Rationalize Cylinder Production with high Pressure

1. Introduction

This presentation shall outline how to rationalize production of short hydraulic cylinders by a change of the process sequence. This requires a small number of measures, consisting of relocating the bore finishing to a CNC-lathe, advanced tools and the finish operation using high pressure coolant. The change of process chain, the new tool generation and machine integration are explained.

2. State of the art

One or both ends of most hydraulic cylinders need machining of faces, seal grooves, threads, or chamfers on a CNC-lathe. In some instances, the outside diameter of cylinders is machined as well. This takes place before or after bore finish by skive/burnishing on a deep boring machine. This sequence requires removing the cylinders from one machine tool, transportation, resetting to the next machine and is consuming time and causing costs.

Using up-to-date technology, these costs can be eliminated on cylinders with a length to diameter ratio (L/d) up to 20 (Fig.1).

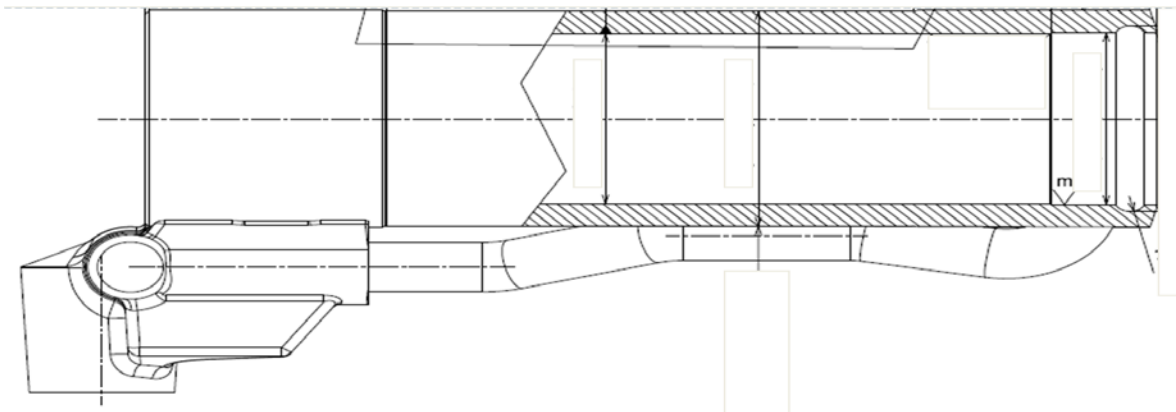


Fig.1: Hydraulic cylinder L/d = 5

Table 1 shows the cost-saving potential of 3 cylinder categories. The blue arrows show the cost-saving potential by relocation of the skive/burnishing process to the CNC-lathe.

3. New concept

This process sequence is to be changed according to Table 2.

Separate skiving and burnishing tools are recommended for very short cylinders (category 1: L/d ratio < 10) as well as stepped cylinders (category 2). The shorter tool length requires shorter tool travel and therefore saves time. The tool change from skiving to roller burnishing can be done quickly. Therefore, combined skive/burnishing tools are not required for these categories. The longer cylinders of category 3 can be finished on the CNC-lathe preferably with combined skive/burnishing tools, alternatively with separate tools. The benefits of the process cycle change are listed in the column 4 of Table 2.

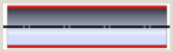
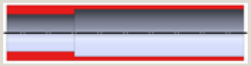
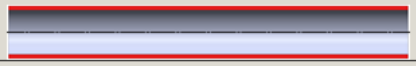
Category		CNC-Lathe	Deep Boring Machine
1	Short cylinders (L/d≤10) with through holes ≥ 35 mm 	Cylinder ends outside diameter	Skiving and roller burnishing with combined or separate tools
2	Cylinders (L/d≤10) with step bores ≥ 70 mm 	Cylinder ends outside diameter	Counter boring, skiving, roller burnishing with separate tools
3	Longer cylinders(L/d≤20) from cold drawn tubes with dia. ≥ 100 mm 	Cylinder ends outside diameter	Skive/burnishing with combined tools

Table1: Cost-saving potential

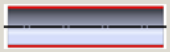
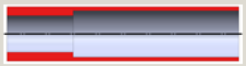
Category		CNC-Lathe	Users Benefit
1	Short cylinders (L/d≤10) with through holes ≥ 35 mm 	Cylinder ends Outside diameter Skiving and roller burnishing with separate tools	• Machining in one setting. • Elimination of transportation and setting costs. • Reduced investment. • Automatic tool change on CNC-lathe by machine integrated tool handling system or ECOROLL tool connection and robot
2	Cylinders (L/d≤10) with step bores ≥ 70 mm 	Cylinder ends Outside diameter Counter boring, skiving, roller burnishing with separate tools	
3	Longer cylinders(L/d≤20) from cold drawn tubes with dia. ≥ 100 mm 	Cylinder ends Outside diameter Skive/burnishing with combined tools	

Table 2: Benefits of the new process cycle

The conventional coolant circulation of deep boring machines with high coolant flow rate and pressure below 10 bar through the pressure head and the annulus gap between boring bar and tube is not compatible with the conditions of CNC-lathes.

- Pressure heads cannot be installed in the work space of the CNC-lathes due to collision problems.
- So, the coolant supply through the annulus gap is not possible.
- The conventional coolant flow rate of **Q (l/min)=4xd (mm) (e.g. 200 l/min for 50 mm cylinder dia.)** is not available on CNC lathes.

Therefore, a new tool coolant supply concept compatible with CNC-lathes has been developed by ECOROLL.

4. Tools

The most significant modification of the skiving tools (Fig. 2 and 8) is the high pressure coolant supply through the I.D. of the boring bar and through nozzles into the chip spaces of the tool. This makes the pressure head obsolete and the coolant discharge can be reduced to 10 up to 50 l/min. The chip formers of the cutting inserts generate slim spiraled chips which flow away in the feed direction on their own.

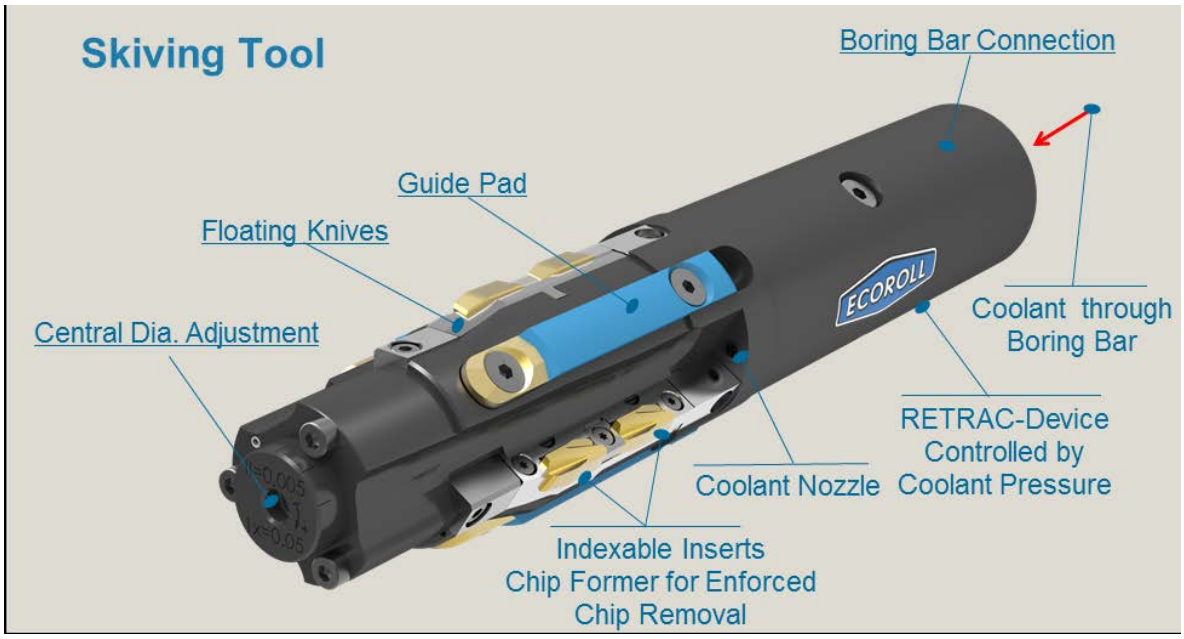


Fig. 2: Skiving Tool

The high coolant pressure ranging between 70 to 120 bar generates high-speed jets in every chip space. They are directed to the cutting inserts, generate a high forward acceleration impulse to the chips and cool chips and cutters efficiently (Fig. 2).

For these tools, there is no more hydraulic control circuit necessary to activate or retract the tools. Moreover, the tools are activated automatically when the coolant pressure is switched on. Switching off the coolant pressure retracts the skiving knives.

The remaining details and functions are identical with the proven OMEGA tools with 3 skiving knives equipped with tandem cutters and the central diameter adjustment for all 3 knifes. Both tandem cutters are fixed with only one screw. This clamping system saves time during indexing or changing of the cutters, because clamping screw and inserts are accessible while the knifes are in place in the skiving head. So, the knives must not be removed for this operation and the screw needs to be turned about 2 revolutions only.

The roller burnishing tools are also provided with internal coolant supply and high pressure nozzles. The latter are directed towards the cylinder wall of the tubes in a way that chips and metallic particles are removed efficiently due to the high speed of the coolant jets (Fig. 3 and 5).

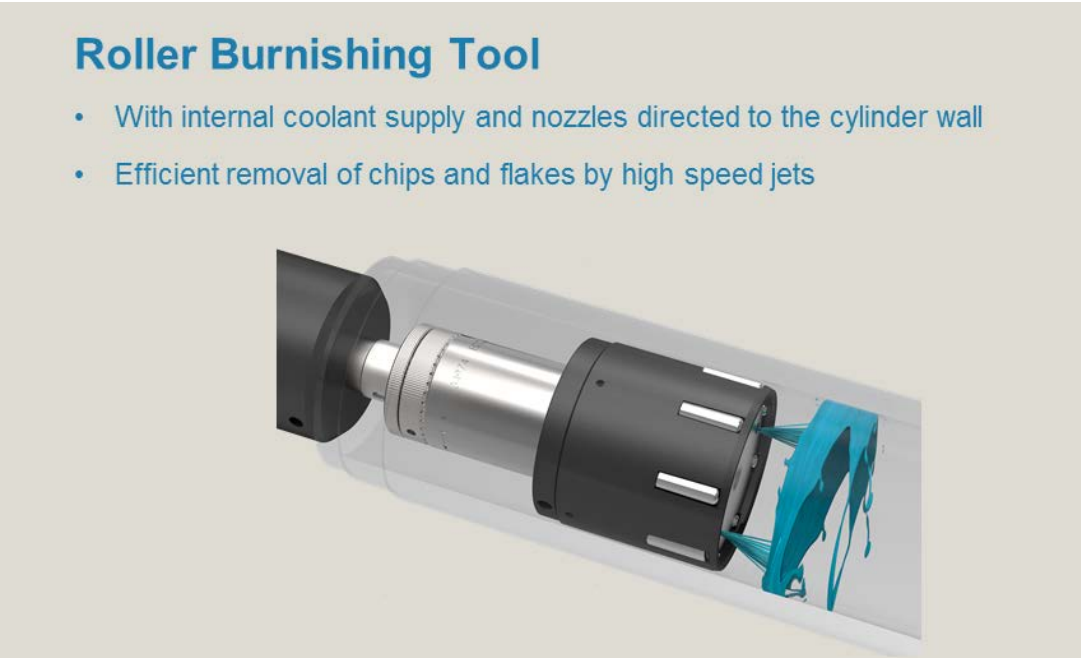


Fig. 3: Roller Burnishing Tool

The finishing process of 40 mm cylinders, 200 mm long cylinders on a CNC-lathe is shown in a short video (Fig. 4). The total process time including the tool change takes 25 seconds only. This video is available under
http://www.ecoroll.de/en/service/downloads.html

Fig. 4: Video

Counter boring tools, skiving heads and roller burnishing tools for stepped cylinders (category 2) are also equipped with internal coolant supply and high pressure nozzles (Fig. 5). Moreover, these tools are provided with the new ECOROLL quick coupling QC. The base for this quick connection is the proven and standardized hollow taper shank HSK. But it is modified because the standard version does not offer enough space for the internal coolant supply due to its internal clamping mechanism.

Fig. 5: Counter boring head, skiving head and roller burnishing tool with internal high pressure coolant supply and ECOROLL quick connection QC

The hollow taper shank (Fig. 6) is provided with an external clamping mechanism for cylinder processing tools on deep boring machines and lathes. So, the standardized internal clamping mechanism can be purged. This opens a large internal diameter to lead through all required liquids for different processes. In contrast to the well-known BTA threat connections, the tools must not be rotated during connecting or disconnecting. They are only inserted in axial direction but not rotated. The connection is tightened by an only 40° rotation of the external Jay-slot nut. This makes the manual tool change more easy and safe and allows first-time the automatic tool change of cylinder processing tools by means of a robot or machine integrated tool changer. Deep boring machines and CNC-lathes can be provided with such tool changers.

The new quick connection QC can be adapted by suitable inserts for counter boring and skive/burnishing with high pressure coolant, and for the ejector boring process or for the operation of conventional skive/burnishing tools with hydraulic Retrac® device.

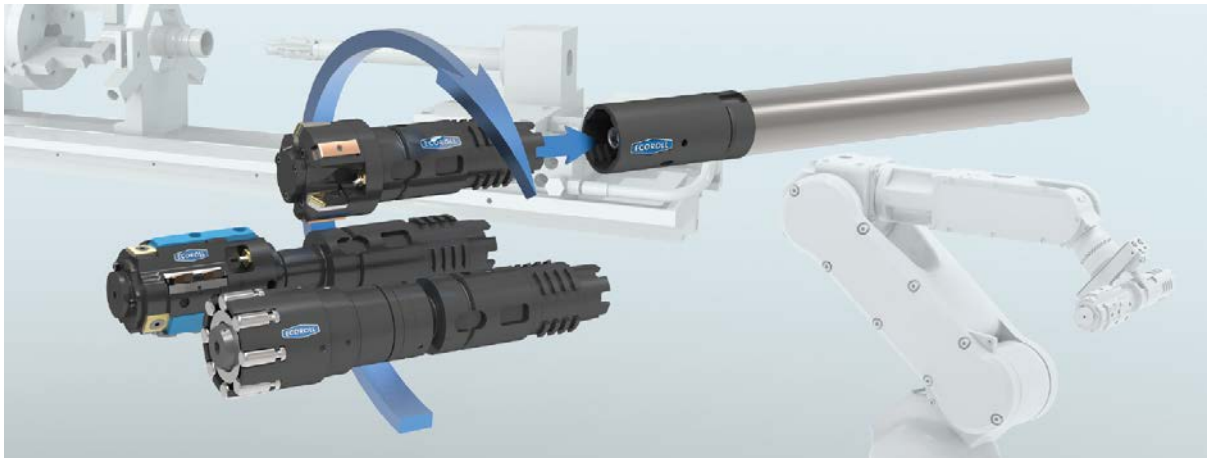


Fig. 6: ECOROLL quick connection QC

Fig. 7: Removal of counter boring chips (video sequence)

Fig. 7 shows one picture of a 2nd video, showing tests of removal of counter boring chips with high pressure coolant. The test specimen was a step cylinder I.D. 135 mm, 1200 mm long.

The cylinder was clamped in the chuck with 3 elongated jaws with an axial distance of about 100 mm between tube end and chuck body. The chips were driven forward in the tube by the high pressure coolant and centrifuged into the working room of the machine through the above-mentioned 100 mm distance.

Remark: the chips visible in the background do not still lay in the tube. A small amount of chips was driven further by the coolant/air mixture into the hollow spindle of the lathe in this test setup. This video is available under

http://www.ecoroll.de/en/service/downloads.html

4. Outlook

Combined skive/burnishing tools whith the internal high pressure coolant supply (Fig. 8) are designed for the bore finishing of longer cylinders up to a length/diameter ratio of L/d ≤ 20 on CNC-lathes. In this case, they can replace separate tools, saving one tool change. These tools can also be provided with the new quick connection QC.

Fig. 8: Combined skive/burnishing tool for CNC-lathes with internal high pressure coolant supply

These tools are also suitable for especially equipped deep boring machines with high pressure coolant system. The advantages of such machine concept are:

- significantly smaller coolant tank
- less work floorspace required
- less coolant costs
- less mist
- shortened time to empty the tube
- faster tool change

Materialization of this new, slim machine concept is recommended due to the above-mentioned benefits. ECOROLL is ready to help you working out concept in more detail.