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How to process materials which are hard to machine with LACH dreborid-G tools

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Processing materials which are hard to machine has always been difficult and time consuming.
Various lathe systems achieved more or less mediocre results. However, with the development of highly compressed cutting edges, the results could be improved considerably (this development started with the introduction of polycrystalline tools about 10 years ago).
Whatever the material, hardened steel, cast-iron ware or special hard alloys on a nickel or cobalt base, turning is now more economical than grinding which has often been used alternatively.

An example: Grooves had to be cut into steel AISI02 (groove width 1,1 mm, tolerance +0,05 mm, groove depth 3 mm, V = 100 m/min). The requested tolerance was maintained with 100 pieces. The wear on the cutting edges was negligible even after these 100 pieces.

Many of the modern lathes allow the cutting of metals with high material removal. However, their productivity is drastically limited when cutting extra hard materials because of the cutting edge wear.

This cutting edge wear makes it difficult to keep to the requested workpiece dimensions, and also the surface finish deteriorates. The problem of cutting tools which are getting dull can be solved in different ways.

The most common method is changing the tool, which results in machine down times and a diminuition of the machine productivity. Another method is to reduce feeds and speeds. This reduces the tool wear but also the productivity of the machines.

A third solution improves the machine performance using abrasion resistant cutting tools.

There have been many new developments in improving tool materials and cutting materials. Some of these cutting materials, especially the higher developped types of carbides and ceramics, have considerably improved the production capacity for many materials to be processed, but they are not always satisfactory for materials which are hard to machine.

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The „perfect“ tool material for machining super hard and abrasive materials should have the following qualities:

- hardness, abrasion resistance, fracture and impact resistance, toughness insensitivity to high temperatures

- Oxidation resistance, chemical resistance against the materials to be cut at high temperatures

Many of the cutting tools which are used in industry today have some the above mentioned qualities, but not all of them.

The perfect tool for materials which are hard to machine with high removal rates would have the hardness and abrasion resistance of the diamond, the chemical resistance of ceramics and the impact resistance of carbide. It is unlikely that there ever will be a cutting material which combines all of these excellent qualities.

Scientists and technicians of General Electric Company USA have succeeded in creating highly compressed cutting material using high temperature and high pressure technology and offer this in form of cutting inserts.

10 years ago, LACH-DIAMANT Hanau started to work up these cutting materials and has put them on the market under the trade name LACH-dreborid-G. In the meantime innumerable problems have been solved, turning operations can be effected more economically than with other cutting materials before.

After the diamond dreborid-G is the second hardest cutting material which is on the market at present.

LACH dreborid-G inserts go into competition especially with grinding operations because there is no other cutting tool which is able to turn the materials listed below economically.

Which materials can be processed economically with LACH dreborid-G?

Some of the materials mentioned could be machined to some extent with special carbides and ceramics, but in most cases this cannot be done economically, this is only possible by grinding. Grinding, however, is very time consuming so that labour cost are too high. Therefore the requested economy cannot be achieved.

The following materials can be machined econimically with LACH dreborid-G inserts:

1. Hardened steels with at least 58 G´HRc, for example:
a) Carbon tool steel AISI M 44
b) Chrome tool steel AISI M2
c) Heat treatable steel CA AISI 4337
Cementation steeel CA AISI 4317

d) Ball bearing steel AISI E 52100
e) Nitride steel CA UNS J 24056

2. Cast materials such as
grey cast iron, modular cast iron, chilled cast iron, cast steel

3. Super hatd alloys (Nickel or cobalt base)
a) Inconel
b) HAS Telloy
c) powdered metals coatings colmonoy or Metco

4. Special materials such as Moly-Chrome

Which demands are made on the lathe?

When working with natural diamond turning tools a lathe with maximum stiffness and perfect mounting is required in order to protect the expensive and sensitive natural diamond tools. LACH dreborid-G turning tools can be used on any conventional production lathe. Of course the turning results will be better and the tool lives longer on lathes with optimal stiffness and mounting, but these are not absolutely necessary. This lathes permit the the unrestricted realization of the complete production potential of LACH dreborid-G inserts.

An important prerequisite for optimal use, staisfactory surface quality and a long tool life of the dreborid-G insert is an intensive cooling on the turning point using water-soluble oil. The coolant does not only improve the surface quality of the workpiece but has also favourable effects on the tool life respectively on the flank wear of the tool cutting edge.

Which machine parameters are applicable?

It is important to observe the regulations concerning the machine parameters such as speed, feed and cutting depth.

Cutting speed

For steels from 58 HRc the cutting speed should be 60 - 100 m/min.
For cast iron materials such as grey cast iron, chilled cast iron and malleable cast iron the adequate cutting speeds are 400 - 500 m/min respectively 100 m/min. For superhard alloys the recommended speeds are 150 - 200 m/min.

Depth of cut

For hardened steels the maximum cutting depth is 1,0 mm, for interrupted cut appr. 50% less. The same goes for cast iron materials.
For super hard alloys cutting depths up to 2 mm can be used (attention: intensive cooling is necessary).

Feed

The maximum feed for hardened steel and cast iron materials shoould be 0,1 mm/U, in case of interrupted cut appr. 50% less. For super hard alloys feeds up to 0,15 mm/U can be used.

LACH dreborid-G achieve top performances in production and tool manufacturing.

Often the toolmaker has to grind for example hardened shafts to a smaller diameter. Where up to now a time consuming grinding method had to be used, now the shafts can be turned with dreborid-G inserts within a few minutes with equal precision and surface finish.

Other applications are:
turning hardened steel rools with higher grinding ...,
repairing hardened spindles or shafts, removal of case-hardened coats from shafts, spindles or rolls, turning recesses for holding-down bols on shell end mills, turning shanks of milling tools and drills.

Where are other areas of application, which operations are possible?

The most interesting area of application is of course in the mass production of parts. Here LACH dreborid-G turning tools have proven themselves during the last few years, e.g. on transfer lines for mass production.

External straight turning, turning inside diameters, surfacing, grooving, are the most important operations.

Description of the tool

The dreborid-G turning tools consist of cubic boron nitride crystals pressed into a substrate of carbide. This substrate gives toughness, rigidity and insensitiveness to shocks to the insert which consists of tiny crystals in a rigid bond.

The tool is either brazed in a standardized carbide insert which is then clamped in a holder, or in a steel turning tool and then ground into the desired geometry.

Tool life, surface finish, accuracy

General statements concerning the tool life of dreborid-G inserts cannot be made. However, after seven years of experience in the application of dreborid-G turning tools it has been proven many thousands of times that the inserts achieve tool lives which have completely convinced the user. In many cases a saving could be achieved even though the LACH dreborid-G insert is more expensive than e.g. carbide or ceramic insert. In addition considerable time savings and absolute accuracy have been achieved. The surface finish is as good as if it had been ground.

The following example may show which surface finish and accuracy can be easliy achieved.

Example

Finish-turning of a shaft (material 1.2080 with HRc 64), workpiece dimensions: diameter 40 mm x 250 mm length. This shaft has been turned on a conventional lathe with coolant. Cutting speed 117 m/min, cutting depth 0,25 mm, feed 0,08 mm/u.

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The results were:
surface roughness Ra = 0,4 um and Rt = 1,8 um
Turning time was exactly 3 minutes
Tolerance 0,005 mm for a workpiece length of 250 mm!

Cutting edge geometry

Known tool geometry of carbide or ceramic tools had to be changed drastically for the production of dreborid-G turning tools. For example, a negative rake angle of about 3° has to be used. The clearance angle is 5°, the radius is 0,8 to 1,0 mm.

Resharpening of dull or worn inserts is accomplished with special diamond grinding wheels with with special bonds and grit sizes. This is important for manufacturing and resharpening . The way in which an insert has been resharpened has an influence on the tool life. The insert must not be resharpened with „any“ grinding wheel because the wrong wheel might cause micro-fractures which again will reduce the tool life.

Resharpening of turning tools

Tool grinding machines with a radius fixture and cooling attachment are suitable. As a rule LACH dreborid-G inserts can be resharpened 6 - 8 times, depending on wear.

Examples:

Material: HSS tool steel No. 1.3343

on copy lathe
3 bore holes had to be turned on forging die parts. Copy-turning, inside diameter of 27 mm over an angle of 45° to a diameter of 25,25 mm. The turning length was 65 mm. This was accomplished in 4 operations with a chip thickness from 0,2 mm (roughing) to 0,02 mm (finish turning), using a dreborid-G turning tool BD-R.

Material No. 1-2842 90 NV 8

Grooving operation:
1,1 mm grooves had to be cut with a tolerance of +0,05 mm. Grooving depth was 3 mm, cutting speed 100 m/min. Coolant was used. The requested groove tolerance was held over 100 pieces. After these 100 pieces the wear of the insert was insignificant. A dreborid-G turning tool type AT-M was used.

Material: heat treatable steel 1.7225

straight turning: tubes with diameter 150 mm and length 7.500 mm (!) should be turned longitudinally. Machine parameters: v = 90 m/min, s = 0,8 mm/U, a = 0,3 mm, with intensive cooling.

The tool life of the insert until the first resharpening operation was 3,5 hours. The turning time for one workpiece was 9,5 hours. Of course a tail center was used for this extremely long workpiece.

After the turning the workpieces were ground cylindrically because the lathe was not able to achieve the requested cylindricity for this length. The grinding time which had been necessary so far could be reduced considerably. A dreborid-G turning tool type AE was used.

Material: Inconell 710

straight turning: cylindrical workpieces with diameter 30 mm and length 90 mm were turned externally.
Machine parameters: v = 180 m/min, s = 0,15 mm/U, a = 2,0 mm (!), using an intensive cooling (turning operation not possible without cooling).
Small and large chip depths were possible.

Material: heat treatable steel Cr Mo 4 V, dry nitrided;
HV 500 to 550, nitriding hardness 0,4 mm, material No. 1.7225

Groove recessing: grooves with 4 mm width and 6 mm depth, which were already in the workpiece, should be widened on one side. The workpiece diameter was 83 mm. Machine parameters: v = 51 m/min, s = 0,08 mm/U, a = 0,03 mm.

The grooves were widened exactly with sharp edges, number of pieces: 80.

Surface finish: Rt = 5 - 6 um (requested: 8 um). A dreborid-G turning tool type AT-L was used.

Material: chilled cast iron

Straight turning: chilled cast iron rolls with several points of weld and shrinkholes were straight-turned externally. Dimensions of the rolls: 3000 mm diameter (!) x 500 mm length.

The cutting material used so far was carbide or ceramic, cutting speed v = 5 m/min. Both materials did allow higher cutting speeds. After appr. 100 mm both materials were completely worn out so that the tool had to be replaced. LACH dreborid-G tools type AE multiplied the tool life serveral times using the following parameters: v = 18 m/min (v = 25 m/min is also possible), s = 0,23 mm/U, a = 0,25 mm.

Material: roll material C 2005

Result: rolls with diameter 250 mm and length 500 mm were turned with LACH dreborid-G. Speed = 56 min^{-1}, cutting speed 44 m/min, s = 0,125 mm/U, a = 0,5 mm.

Since the processing time was still too long, the depth of cut was increased to a = 1,0 mm.

After a turning length of appr. 550 mm the tool type AE had to be exchanged. Nevertheless considerable time savings could be achieved in comparison to grinding operations.

Material: grey cast iron

On a transfer line 4 different turning operations had to be accomplished on mass-produced workpieces. The carbide or ceramic tools which had been used so far had achieved appr. 100 turning operations. This number should be increased considerably with dreborid-G tools.

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The tools used for this task were dreborid-G-tipped inserts, fitting in clamping holders. Due to the different diameters of the workpiece the cutting speeds were different, i.e. from 180 to 500 min^{-1}. Therefore the tool lives of the inserts were of varying length. The speed was constantly 3.200 min^{-1}, the feed 0,08 mm/U.

The tool life could be increased 50 times; in addition the turning quality was better than the quality of carbide or ceramic tools.

Since the tool life was many times longer in comparison with carbide or ceramic, the set-up times were reduced to a minimum.

Prospects

Although highly compressed tool inserts of the high temperature and high pressure technologies have been existing for a short period of time, the industry has already realized that they belong to the most effective materials for reducing production costs and quality improvement. The number of successful applications will increase quickly in the next few years, especially if we take into consideration that production engineers are confronted with a double challenge, i.e. they have to keep the production costs under control and at the same time to process new materials which are harder to machine.