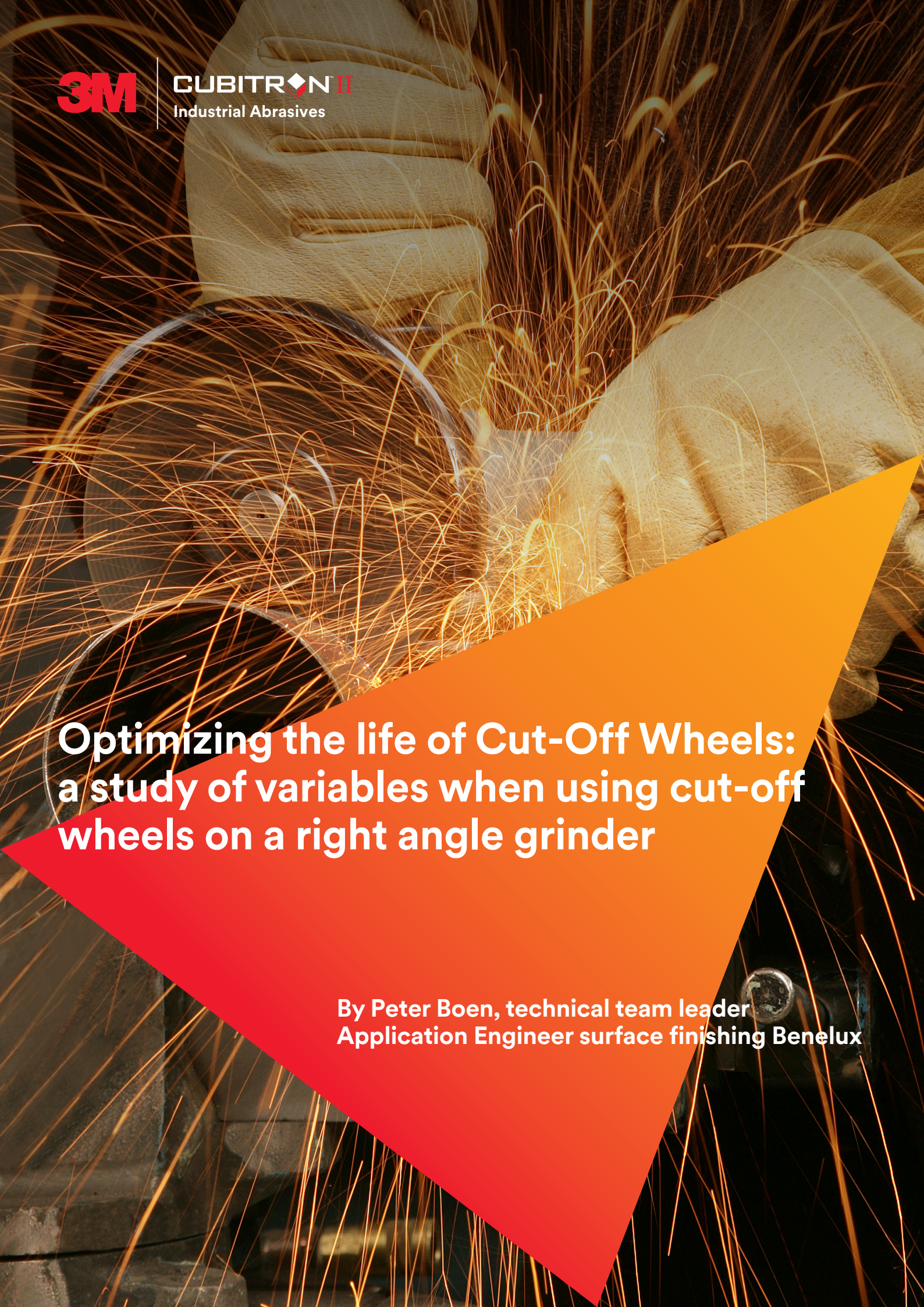

3M | CUBITRON™ II
Industrial Abrasives

Optimizing the life of Cut-Off Wheels: a study of variables when using cut-off wheels on a right angle grinder

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Optimizing the life of Cut-Off Wheels: a study of variables when using cut-off wheels on a right angle grinder

Introduction

Since a few years 3M is commercializing Cubitron™ II cut-off wheels. While the quality has proven to be superior in the lab, this didn't always show during demonstrations or tests at the end users. The life of the Cut-off wheels showed broad variation, on average exceeding 100% with peaks up to factor 6(!). In most cases test results could also not be reproduced. With this kind of variation, no matter how good a cut-off wheel is, in many competitive tests it will not show added value, resulting in lost opportunities, sales time without return, and frustration on the side of the sales reps.

Literature on the topic proved to be scarce. Not much (if any) studies or papers have been published on this matter. As many information there is on Precision Grinding & Finishing, as limited is the information on flexible abrasives or portable bonded that can be found on the internet. To find out what the issues were, the 3M Benelux Application engineers of the surface finishing team needed to look into this themselves and started the "science applied to cut-off wheels" project.

Data generated in many field- and lab tests of T41 125mm diameter cut-off wheels, showed same high levels of variation and many inconsistencies in life of cut-off wheels of any brand and any quality. Same products compared under apparently similar circumstances resulted in different outcomes, making clear that there were at 1 or more variables that were unknown, not monitored, not under control or of which the impact was underestimated.

After analyses of historic data 3 variables likely to have high impact were selected for quantification:

- The thickness of the cut-off wheel
- The cutting direction
- The power of the right angled grinder

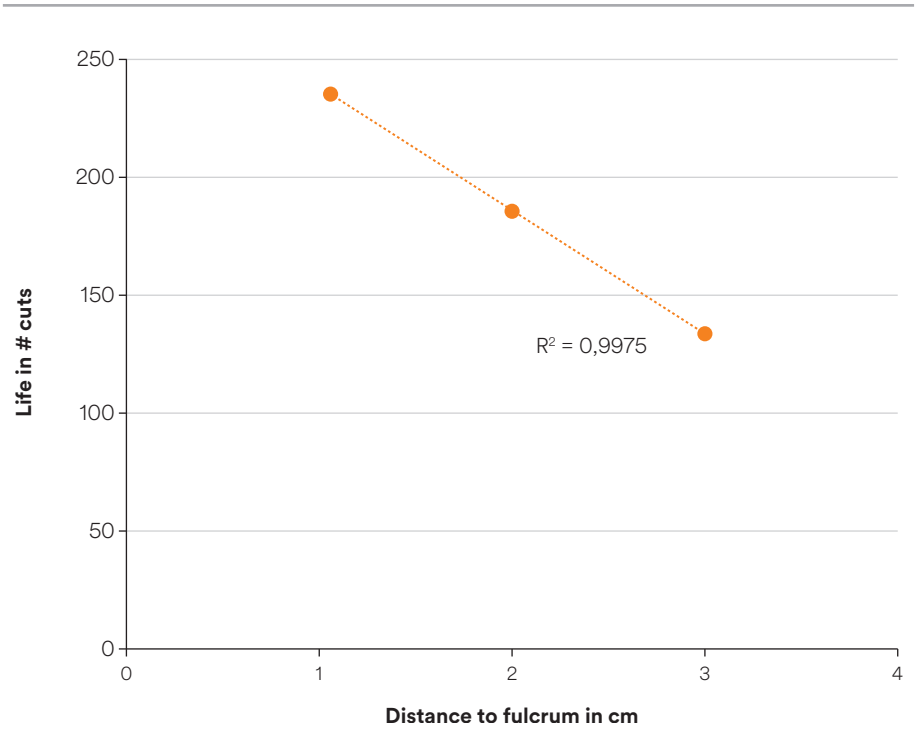
For this quantification, a number discs of multiple qualities from different manufactures were tested under a variety of conditions. The tests were repeated at least 3x, each time with a new disc and until 3 data in line. They lead to some very interesting results and insights.

The thickness of the cut-off wheel

Most obvious is the influence of the thickness of the cut of wheel. A thicker cut-off wheel contains more minerals what should result in a longer life. Thickness already makes part of the positioning of these products: 1mm discs for cutting thin sheet <3mm and 1,6mm for more solid material. This positioning is based on heat generation, rather than life: 1mm thick discs need to remove less material to make a cut thus are faster and less heat will be cumulated in the metal. This is important because thin metal foils tend to deform under heat. However, the majority of the customers use 1mm cut-off wheels for any application.
Of 11 types of cut-off wheels, 1mm & 1,6mm versions were tested. A bit unexpectedly, on 1mm sheet metal, there was no clear correlation found between thickness of the cut-off wheels and life. For some wheels an advantage was found for 1,6mm wheels, but other showed an advantage for the 1mm wheels. On solid metal however all 1,6mm discs showed a longer life than there 1mm counterpart, on average 40% longer. This is still less than the intuitively expected 60% but some types showed up to 6 times longer life.

During this tests, we noticed that there was still variation too big to be ignored when testing same type of cut-off wheel under what were considered identical conditions. A number of tests were repeated and filmed, to detect anomalies or variations in the MO and 2 more variables were determined: the distance from the cut to the support point and the position of the discs at the beginning of each cut, on the metal surface or in front of the work part.
The position of the wheel at the starting point did not show significant effect on the life of the disc, but the quality of the cut as well as the comfort of the operator, benefit from starting in front of the metal. The distance to the support point however, proved to be a serious influencer. Comparing life cutting 1mm sheet on 3cm distance to the support point or on 1cm, life is reduced 30% to 60% with an average of approximately 50% . The further away from the fulcrum, the higher the vibration, the higher the wear of the cut-off wheel. In the field we noticed that none of the operators payed any attention to this while testing or working with cut-off wheels. Sometimes we saw tests starting more than 10cm away from the support point moving closer to the fulcrum during the test.

Figure 1
Life of 1mm 125mm COW vs distance of cut to fulcrum

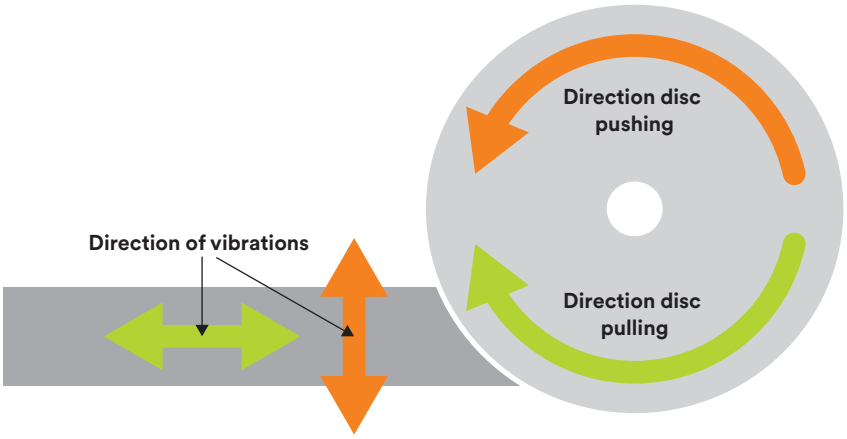


When the tests were ran again, also controlling the distance to the support point, variation was reduced to acceptable levels and results could be reproduced.

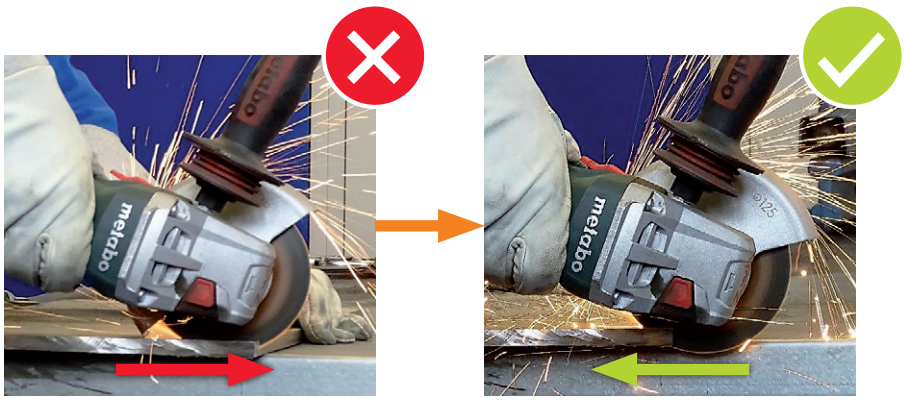
The cutting direction

Using a right angled grinder, an operator can work pushing, moving the tool away from his body or pulling, working towards his body. Test showed life of the cut-off wheel is on average 3 X longer when used “pulling” then when use “pushing”. One type even lasted factor 11 (read: “eleven”) longer. The effect was most pronounced when cutting thin sheet metal but still more than factor 2 when cutting solid metal bar. Probable cause for this difference again are vibration, more specifically the direction vibrations are generated in. When pushing the work parts, and especially flat parts, are allowed vibrate freely when the disc hit the surface from above. When pulling, the vibrations are generated in the length direction and thus damped by the length of the metal and thus less affecting the wear of the abrasive.

Figure 2



When “pushing” the cut of wheel tends to “jump” on the part, demanding much more effort of the operator, while pulling feel much smoother. Yet in the field we almost only observed operators “pushing”. The reason for that we found in the footage of the tests: the direction the sparks are projected. If the guard of the right angled grinder is not adjusted properly, when pulling the sparks are projected towards the operator. When pushing the sparks are projected forward, away from the operator. This can easily be addressed by simply adjusting the guard, as, following the hand out of the tool, is required for any application. When the guard is in the right position, when pulling, sparks are projected to the left, away from the operator.



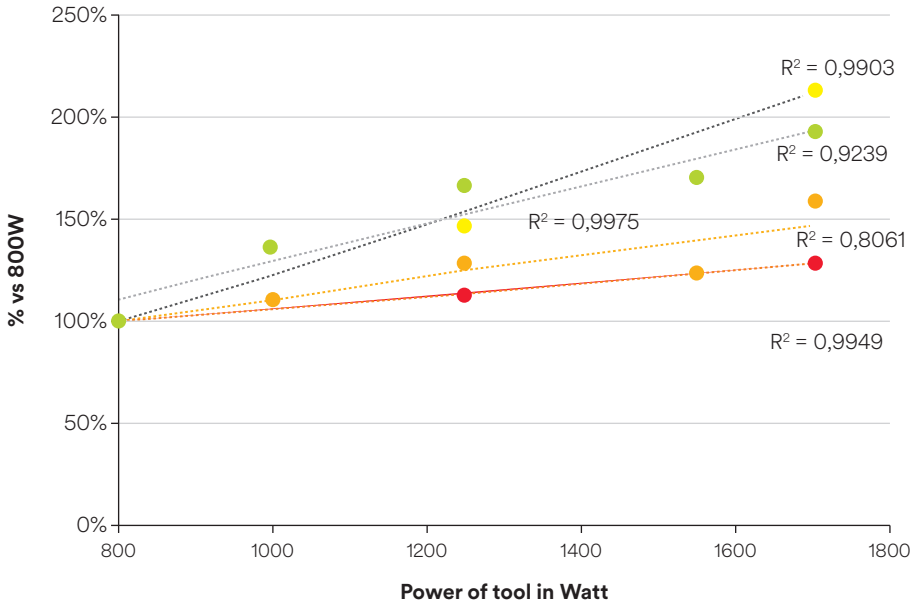
The power of the right angled grinder

Obvious for speed, the tests show also the life of cut-off wheels benefit of a more powerful tool. To test the influence of the power of the right angled grinder on life, multiple discs were tested on tools of different power starting from 800W up to 1700W. Any wheel tested showed increased life when used on tools with higher power but similar to the other tests, some types were more affected than others. On average a 1250W tools delivers 30% longer life than an 800W tool. On a 1700W right angled grinder 90% longer life can be expected compared with the same wheel on an 800W tool.
The theory explains. The power of a tool is an indication of how well the tool stays on speed under load. Low power tools will turn slower compared to a high power tools under the same conditions. Since wear is cumulative over time, at lower speeds contact time during each revolution of the cut-off wheel is longer and thus wear is higher, resulting in shorter life.

Figure 3

Life of 125mm COW's in function of tool power vs life on 800W

- COW a
- COW b
- COW c
- COW d



Looking at the cumulative effects, just by changing the MO, in theory life improvement of factor 25 could be attained at the least efficient working customers. Overall the 3M cut-off wheels proved to be rather robust. Cubitron™ II cut of wheel showed a maximum impact of slightly more than 6 times the life span.

Conclusions: First of all, a successful test with cut-off wheels or any other abrasive starts with eliminating all variation and all causes of vibration. It's easy to do: just make sure to cut close to a support point and work pulling, not pushing. To work pulling and more important, to work safe, the guard of the right angled grinder should be adjusted.
Second, life of cut-off wheels can be optimized by using the right thickness cut-off wheel and work pulling, closely to a support point with the most powerful right angled grinder. This will definitely have a high impact on the life of any cut-off wheel.

Applying scientific methods brings added value in every step of the production process. Translation of the findings of "science applied to cut-off wheels" into training how to work with cut-off wheels, or even how to work with a right angle grinder, for even the most experienced operators, will improve productivity and reduce cost in any metal work shop. "Science applied to life" is not a slogan from 3M, it's a key factor in optimizing industrial production.

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