Durum wheat DEBRANNING STUDY

by Roberto Montanari and Davide Marchini

Research conducted by university and Ocrim shows strong argument for usage of diamond wheels.

Debranning removes the outer layers of the pericarp from wheat kernels, and an increasing number of industrial and research studies reports the advantages of debranning durum wheat prior to milling. These advantages include:

- Improving the yield and refinement of semolina in durum wheat milling.
- Ensuring a higher chemical safety of the products coming out from milling (mycotoxins).
- Lowering capital investment because mill flow is shortened.
- Speeding up the hydration process of grain prior to the milling phase.

A recent debranning study was carried out as part of a collaboration between Cremona, Italy-based Ocrim, the Industrial Engineering Department of the University of Parma and FMB-Eng.In.E., a spin-off company of the University of Parma.

Ocrim, a leading milling facility producer for the global milling sector, with a particular emphasis on wheat milling, already produces debranning systems based on the use of traditional silicon carbide wheels. However, the mineral nature of these traditional wheels can lead to the formation of cracks and crevices after a certain number of production cycles. For this reason, Ocrim proposed an innovative grinding wheel with a metallic support structure and a thin surface deposition of synthetic diamonds.

This study demonstrated how innovative wheels are much more reliable, have a longer operating life and are cost-effective compared to the traditional ones.

DIAMOND VS. TRADITIONAL WHEELS

The experimental tests were conducted at the Industrial Engineering Department of the University of Parma and at a production site, a durum wheat mill located in the U.S., which utilized a milling line provided by Ocrim.

The mill has two parallel debranning lines, each operating at a milling capacity of 4 tph. One of the two debranners has been equipped with a whole grindstone package of silicon carbide wheels. In the other one, the two lower wheels (the sixth and the seventh) have been replaced with diamond wheels.

Diamond wheels have a superficial layer in which synthetic diamonds, with a specific dimensional distribution, are partially incorporated. The performance of the systems were evaluated using two Key Performance Indicators (KPI). To be conservative, the wear indicator has been calculated on the lower wheel, the one most subject to stresses.

The first (KPI1) is the debranning ratio, i.e. the ratio between the overall processed mass of wheat and the relative separated mass of bran. The second (KPI2) is an indicator of the wear of the diamonds, calculated via image analysis.

TREND OF DEBRANNING RATE TIME

The experimental campaign was planned to give statistical significance to the results. During the tests, the researchers also varied the power absorption of the machine. At a constant flow rate, it can be assumed it is proportional to the residence time of the wheat inside the debranning machine. The debranning results obtained are collected in Table 1 (below).

With the diamond wheels, the researchers noticed an

Table 1

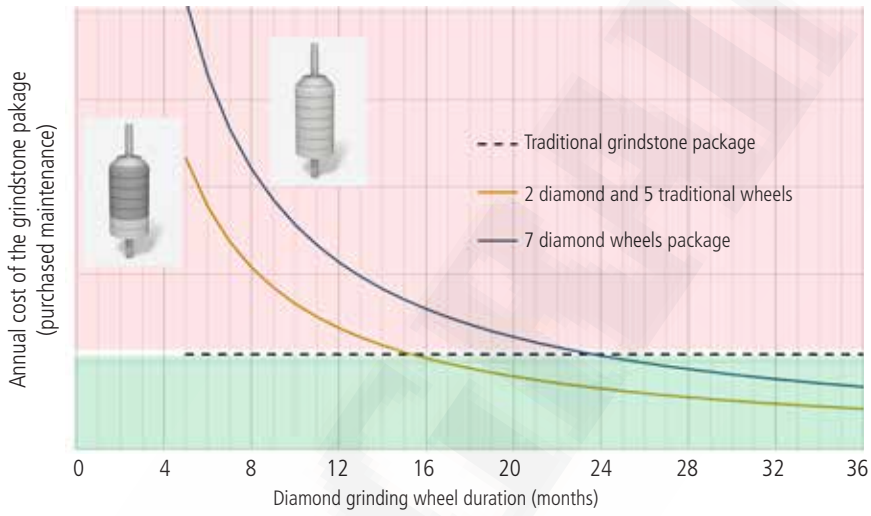
Time 0 - installation		
DHB North	Diamond	Silicon carbide
65 [A]	7.4%	8.1%
75 [A]	9.5%	9.0%
85 [A]	11.7%	9.3%
Time 1-3 months		
DHB North	Diamond	Silicon carbide
65 [A]	7.6%	8.3%
75 [A]	9.2%	9.0%
85 [A]	11.0%	9.3%
Time 2-12 months		
DHB North	Diamond	Silicon carbide
65 [A]	7.7%	7.9%
75 [A]	9.1%	8.5%
85 [A]	10.9%	8.7%

important improvement in debranning yield when increasing the absorption of the machine. Moreover, after one year, the yield with diamond wheels is still very good, while with silicon carbide wheels the performance suffered a deterioration.

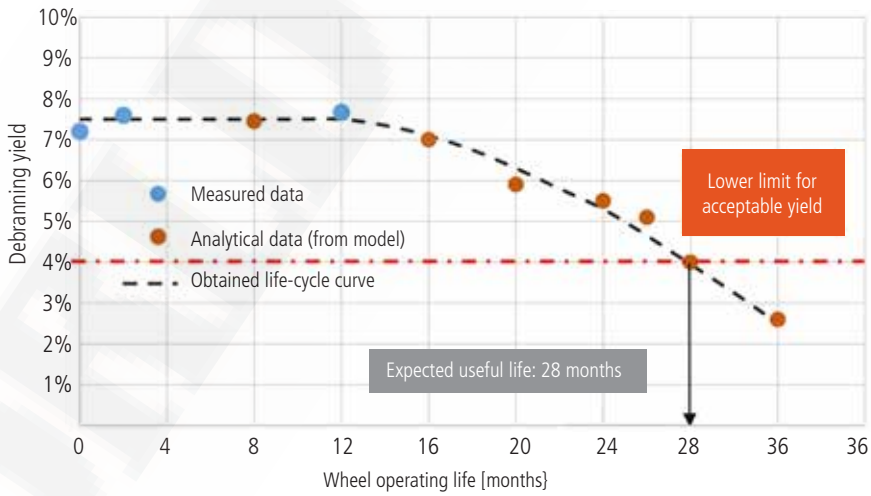
Diamond wheels are certainly much better also from a reliability standpoint. Their wear is more gradual, and the metal structure prevents a sudden rupture event that can instead affect traditional grinding wheels for their mineral nature.

Considering the silicon carbide grindstone package, after 12 working months its wear was evident, and was particularly concentrated on the lower wheels. The researchers could observe an important thinning of the debranning material layer, along with a shape deformation.

Annual cost variation vs increase of the duration of the grindstone package



Debranning trend over time



WEAR INDICATOR

To determine the wear of the diamond wheels over time, researchers used, as mentioned, an Image Analysis tool developed by FMB Eng.In.E., a spin-off company of the University of Parma. In particular, they took a series of pictures of the wheel surface and the software allowed them to measure diamonds dimensions and their dimensional distribution.

Traditional silicon carbide wheels have an average useful life of about one year, which can vary as a function of the processed product. After this period, they need replacement.

Since after one year the diamond wheels were still functional, the researchers had to develop a predictive model to extrapolate their behavior over time. They based it on the two KPIs to find out the relationship between diamonds conditions and the obtainable decortication yield over time in order to define a plausible useful life of the devices. The performance shown by the curve remains constant for about 12 months, even though the diamonds wear has already begun. Later, the wear becomes too heavy and the debranning rate starts to decline.

Results indicated a life expectancy of about 28 months for diamond wheels. This value refers to the wheel located in the most stressful position, namely the last one of the grindstone package. It represents a considerably better result if compared to the average duration of 12 months of the silicon carbide wheels. In addition, diamond wheels wear is a much more controllable process as the diamonds are embedded in a resistant metallic substrate.

Ultimately, the diamond wheels were shown to be much more durable and reliable than the silicon carbide ones.

ECONOMIC CONSIDERATIONS

In the study analysis, researchers concentrated on the differential costs between the alternatives, which are mainly connected with the initial investment and with the maintenance interventions. For instance, they considered costs resulting from downtime and workings, but also opportunity costs and product discarded. The incidence of these variables is inversely proportional to the useful life of the grinding wheels: a longer life will result in lower operating costs.

As said, a grindstone package is composed of seven wheels. The experimental tests described used a package with only two diamond wheels. This number could, however, be increased up to a

grindstone package entirely composed by diamond wheels. For this reason, the researchers evaluated all the different scenarios.

Considering a useful life of one year for the silicon carbide wheels, they gave a certain operating annual cost. This level was compared with the annual cost of a grindstone package with diamond wheels, which was calculated as a function of the lifetime of the devices. The aim of this analysis was to find out a break-even point between the plant solutions, i.e. the duration of the diamond wheels that ensures the same level of operating costs of the traditional ones.

The plant solutions with two diamond wheels gave a break-even point of 15-16 months, while with seven diamond wheels the break-even point is at 23-24 months. Therefore, the economical results were better if compared to the silicon carbide grindstone package, as the duration of diamond wheels was estimated to be at least 28 months. This means that the difference in the initial investment cost is more than offset by performance improvement.

CONCLUSIONS

The study highlighted a series of advantages connected with the adoption of diamond wheels for the wheat debranning process. It found that:

- The decrease of the debranning yield over time is slower than the one of traditional wheels.
- After 12 months, despite a certain superficial wear, diamond wheels still maintained their debranning performance.
- The useful life of a diamond wheel was estimated to be at least 28 months, thus more than twice in comparison to the 12 months duration of the traditional wheels. Moreover, diamond wheels, thanks to their metallic and not mineral structure, have a much higher reliability, and ensure a superior stability.
- A grindstone package that includes diamond wheels has a break-even point between 15 and 24 months (depending on the number of diamond wheels) if compared to a traditional grindstone package. Therefore, the choice of diamond wheels is convenient also from an economic point of view. WG

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