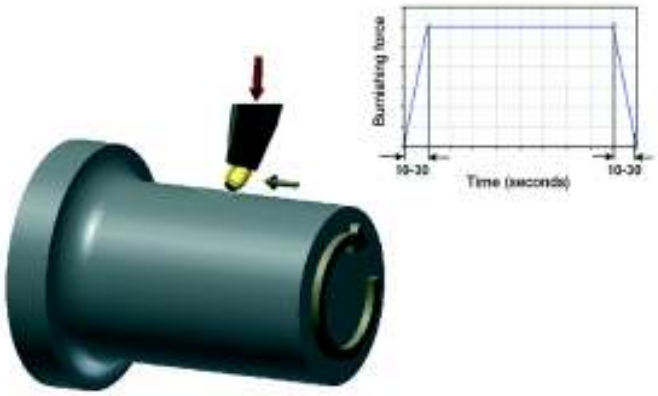
The adjustable rollers align automatically with the workpiece's inclination (the fillet radius in this example). This extremely reliable process takes production tolerances into account and distributes the residual compressive stresses exactly as desired.



The plunge-in process requires two movements:

- *a rotating tool or workpiece (depending on machine and workpiece type)*
- *for multi-roller tools, in-feed in the axial direction; for single roller tools in-feed in the direction of the rolling force*

This process works well for narrow, hard-to-reach areas, such as screw threads or fillets with radii R < 4 mm.



Feed process

This process works well for machining larger surfaces. The rotation and in-feed movements required for the plunge-in process are supplemented here by a simultaneous feed.

Both mechanical and preferably hydrostatic tools can be used for this process.

Deep rolling with hydrostatic tools

Hydrostatic "ballpoint" tools can deep roll not only rotationally symmetrical surfaces, but also flat and curved surfaces or free-form surfaces. The tool moves over the surface such that it creates parallel traces in the shape most advantageous for the particular component—for example, in a spiral or in nested squares. The hydrostatic bearing allows movement in all directions, so the feed direction can be changed even when the tool is fully engaged. The tool's integrated following system automatically compensates for deviations between the programmed trace and the workpiece's actual contour. The adjustable rolling force, generated by a pressurized liquid medium, remains constant throughout the process.

Controlling the rolling force

The rolling force significantly affects the amount of cold work and compressive stress induced. Controlling this parameter therefore guarantees process reliability.

The rolling force of mechanical tools is determined indirectly by measuring and monitoring spring deflection with mechanical dial indicators or inductive sensors. The rolling force is gradually increased at the beginning of the process and slowly decreased at the end by slowly in-feeding the tool or pulling it out. This procedure prevents stress transitions.

The pressure of the liquid operating medium determines the rolling force applied by hydrostatic tools. Pressure transducers can monitor and record this force. Electro-hydraulic servo valves or a set of hydraulic accumulators produce the gradual pressure build-up and release that prevent stress transitions. Manual valves connect these devices to the tool, ensuring a gradual pressure increase or decrease as appropriate within a desired time frame. Controlling the pressure in this way creates specific compressive stress characteristics in the appropriate areas. The goal is to gradually increase the cold working over time in the desired area to the maximum desired value.