»Contour-profiled«

A renaissance for the metal-bond diamond and CBN grinding wheel

"Poly – Poly - or what?"

Part 11: »contour-profiled« shows its claws. A renaissance for the metal-bond diamond and CBN grinding wheel.

Horst Lach, managing director and CEO of LACH DIAMANT, agreed to write an ongoing series of articles about the development of diamond and CBN tools and grinding wheels in modern industries.

Horst Lach is known as a true industry veteran, and we are excited to have this pioneer of technology share some insights from his 59 years of professional experience in the diamond tool business. This time only a few historical remarks – but indeed most relevant regarding the trade shows in 2020.

The attentive reader may wonder whether the author may have chosen the wrong title for this series "Poly – poly – or what?", since he is writing about diamond and CBN grinding wheels. Wikipedia provides the (comforting) answer: "Poly, from the Greek, a word stem found in many German loanwords, meaning "much, or many"... The author is relieved and points out how many individual CBN and diamond grains are present in the grinding layer, depending on the desired concentration – a truly polycrystalline structure.

By comparison, the "aggregates", commonly known as polycrystalline inserts since 1973, are "baked" during high-pressure synthesis and studded with many, many microscopic CBN and diamond grains; "baked" so compactly and sturdily that they changed the world of machining, practically providing a single cutting edge.

Back to the grinding wheels: "Bite", yes – but "claws"? This requires a brief look back into the history of metal-bond grinding wheels, and in doing so, I found the following excerpts from the book "Diamanten im Dienste der Industrie" [a translation from the English original "Industrial Applications of the Diamond" by Norman R. Smith] fascinating:
"The use of diamonds for grinding hard materials has been known for hundreds of years. Already in 1824, Pritschard used diamondiferous wheels for manufacturing diamond microscope lenses. These wheels were actually produced by hammering diamond particles into the iron body. By the middle of the century, these one-layer diamond wheels were already commonly used. It is known that differently sized natural diamand grains were hammered into copper coins for the production of small diamond wheels. It is very likely that such hammered diamond wheels were used to grind the first carbides (HM).

Many patents followed, based on a wide variety of different procedures to produce these kind of grinding wheels. Most procedures utilized cold pressing and sintering or infiltration methods still used today. It is also worth mentioning that, in 1927, Krupp in Germany developed "Widia", a cemented carbide, initially meant for drawing dies for wire drawing, which presented new challenges to the until now small market for diamond wheels. The resin-bondgrinding wheel with today's quality was still far from being invented. In addition to the natural diamond grains, a rubber-bond wheel was available for polishing tasks until the mid fifties."

A Breakthrough for Grinding with Diamonds

Until the early 1970s, metal-bond diamond wheels were still used on simple tool sharpening machines (Simon L 15), e.g. for for grinding chip grooves on hardened carbide turning tools , mainly because of their form stability and hardness; or as pointed profile wheels on optical profile sharpening machines (example PTW).

To date, the glass industry is an exception which, without diamonds, could not have gifted us with gems such as crystalline glasses. One would hear similar stories from ceramics manufacturers. The year 1955 brought a breakthrough for grinding with diamonds, the development of diamond grain synthethis, which first became available to diamond tool manufacturers two years later.

Ten years later, the innovative ability to metal-coat diamond grains completed this breakthrough. Thanks to the metal coating, the diamond grain could be securely fastened to the grinding wheel's resin – with the result that the abrasive grain could be used up to 80/85 percent until it broke out of its bonding.

Example of a popular application of metal bond diamond grinding wheels in the 60-ies and 70-ies.

Suddenly it was possible to use diamond grinding wheels even for rough grinding; until then, only silicon-carbide grinding wheels were recommended for rough grinding.

Polyamide grinding wheels were the highlight for this development for deep grinding of carbide and hardened steel, developed by the manufacturers Winter & Son and LACH DIAMANT, e. g. Gresso® (Winter) and tressex® (LACH DIAMANT). These innovations also contributed to the boom-like development of the carbide tool industry. (See dihw MAGAZIN, edition 2 I 2017)

Resin versus Metal-bonds

Grinding wheels with metal-bonds could not hold up to this development – apart from their edge stability and profile retention, they were inferior to the high-performance grinding wheels based on phenole and polyamide resins as well as with hybrid and ceramic bonds. The CBN or diamond grains, closely embedded into the metal-bond, simply did not allow for enough chip space for fast, erosive grinding.

In order to manufacture complex components, modern CNC-controlled tool sharpening machines allow for a fully automated exchange of different grinding wheels, but the disadvantage of the bonds used, compared to the metal-bonds, remains.

Increasing cost pressure in mass production, and grinding more and more frequently requested profile components – concave and convex structures with maximal profile precision of up to 2-4 µ – led to a "Déjà-vu" at LACH DIAMANT and the renaissance of metal-bond diamond and CBN grinding wheels.

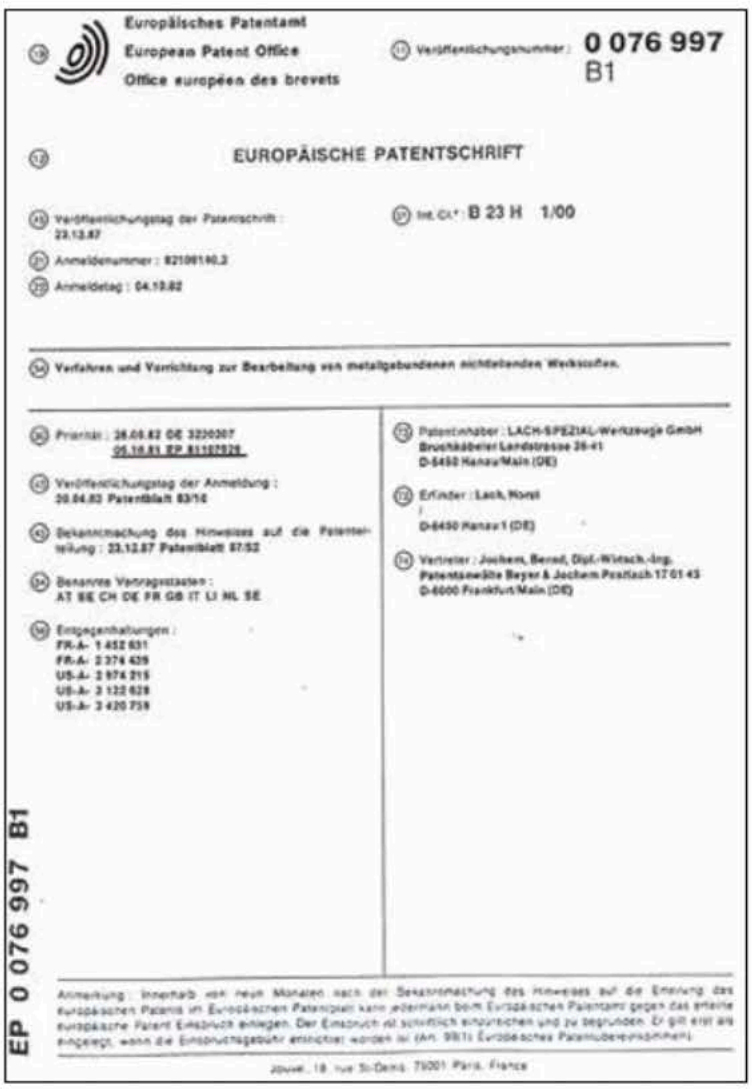
One plus one equals two. Firstly, the discovery of spark/electrical discharge grinding in 1978, and secondly the European patent "Procedure and Device for Machining Metal-bond Materials" (EP0076997) with priority of 5/10/81.

The additional expertise relative to the Electric Discharge Grinding (EDG) procedure, developed by LACH DIAMANT – superior to the EDM wire procedure – combined all of the advantages; thanks to the form electrode, broadly set to the metal-bond grinding wheel during profiling, all of the following is possible: Concave or convex profiles; high precision, even for inner profiles with 2 – 4 µ; even a zero-radius is possible. Since even grain sizes of 180 µ can be processed, a large chip space (with grain protrusion of up to 90 percent) is available to users during the grinding process.

Deep Grinding Revolutionized

It can rightly be argued that the »contour-profiled« procedure, developed by LACH DIAMANT, revolutionized deep grinding. The »contour-profiled« profiling grinding wheels and the sharpening machine »mini-contour«, especially developed for the EDG-Plus dressing procedure, were first introduced at EMO 2017 in Hanover.

Product Manager, Alexander Kern, chose a few especially interesting cases from the abundance of actual customer experiences, and the results speak for themselves:



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EP 0 076 997 B1

Patent "Procedure and Device for Machining Metal Bond Materials" (EP0076997) with priority of 10/05/81.

Schematic picture of a metal bond diamond profiling grinding wheel, »contourprofiled«, during deep grinding of a threading insert – Cost efficient: 1 instead of 3!

"Deep Grinding of Solid Carbide Threaded Inserts from the Solid with »contour-profiled« Grinding Wheels"

Another manufacturer's resin-bond diamond grinding wheels were compared with a metal-bond »contour-profiled« profile grinding wheel. For this application, three resin-bond wheel sets with the dimensions of 150-3-5, form 1A1, 150-4-5-45°, form 1V1, and model design 150-3-5-R1, form 1F1, were clamped consecutively onto the grinding mandrel.

By comparison, the »contour-profiled« profile diamond grinding wheel had a width of 15 mm and a diameter of 150 mm. The wheel geometry was manufactured according to the contour of the threading insert so that only one wheel was needed to produce the insert.

The solid carbide (K30) inserts were produced via deep grinding on a tool sharpening machine, using emulsion of 3-5 %, and with a nominal capacity of 20 kw.

A: Operating parameters of the resin-bondwheels:

After 100 inserts, the wheels had to be taken off the machine, due to loss of profile, and had to be profiled on an external dressing machine. With an usable grinding layer height of 5 mm, and assuming 33 dressings, this would result in a tool life of 3,300 finished inserts.

The total projected cost for solid carbide inserts would be 9.73 EUR per insert. This cost calculation considers cost for abrasives at 0.075 EUR per insert, as well as machine costs and additional setup times due to the necessary dressing procedures.

	A) resin bond wheels	B) »contour-profiled« metal bond profile diamond grinding wheel
Cost of Wheel	3 x 245 = 735 €	1.090 €
v_s	24 m/s	20 m/s
$a_{e\ ges}$	3 mm	3 mm
v_f	15 mm/min	25 mm/min
t_s	3.35 min	2.40 min
Dressing Cycle after	100 inserts	2,300 inserts
Dressing Amount	0.15 mm	0.1 mm
Dressing Time, setup time included	approx. 15 min	approx. 30 min

Comparison of operating parameters of resin bond wheels to metal bond profile diamond grinding wheel »contour-profiled«.

B: Operating parameters of the »contour-profiled« metal-bond profile diamond grinding wheel:

Compared to the resin-bondwheels (A), the »contour-profiled« metal-bond wheels had to be taken off the machine only after 2,300 finished inserts in order to guarantee a profile precision of 0.005 mm. With an usable grinding layer height of 0.005 mm, and assuming 50 dressings, this would result in a total tool life of 115,000 finished inserts for the »contour-profiled« wheel (B).

The total projected cost for solid carbide inserts would be 6.8095 per insert. This cost calculation considers cost for abrasives at 0.000095 EUR per insert, as well as machine costs. Considering the high tool lives, setup costs were negligible.

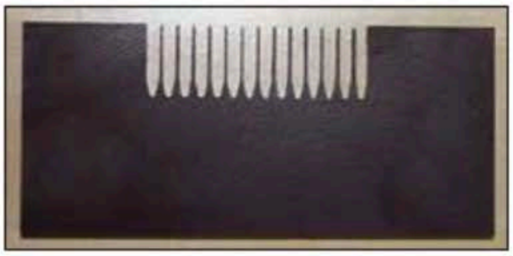
EDM Wire Procedure versus EDG Spark Erosion Procedure

Over the last three years, the successes of »contour-profiled« became known within the industry for revolutionary cost and time savings in deep grinding carbides, ceramics, hardened and even soft steel. Market insiders did not fail to notice that even suppliers of EDM wire machines addressed this issue. I almost gained the impression that customers as well as competitors were led to believe that the possibilities of the profiling procedure developed by LACH DIAMANT were simply the same, 1:1 so to speak. This strikes me as strange.

New EDM wire machines are advertised with statements such as "0.05 mm precision, porous structures on surface topology of the grinding layer as well as highest repeatable precision, erosion wires of 0.1 mm are capable to profile grinding layers in metallic bond matrix with diamond or CBN grain sizes of up to 46/50 µ, with a wheel diameter of max. 150 mm."

However, we can check these attributes off as doable – but we are not including into our efficiency calculation the enormous amount of wire needed for contouring the processed profile. Let's ask ourselves what customers may expect from this new technology – from the change of resin-bond or hybrid grinding wheels to the metal-bond »contour-profiled« grinding wheel.

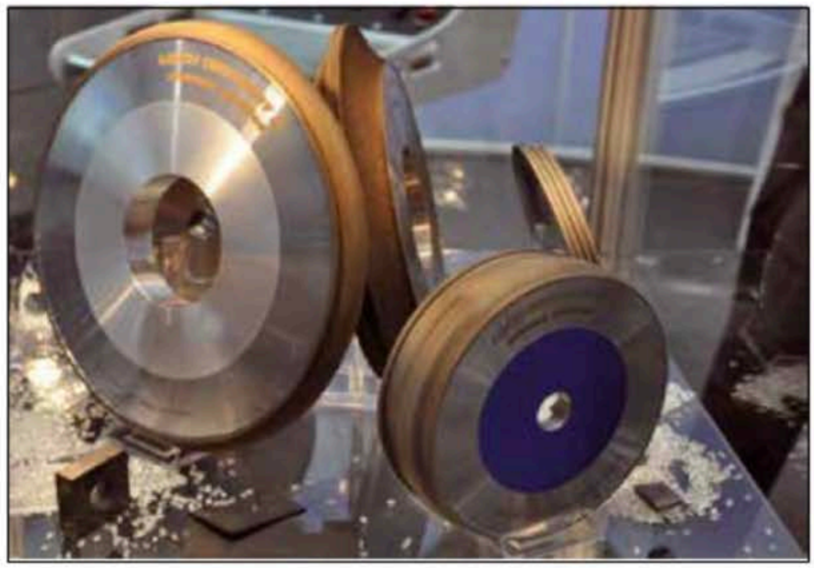
Example of a multi-part »contour-profiled« metal bond CBN grinding wheel, Ø 400 x 110 mm, on an »EDG-plus-mini-contour-profiled« EDG sharpening machine – during service, profiles can be resharpened with highest precision and repeatable quality for high tool times.



»contour-profiled« CBN grinding wheel with test template for a hair trimmer – with a profile depth of 13.5 mm and a web width of 0.5 mm. Operation during deep grinding.

In doing so, the »contour-profiled« wheel shows – depending on the size of the diamond or CBN grain – not only its "bite" but also its "claws", even at a grain size of 180 μ.

With the latter, the »contour-profiled« grinding wheel profits from a trailblazing bond technology which exposes each grain up to 90 percent and holds it in place, even during aggressive deep grinding tasks; »contour-profiled« becomes a "milling wheel" with until now undreamt-of potential for grinding carbides, hardened steel, ceramics and even soft steel.



The EDG-plus sharpening machine profiles with top precision, even for grain sizes of up to 170 μ, without having to stumble over up to 90 % exposed diamond or CBN bodies; compare to EDM wire procedure. It is not without reason that here at LACH DIAMANT we refer to the "claws" of our so-called »contour profiled« grinding wheel, whether with concave or convex profile which provide maximal removal amounts due to the cleared chip space.

We are indeed experiencing a renaissance of the metal-bond diamond and CBN grinding wheel.

Horst Lach

More than Bite

First of all, we should focus on tool life; this is an area in which metal-bonds have always been superior to any other bond variations. However, the structural design typical for this type of manufacturing, does not provide a lot of room for the embedded diamond or CBN grain for long-lasting chip formation. What does the "hot EDM wire" do when it is almost – as one should visualize it – "stumbling" over the single abrasive grains and as it is continuing its path in a wavelike fashion? One thing should be clear: The EDM "hot wire" is not able to cut the protruding diamond or CBN grains.

The EDG procedure is different. Here, the electrode moves towards the grinding layer as in deep grinding; the wheel will be profiled with highest precision – concave or convex. Profile widths of 200 mm and more as well as the production of »contour-profiled« grinding wheels with, at present, up to 600 mm diameter are possible.

»contour-profiled« shows its claws – the diamond grain, exposed by the EDG procedure, is available up to 90 % for maximal removal or chip formation.