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Tin influence on cutting behaviour of diamond sawblades for stone cutting

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Abstract: The article describes the continuation of the research presented in 2 previous articles. 4 pairs of diamond sawblades have been tested by „wet" cutting 4 types of granites: grey, black, impala and red one. The sawblades' hot-pressed segments of each pair differed in a tin addition – the ratio of the other elements was the same. The main conclusion is that tin addition on the segments matrix composition causes better cutting properties of the tool and such tools are more versatile for a specific application. On the other hand matrices rich in iron seem to be hardly applicable.

Keywords: Diamond sawing, Diamond tools, Stone cutting, Powder metallurgy.

1. INTRODUCTION

Typical circular sawblade for stone cutting is composed of the steel disc and the diamond-metal matrix segments welded or brazed at the peripheral. The synthetic (the most often) diamond grit is being set in a metal matrix. Such segments usually are being produced by means of the powder metallurgy from the mixture of metal(s)/alloy(s) powder(s) and diamond grit, they are cold pressed and then sintered, cold pre-pressed and then hot pressed or just simply hot pressed [1]. Such segments have a self-sharpening effect while working. When the diamond wears out and pulls out due to the hard stone cutting conditions the matrix also wears out thus in turn recovering the new diamonds able to work [2]. In general for cutting hard stones (e. g. granite) we use smaller but stronger diamonds set in quite soft matrix than the softer ones (e. g. sandstone) but more abrasive; we should use the bigger diamonds (not so strong as for the granite), but set in a very wear resistant matrix [3]. Diamond concentration 100 means 4.4 carat/cm^3 i. e. 25% of the volume. In practice the toolmakers apply concentrations in a range from 20 to 40 [4]. The higher the concentration the longer the tool life, on the other hand the more power consumption by the machine [5].

The work is a continuation of the research described in details in [6, 7]. Their main conclusions were that the segments containing tin are better densified, harder and have multiphase microstructure which let us expect better diamond retention in comparison to those with the same composition ratio but don't contain tin. The matrices rich in iron and not containing tin seem to be degradable environment for the diamond grit.

The powders' mixtures have been hot-pressed in graphite moulds of the *Sintris* furnace, computer operated. The process parameters were: *temperature 700°C, pressure 42.8 MPa,* *time 120 s*. Such conditions were appriopriate only for samples nr 2, 2a, 3 and 3a. The others segments were not strong enough so that a man could break them in his hands. The operation has been repeated for them in a higher temperature (table 1) [6].

Table 1.
Hot pressed segments' composition & parameters [6]

sample number	time [s]	temp. [°C]	press. [MPa]	segment height [mm]	matrix composition [% wt.]	diamond conc.
1(2nd time)	60	850	25.3	8.90	Ni 59; Cu 35; Fe 6	15
1a(2nd time)	180	850	25.3	7.96	Ni 55; Cu 33; Sn 6,5; Fe 5,5	15
2	120	700	42.8	8.22	Cu 61; Co 20; Fe 19	15
2a	120	700	42.8	7.43	Cu 55; Co 18; Fe 17, Sn 10	15
3	120	700	42.8	8.04	Co 100	15
3a	120	700	42.8	7.79	Co 89; Sn 11	15
4(2nd time)	60	850	25.3	11.12	Fe 77; FeCr 23	27
4a(2nd time)	60	850	25.3	8.76	Fe 68; FeCr 20; Sn 12	15

2. EXPERIMENTAL PROCEDURE

The 8 sawblades of Ø300 mm were examined while „wet" cutting 4 types of granite: grey black, impala and red one (fig. 1). The cooling and slurry removing medium was water. The stationary cutting machine was powered by triple-phase engine of 380 V. The rotating velocity was 1500 rev./min and resulted in linear velocity of 23.5 m/s. The authors paid a special attention to achieve uniform conditions for each of the sawblades.

Figure 1. Four types of granite on which the tests have been performed, from the top: black granite (Zimbabwe), impala african, red granite and the grey one on the bottom.

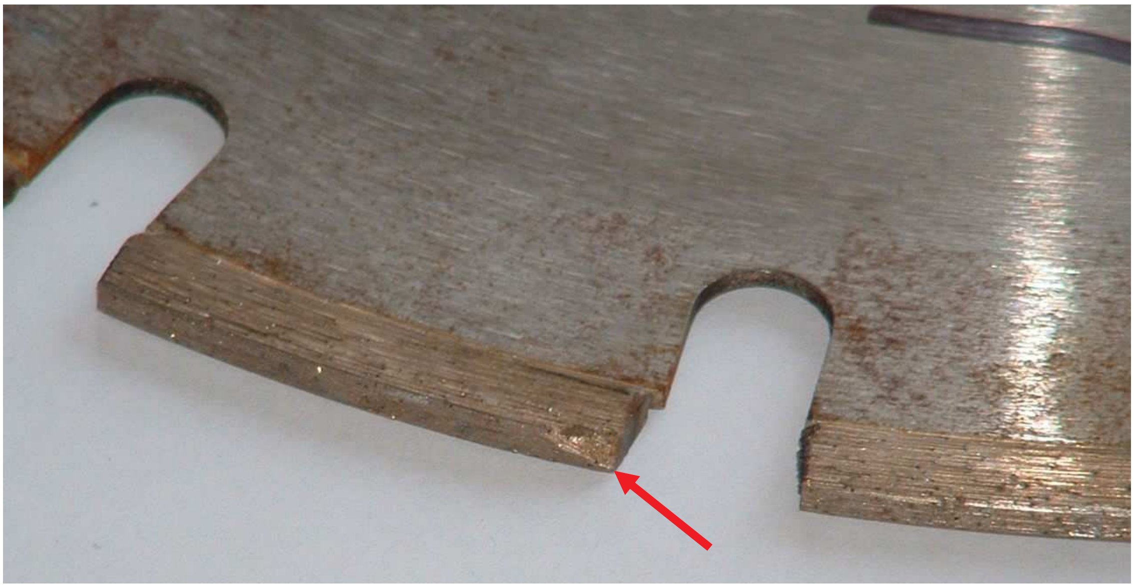

Figure 2. Segments of the sawblade 2a, the arrow shows the place where it tends to „peel off".

The main observation of the working behaviour of the above mentioned tools are:

- sawblade 3a and 3 are the best, they can cut each type of granite, a little better is nr 3a,
- sawblade 1a cuts red, grey and impala granites well, while cutting black one is very noisy and emitts the sparks at the begining of cutting,
- sawblade 1 has been estimated as little better than nr 2, cuts quite well red and grey granites, rather not suitable for impala nor black because needs very slow cutting progress, melts the black granite,
- sawblade 2a is only a little worse than 3 and 3a, Cuts well black and red granite, little worse for grey one but express a small tendency to „peel off", see fig. 1,
- sawblade 2 melts red granite as well as impala, a lot of sparks can be observed, also a noise, needs very slow progress, able to cut grey granite and black (with sparks),
- saw 4a lost several teeth while cutting red granite (fig. 3.), the brazing keeps the segments insufficiently, needs slow progress, the segments break and „peel off", hardly cutting,
- sawblade 4 cuts red granite a little better than 4a but also very noisy and sparking, similar behaviour while cutting black stone, also looses 2 teeth and tends to „peel off".

Figure 3. Broken and lost segments of the saw number 4a.

Basing on the above the sawblades ranking can be estimated (see table 2) and it is possible to work-out an application diagram (table 3).

Table 2.
Ranking of the examined sawblades after the field tests.

classification	1 (the best)	2	3 (ex aequo)	4	5	6	7 (the worst)
sawblade nr	3a	3	2a and 1a	1	2	4	4a

Table 3.
Application possibilities diagram of the examined sawblades.

Sawblade number/stone	**grey granite**	**black granite**	**impala granite**	**red granite**
1	RATHER YES	NO	NO	RATHER YES
1a	RATHER YES	YES	YES	RATHER YES
2	RATHER YES	RATHER YES	NO	NO
2a	NO	YES	NO	YES
3	YES	YES	not examined	YES
3a	YES	not examined	not examined	YES
4	NO	NO	NO	NO
4a	NO	NO	NO	NO

3. CONCLUSIONS

The main conclusion can be drawn that in general small tin addition to the segments' matrix composition causes better cutting properties of the tool. Such tools are also more versatile for a specific application i. e. for cutting different types of granite though opposite effect was observed in case of high iron amount in the segments. Probably the matrices rich in iron are not suitable for production of diamond tools for stone processing. On the other hand literature gives us often the examples that certain amount of the element can be important and crucial for improvment of the tool properties for specific application.

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