YOUR PARTNER IN THE **TURBINE INDUSTRY**

Tools and systems for

- Viper grinding
- High speed reciprocating grinding
- CD / non CD creep feed grinding
- Reciprocating grinding

TYROLIT

A Company within the SWAROVSKI Group

TYROLIT
THE TECHNOLOGY LEADER FOR GRINDING APPLICATIONS IN THE TURBINE INDUSTRY

TYROLIT, Europe's market leader in grinding technology for turbine parts and a global player in this industry sector, manufactures and supplies grinding and dressing tools for specific customer requirements.

Technology leader and partner

Through basic research and optimization of production runs, we, as technology leader, and together with the relevant machine manufacturers, universities and end customers, are the driving force behind advancements in the grinding processes for the turbine industry.

Appropriate ideas and the backing of TYROLIT have led to completely new production processes, which in turn have set new trends in mass production.

The latest technical expertise from the world of abrasives and new grinding strategies are put into practice by our team of application engineers, whose professional competence is valued by our customers.

Our outstanding market position justifies our total commitment to sustained customer performance, year for year.

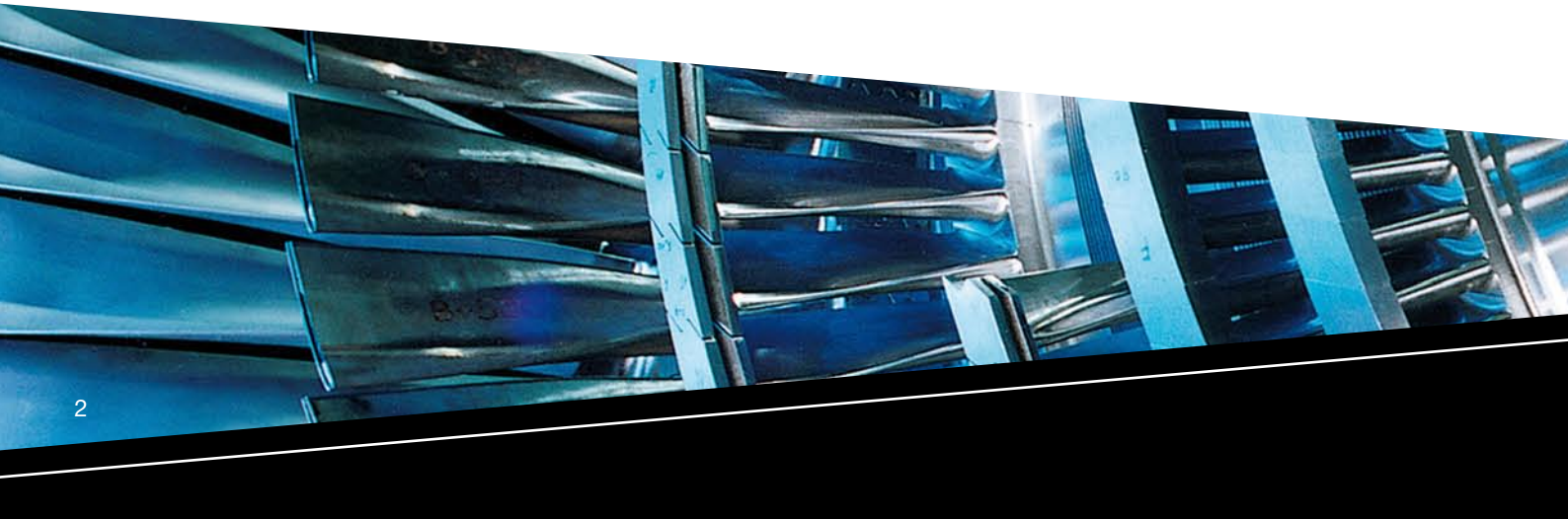
We believe in customer proximity which is reflected in our global presence. Technology leader TYROLIT thereby constantly secures your innovative edge.

The turbine industry is split as follows

Aircraft Turbine
From engines for business jets to the world's most powerful thrust engines for long-haul aircraft through to the military sector. In all cases TYROLIT plays a leading role, supporting the engine manufacturers and their subcontractors with continuous further development of products and know-how.

Stationary Turbine
Nowadays the largest and most powerful gas turbines are built with a capacity of 340 megawatt. With an efficiency factor of more than 60% these high-tech power stations set new benchmarks for ecological and cost-effective power generation.

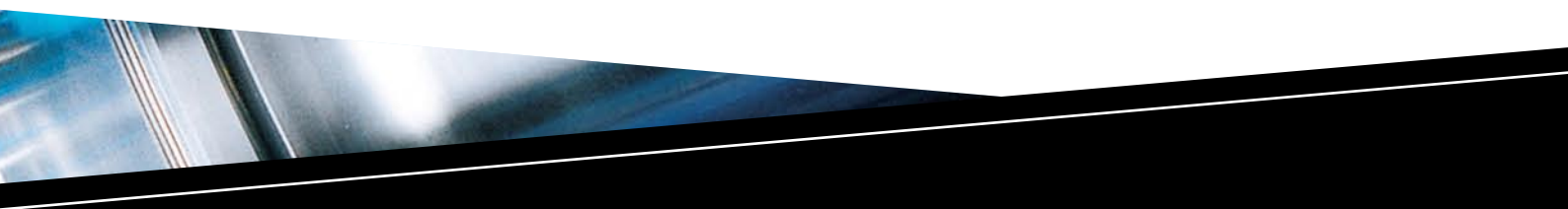
Extreme grinding lengths and deep profiles present a particularly tricky challenge in terms of grinding technology, one which TYROLIT has already mastered for some decades.



OVERVIEW OF GRINDING OPERATIONS
IN THE TURBINE INDUSTRY

An ongoing challenge is that of increasing the material removal rate (Q'_w) of the grinding system. The table below shows the development of this parameter from 1950 to the present day.

Year	Method	MRR Q'_w [mm^3/smm) Clamping		Advantage	Restrictions	Flexibility
		rigid	flexible			
< 1950	Reciprocating	5	3	Profile holding high Complexity low	Profile holding high MRR low Grinding time very high	low
1975	Creep Feed	15	5	Complexity low	Profile holding low MRR low	low
	CBN Creep Feed	15	5	Profile holding high	MRR low Normal force high Very expensive	low
	CD Creep Feed (Continuous Dressing)	25	10	Profile holding very high	Complexity high MRR low Wheel usage high	low
	IPD Creep Feed (Intermittent Pulse Dressing)	25	10	Profile holding very high	Complexity high MRR low Wheel usage moderate	low
1999	VIPER Creep Feed	100	50	MRR high Profile holding high Low consumable costs Less burning	Small wheels Short components High pressure coolant	very high
	HSCD Creep Feed (High Speed Continuous Dressing)	300	120	MRR very high Profile holding very high	Complexity high Motor power high	low
2006	High Speed Reciprocating (PROKOS)	80	50	Motor power low Less burning Profile holding high	Complexity high High cutting speeds & table speds needed	very high



CD OR NON CD CREEP FEED GRINDING

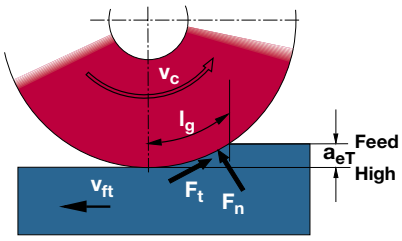
During creep feed grinding the material to be removed is reduced in either upgrinding or downgrinding mode. The back stroke is always an idle pass without any machining. The total material is removed in just a few cuts/passes.

Grinding with the same material removal rate with reciprocating grinding (surface creep feed) would result in a considerably extended grinding time as only low feed rates are possible.

This process is sub-divided further into Continuous Dressing creep feed grinding or non CD creep feed grinding.

With non CD creep feed the grinding wheel is dressed intermittently. This is normally done between the rough and finish grinding processes.

As the name suggests the wheel is continuously sharpened and cleaned during CD creep feed due to the constant contact with the roller dresser.

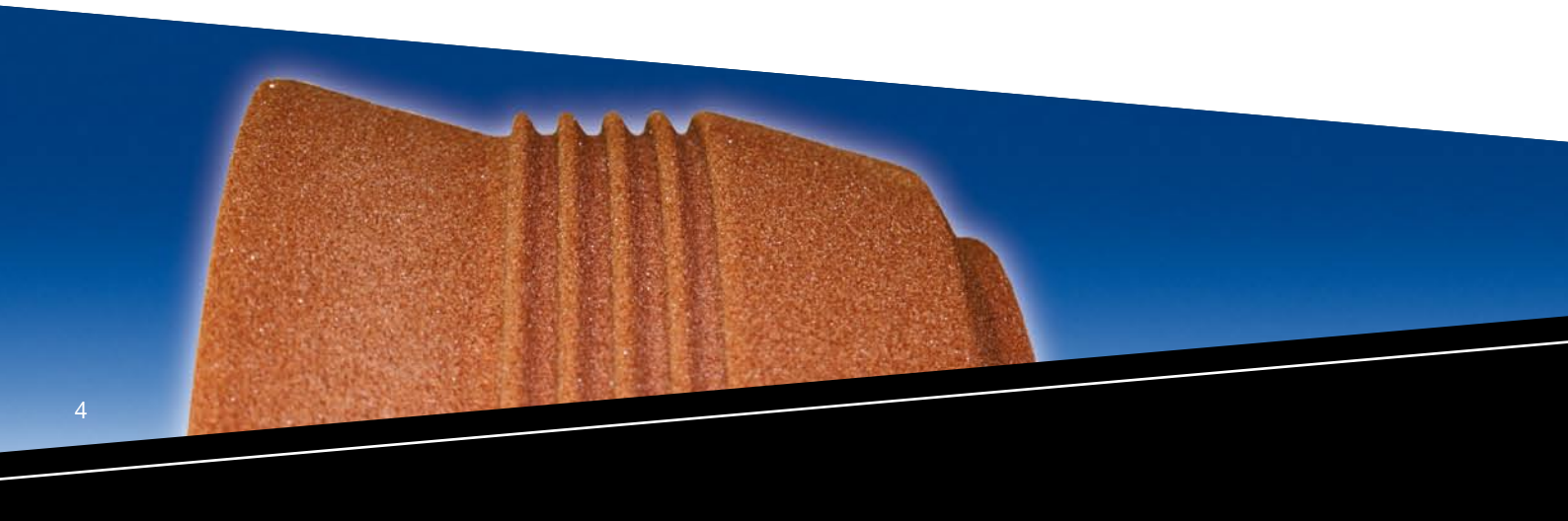


The principle of creep feed grinding

Non CD creep feed is applied with the following tool variations

- Conventional grinding wheels
  These are by far the most commonly used wheels as they are more economical and can also be applied on older, low-power machines.
- Vitrified bonded CBN wheels
- Electroplated CBN wheels

Vitrified conventional STRATO ULTRA grinding wheel



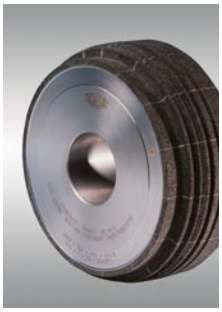
Electroplated CBN wheels

Electroplated CBN grinding wheels are frequently applied for complex profile segments with difficult wheel access, such as NGV slots.

Advantages of creep feed grinding with electroplated CBN

- Extremely complicated wheel geometries can be produced
- Less complex machine layouts as no dressing unit is required

Electroplated
CBN grinding wheel
for NGV slots



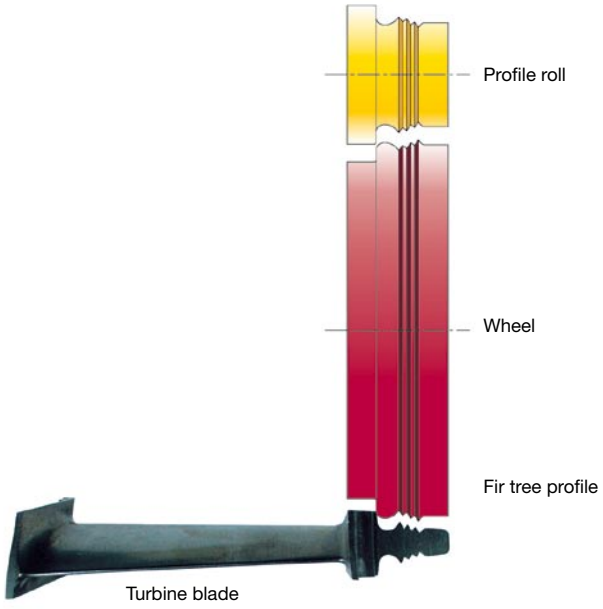
Vitrified bonded
CBN grinding wheel

Advantages of CD creep feed grinding

- Grinding wheel topography remains effective due to continuous action of the roller dresser
- Shorter grinding times, as very high feeds are possible
- Excellent form stability and cool cutting

The cutting ability of the wheel is dependent on the dressing feed and the infeed per grinding cycle.

Only vitrified bonded conventioned wheels are used for CD creep feed grinding.

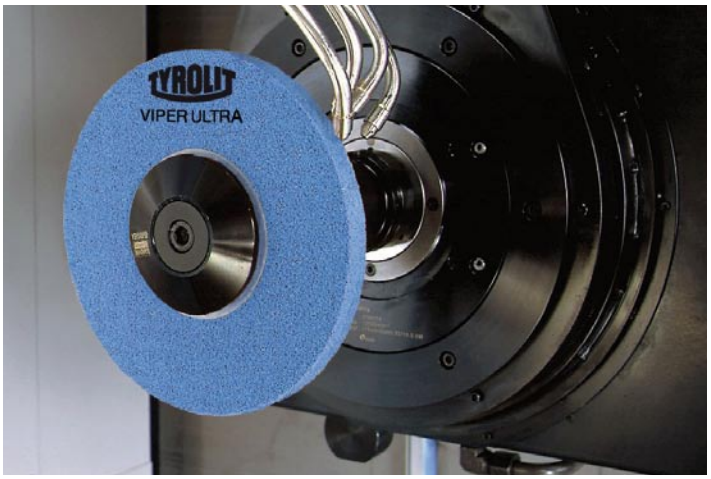


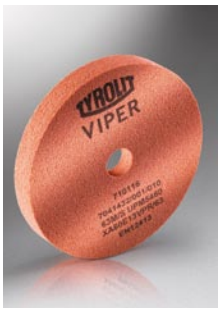
Principle of CD creep feed grinding

VIPER
THE MULTIFUNCTIONAL PATENTED SYSTEM SOLUTION

VIPER is a new special SYSTEM for the creep feed grinding of the Ni-based alloy materials used for aircraft engine components. VIPER was developed in a joint venture between TYROLIT, Rolls Royce UK and the engineering company Raysun.

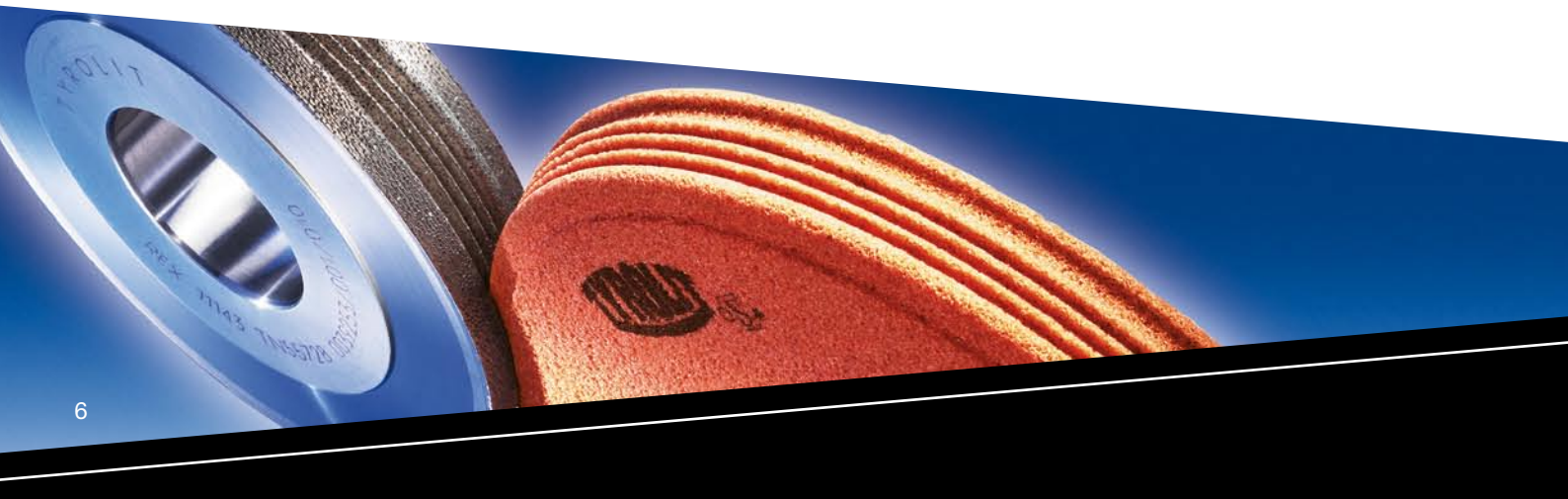
VIPER offers high material removal rates (Q'_w) thanks to the coolant supply and the specially developed VIPER and VIPER ULTRA grinding wheels.





As a rule such parts are ground in a “closer-to-form“ mould in a cellular concept on several machines with up to 10 set-ups. The total cycle time for such a part is much higher than with the VIPER system. Having multiple set-ups can also lead to tolerance problems.

With the VIPER system this is no longer necessary as owing to the tool changer all profiles can be machined with the optimum tool. The maximum wheel dimensions which can be used are 280 x 50 x 32 mm.



Advantages of the VIPER system

- Extremely flexible machining center
- Greatly minimized risk of surface damage due to special cooling lubricant nozzle application
- Cool grinding
- Lower tool costs compared with CD creep feed grinding, as small wheels and process-matched roller dressers can be used
- Excellent form holding and profile retention
- Low grinding forces
- High material removal rates (Q'_w values)
- In-Process Dressing (CD) possible (Makino A99)
- Reduced process costs of up to 80 %

The VIPER system is used around the globe on Bridgeport-Hardinge, MAKINO and Mori Seiki machines.

The results are more than convincing.
This system saves both time and money.

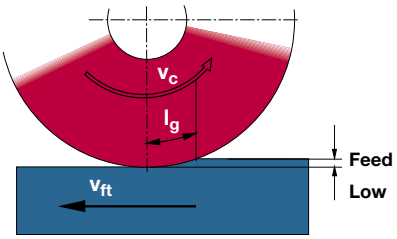
MAKINO iGrinder G5

BRIDGEPORT FGC2

MORI SEIKI NT4250

RECIPROCATING GRINDING

During reciprocating grinding the workpiece is machined in several swings or passes. It therefore takes a number of cycles (passes) with feeds of < 0,1 mm to complete the process of total material removal.



Principle of reciprocating grinding

Advantages of reciprocating grinding

- Low temperatures due to low feeds and high table speeds
- Lower grinding forces due to lower feeds
- High shape stability, the aluminium oxide wheel has excellent form holding properties within the dressing cycles

HIGH SPEED RECIPROCATING GRINDING – PROKOS

High speed or fast stroke reciprocating grinding with high traverse and table speeds combines two technologies. The linear drive technology for the machine has been successfully united with the traditional reciprocating grinding of turbine parts.

Traverse speeds of up to 120 m/min with an acceleration of 25 m/s and feeds of < 0,05 mm/pass and therefore short contact lengths characterize this process.

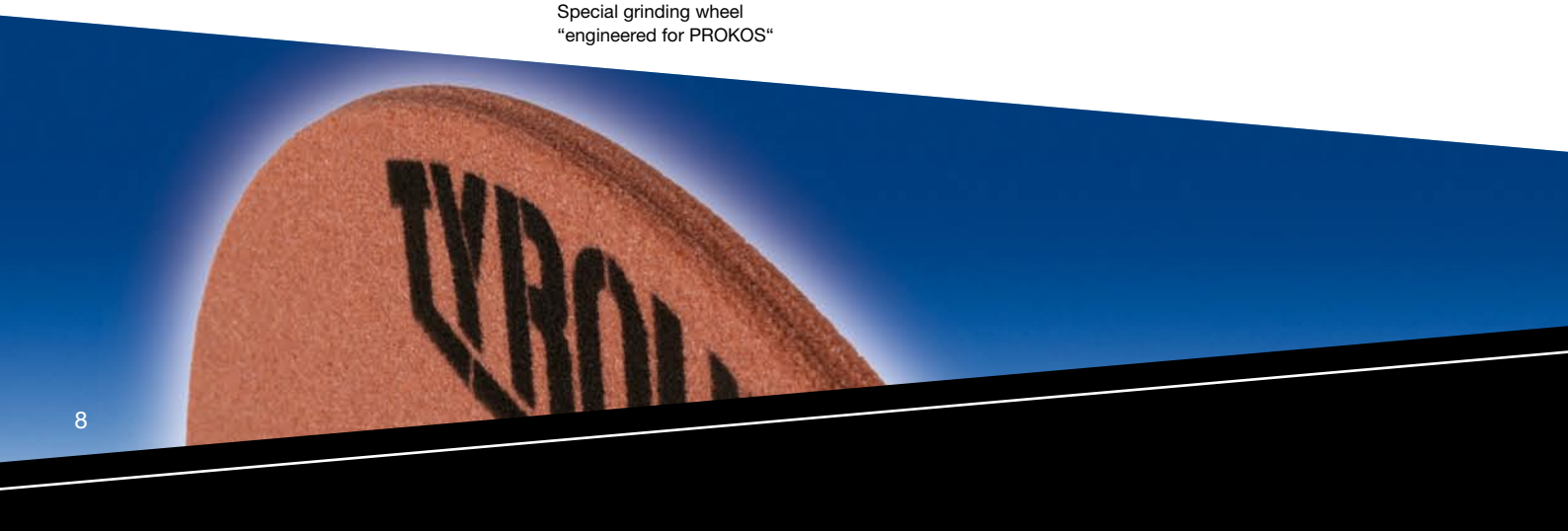
The slow, but very precise reciprocating process has been advanced to a highly productive system thanks to the linear technology and the first-rate efficiency of the data processing system.

The main advantages of this technology

- Low heat transfer into the workpiece
- Lower specific power consumption
- Favorable stresses in the workpiece surface
- Low grinding tool costs
- Shortened grinding times

BLOHM PROKOS

Special grinding wheel “engineered for PROKOS“



APPLICATION ENGINEERING – **SOLUTIONS EXPERTISE**

Successful enterprises expect not only top products from their partners, but also process know-how and a program of comprehensive support for their individual requirements.

Concentration on the production and supply of top quality tools is in itself no longer sufficient. Good “software” has to be offered alongside the “hardware”. With the wealth of process expertise commanded by our team of application engineers we are able to provide our customers with sustained solutions in line with today’s demanding technical and economical expectations.

Clarify the task

We place great emphasis on knowing the targets of our customers. Application engineering specialists analyze the task in detail. A requirements profile which takes technological and profitability aspects into account is then drawn up together with the customer.

Define the concept

The team of experienced application engineers defines approaches to the solution, calling on the additional input from our specialists from R & D and our in-house test center as required.

Realize the solution

The process solution is then taken direct to the customer where it is put into practice on the relevant machine. Within the scope of a sustained process optimization the application engineer sets the mode of operation for the grinding tool, the interaction between machine, workpiece, material, cooling lubricant and kinematical parameters.

Share the know-how

Our know-how in the field of grinding technology is crucial to successful cooperation. A one-off optimization is not the solution for the customer. Sustained results come from the continuous application of the experience on a broad basis. Service is also offered to our customers by way of practice-oriented information, data preparation, trainings and seminars.

REDUCTION OF GRINDING TOOL PRICE -
IS THIS THE WAY TO IMPROVE PROCESS ECONOMICS?

Operation: Fir tree root
Currency: EUR

Main data for saving calculation:
Annual production [pc.]: 20.000
Machine operator costs / h [1/h]: 100,00 EUR

Tool costs		Manufacturer	Specification	Life time [parts]	Costs / tool	Costs / part	Savings / year
Grinding tool:	Old:	TYROLIT STANDARD		160	145,00	0,906	
	New:	Competitor		160	120,00	0,750	
Dressing tool:	Old:	TYROLIT		5.500	4.000,00	0,727	
	New:	TYROLIT		5.500	4.000,00	0,727	
				Difference:		0,156	3,125.–

Setup-costs		Tool-changes / year	Exchange time [min]	Exchange time / year	Prod.-loss [pc.]	Costs / part	Savings / year
	Old:	125,00	20	41,67	572,52	0,208	
	New:	125,00	20	41,67	572,52	0,208	
				Difference:	-	-	0,–

Machining costs		Cutting time [sec]	Cycle time [sec]	Parts / h	Capacity [%]	Costs / part	Savings / year
	Old:		262,00	13,74	100%	7,278	
	New:		262,00	13,74	100%	7,278	
				Difference:		-	0,–

Change-over costs Scrap-costs		Material-no.	Quantity [pc.]	Costs / tool		Total costs	Savings / year
	Old:			145,00		-	0,–

Results	Cost savings total / part	0,156		Cost savings total / Year [EUR]	3.125,-
	Cost savings %	1,7%			
	Pay back rate [years]	0,00		Capacity increase	0 %

The results show the required savings in the tool price, but take neither the optimization of process costs nor increased production capacity into consideration. The consequence is only minimal cost savings.

TYROLIT PROCESS OPTIMIZATION -
GENERATES REAL BENEFITS FOR THE CUSTOMER

Operation: Fir tree root
Currency: EUR

Main data for saving calculation:
Annual production [pc.]: 20.000
Machine operator costs / h [1/h]: 100,00 EUR

Tool costs		Producer	Specification	Life time [parts]	Costs / tool	Costs / part	Savings / Year
Grinding tool:	Old:	Competitor		160	120,00	0,906	
	New:	STRATO ULTRA		200	145,00	0,835	
Dressing tool:	Old:	TYROLIT		5.000	4.000,00	0,800	
	New:	TYROLIT		5.500	4.000,00	0,727	
				Difference:		0,144	2,880.–

Setup-costs		Tool-Changes / Year.	Exchange time [min]	Exchange time / Year	Prod.-Loss [pc.]	Costs / part	Savings / Year
	Old:	125,00	20	41,67	572,52	0,208	
	New:	100,00	20	33,33	571,43	0,167	
				Difference:	-1,09	0,042	833.–

Machining costs		Cutting time [sec]	Cycle time [sec]	Parts / h	Capacity [%]	Costs / part	Savings / Year
	Old:		262,00	13,74	100%	7,278	
	New:		210,00	17,14	125%	5,833	
				Difference:		1,444	28,889.–

Change-over costs Scrap - costs		Material-No.	Quantity [pc.]	Costs / tool		Total Costs	Savings / Year
	Old:			145,00		-	-

Results	Cost savings total / part	1,630		Cost savings total / Year [EUR]	32.602,-
	Cost savings %	17,7%			
	Pay back rate [Years]	0,00		Capacity increase	24,8 %

OPTIMIZATION OF PROCESS COSTS

With optimized grinding parameters and in spite of a higher wheel price up to 10-fold savings on the total process costs can be realized. 25% additional capacity is also generated.

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