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Faster Turning, Boring And Milling With Synthetic Diamonds

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Compact Diamond Blocks

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Prior application areas of natural diamonds, their strengths and economy could be expanded and improved with synthetic diamonds. It was possible to grow diamonds in a thickness of 0.5 mm. They were compacted on a small carbide plate, welded together by pressure and heat and resulted in compact diamond blocks. Such tools, made from thousands of synthetic diamond grains are less sensitive than natural diamonds and are suited for faster turning of non-ferrous metals, thermosetting plastics as well as other materials.

To grow diamonds has been a dream, which can be traced back to antiquity. But there is also modern history. Many ideas were tried resulting in cheating, fraud or misunderstood ambitions, but no diamonds were grown.

But it is really so "easy". One takes carbon, heats it up to 1200-2500°C, adds a melted metal as a catalyst and exposes both to a pressure of 55,000-14,000 bar. The result is diamond, synthetic diamond. Already in 1880 the Scot by the name of Hannay could report about the successful manufacture of synthetic diamonds. He did this with paraffin, bone oil and metallic lithium, which he compounded under high pressure in heavy sealed pipes.

Indeed, only again in 1955 four scientists in the U.S.A. were able to repeat the process of manufacturing synthetic diamonds with success. Since this time, diamonds, indeed synthetic diamonds, have become indispensable for their use in our modern industry. They have surpassing properties over natural diamonds. However, synthetic diamonds, up to this point in time, could only be made to a maximum size of 0.8 mm. No reason to ignore the natural diamonds for there intended purposes.

This was how it was until yesterday: the natural diamond, unsurpassed not only as a jewelry idol but also as a tool for jewelry such as the cutting edge for gold, silver, platinum or as a turning tool for metals such as brass, aluminum, copper or plastics such as thermosetting plastics.

Now diamonds could be grown successfully. Synthetic diamonds in the thickness of 0.5 mm were compacted on a carbide blank with pressure and heat similar to the synthesis for the synthetic diamonds resulting in a compact diamond block (1).

Such synthetic blocks, made from thousands of synthetic diamond grains are less sensitive than natural diamonds and for this reason are ideally suited for the quicker turning of non-ferrous metals, thermosetting plastics, pressed carbon and similar materials. These tools depict the ideal tools, as they have been wanted for years by the modern automobile-, aircraft- and plastics industry.

Synthetic diamonds were introduced for the first time at the Hannover Fair 1973.

Are these polycrystalline blocks really the diamond as we have known it up to now?

The diamond as a turning tool had the shortcoming that its crystalline structure was sensitive to impact or shock even though this diamond was created in millions of years under pressure and heat. Seeing it from this standpoint, it would be better for the introduction of this polycrystalline, synthetic cutting agent if there was no diamond or it had no odium of this name. Because such synthetic blocks are far removed from the impact and shock sensitivity of the natural diamond cutting edge. The synthetic cutting edge can be compared to the insensibility of a carbide cutting edge.

In practice this difference really shows up. Here you have to say goodbye to old prejudices. Turning with diamond, up to now, was only recommended for absolute solid, vibration stable, high-speed lathes. Otherwise, even with the slightest infeed, the danger existed that the diamond cutting edge was damaged by the impact or shock caused by the vibration.

For many, the diamond, as a tool, has only a place up to now as a "polishing play-thing" and is believed only to be suitable for the decoration of rings, bracelets, cuff links and similar.

Whoever, up to now, had to turn aluminum brake housings, pistons, electrolyte copper cylinders, calendar rollers or commutators knows what he owes already to the natural diamond. The synthetic diamond consequently reduces further turning times and set-up times with larger depth of cut. and infeed in comparison to the natural diamond edge.

If, up to now, the economic chip advance in turning aluminum was with a cutting speed of about 300-350 m/min and a feed of 0.03 mm/U with maximum 0.8 mm, with the synthetic edge the in-feed can be increased to 2.5 mm rate of cut. Despite this enormous chip removal, the measured roughness values after machining with these cutting edges are still in the area of 2μm peak-to- valley height *Rt*.

This value, even when turning work pieces with interrupted cuts, is still obtained. In the final analysis, in the technical area, it is not the reflective smooth surface, which is important, but rather the maximum tool life, increased productivity and decreased non-productive time.

Which performances with natural diamonds were already possible with the different materials is shown by excerpt (according to Meyer) on Table 1 [2].

Illustration 1: Rough synthetic cutting inserts.

Illustration 2: Synthetic diamond for outside turning of cutting shape AN.

Illustration 3: Synthetic diamond for the inside turning of the cutting shape BA.

Illustration 4: Synthetic diamonds at face turning of a work piece from Ms 58 with interrupted cut, depth of cut 2.5 mm.

Illustration 5: Synthetic diamond at pre-turning of a copper calendar roll.

A			
Shape AC Right or left	Shape AE Radius 0.2 0.5 0.6 1.2	Shape AF Radius 1.5	Shape AG For turning of copper cylinders
Shape AK Like shape AG however w/chamfer	Shape AL For calendar turning	Shape AN Right or left for turning of commutators	Shape AP Right or left or on center for high-gloss turning
Shape AQ Like AP however with drag finishing	Shape AR Right and left high-gloss turning 45°	Shape AS Right, left or on center high-gloss turning	Shape AT Right, left or on center plunge cut turning
B			
Shape BA Diamond insert	Shape BD Inside turning, diamond	Shape BD Bore cutting edge	Shape BS Plunge cut turning

Illustration 6: Standard shapes of natural and synthetic diamonds

a Outside turning   b Inside turning

Material of work piece	Work step	Cutting speed m/min.	Depth of cut mm	Feed mm/U
Brass Bronze Aluminum	Facing	100 to 200	0.2	0.07
Phosphoric bonze Bearing metal Aluminum	Facing Facing Facing	To 3390 To 3390 To 3390	0.5 0.5 1.0	0.023 0.023 0.023
Copper	Facing Finish cut	220 230	0.35 0.5	0.07 0.07
Copper	Turning	145 to 200	0.5	0.1
Light alloys	Turning	610	0.1	0.014
Copper with insulating material (Commutators)	Turning	2200 to 2500	0.3 to 0.8	0.04 to 0.15

Further examinations shall prove that by the utilization of synthetic diamond cutting edges, the values, depths of cut and feed can be increased by a significant factor.

In the same examination, according to Meyer, the subject of milling non-ferrous metals with natural diamonds is being discussed: cutting speed 450 m/min., depth of cut 0.2 mm, feed 0.05 mm/U. In the meantime, first results of synthetic diamonds are available, which allow a comparison.

At a manufacturer of computer parts, the problem arose to mill such work pieces from aluminum with an available milling machine equipped with synthetic diamonds. At first, the available standard cutting shape AN was clamped in. The machining data were: spindle speed

1500 U/min., a cutting speed of about 600 m/min., feed 265 mm/min. and a cutting depth of 1.0 mm. This milling work was carried out perfectly on 50 work pieces without a trace of wear at the synthetic cutting edge. Thereafter, these tests were interrupted in order to install a second cutting edge, milling off center. The feed was now increased in the average of 1.8 mm. One thousand work pieces were then machined with a two-blade tool. Here also no wear worth mentioning could be determined on the cutting edges. A re-grinding was not yet required. It is planned to use these synthetic cutting tools in the production as a standard machining tool.

Synthetic blocks in the shape of cutting inserts for standard holder according to in- plant development for the inside and outside turning are available. In addition, cutting tools in the size, according to some ISO Standards can be shipped for existing holders. This adaptation to the ISO Standard will mean even greater popularity for turning with diamonds. Of the different cutting shapes in Illustration 6, the manufacturer recommends especially the shapes AC-AE-AN-BA and BD.

Synthetic diamonds are not only an alternative of the available cutting materials, but are also an inevitable must for all those who want to machine, turn, bore and mill non-ferrous metals, thermosetting plastics, carbon composite and similar materials.

Illustrations: Lach Diamant

Literature

[1] Lach, H.: Dreborid – First Time with Synthetic Diamonds, Surface (1973) 4, page 184.
[2] Viergge, G.: Machining of Ferrous Materials, 2nd edition 1970, page 318.