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Change in knife sharpness on forage chopper and its consequences for knife sharpening

Grinding of forage chopper knives creates a sharpness which entails low fuel consumption and a good quality of the chopped material. Because of the continued development of the knife coating, the current grinding strategies which exist for many years have to be critically questioned. For this purpose, measurements were conducted during the harvest of grass and maize silage. The results show that significant differences in wear characteristics of knives exist, which require a change in grinding routine.

Keywords
Forage chopper, knife wear, knife edge

Abstract
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Self-propelled forage chopper are adopting an increasingly important role in the production of silage and biomass. Not only grasses and silage maize, but also short-rotation coppices are more and more frequently processed by chopping. Due to the high-performance chopping process the knives wear out and lose sharpness, requiring regular re-sharpening of the cutting edge. Frequent and intensive grinding may lead to a sharper knife and may benefit the chopping quality, but it also tends to shorten the life cycle of a knife. This can cause a waste of labour time and, in the worst of cases, even affect the crop transport into the clamp. Therefore, it is important to grind the knives at the right time with the correct intensity. In recent years there has been research concerning the life cycle of knives and their grinding strategies [1]. It was found then that in practice, grinding is done too rarely and with too little intensity. As of late, however, survey results have revealed that there has been a change in opinion [2]. Forage chopper drivers now tend to grind their knives more frequently and more intensely, to the point where they are fulfilling the guidelines found in earlier publications. In the meantime, however, there has been a substantial improvement in knife quality. Thanks to enhanced hard-facing processes the wear resistance in knives has been significantly improved. Here the question must be asked whether today's standard grinding strategies are still appropriate for these new high-quality knives. The objective of the below investigation conducted at Dresden University of Applied Sciences (HTW Dresden) was to examine the change in sharpness in current forager knives and to draw conclusions beneficial to the grinding process.

Materials and methods

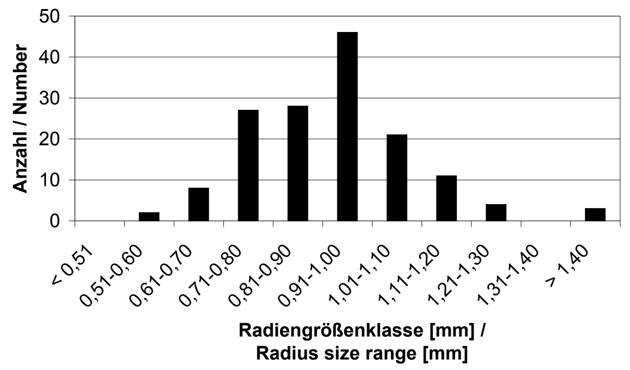
This research was conducted using high-quality standard knives made by manufacturer Busatis GmbH, Austria: curved knives in wilted crop (grass and alfalfa), straight knives in maize. When harvesting grass silage, the forager had half the number of knives installed, whilst maize was chopped with the full number of knives. The knives were installed in a self-propelled forage chopper (Claas „Jaguar 950“, engine power 372 kW). The sharpness of the knives was determined by measuring the radius of the cutting edge. The radii were measured at 20 to 30 points distributed over two 40 mm sections per knife [3]. Three knives were marked and measured in grass, the same was done on four knives in maize. For the forage harvester, the set chopping length and all maintenance work (e.g. time of grinding and number of grinding cycles) were recorded. In addition, the dry matter content and the crude ash content of the foraged crop were measured. The trials were conducted during silage production from 2009 to 2010 in the region around the German city of Dresden.

Results

Approximately 900 hectares of grass and maize were harvested in the course of two years of trial. The operation time required (drum hours) amounted to roughly 200 hours.
The measurement of the radii in grass silage initially revealed that the distribution can be rather broad (**figure 1**).

On one occasion (14 July 2009), 150 single measurements on six knife sections (three knives with two sections each) yielded radii between 0.54 and 1.73 mm (mean value, 0.94 mm;

Fig. 1

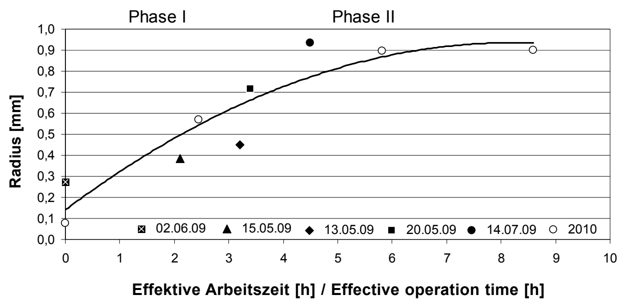


Distribution of the measured cutting-edge radii (14.07.2009, grass, 4.5 h effective operation time)

standard deviation, 0.174 mm). Even the mean values for the six sections ranged from 0.78 to 1.18 mm.

As expected, the mean radius increased with progressing operating time (**figure 2**).

Fig. 2



Mean cutting-edge radius as a function of effective operation time during grass silage production in 2009 and 2010

However, this increase was not uniform. Similar to the process of wear in other areas (e. g. tool wear when machining), the observations revealed different phases of wear. In phase I the radius showed a rapid increase. Later, in phase II, the increase curve flattened (the change in radius decreased). These results correspond to the findings from earlier studies [4]. The data from 2010 are rather close to the best-fit curve.

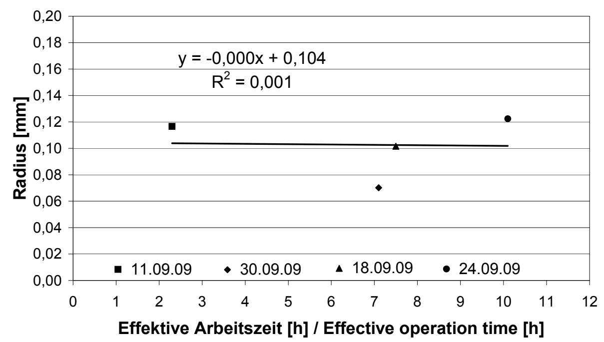
They were collected during a continuous harvesting operation over the course of three days in relatively consistent conditions (crude ash content, dry matter content etc.). For 2009, the silage maize values were compiled from various harvesting operations, some of which were separated by several weeks time. The differences in operating conditions led to different intensities in the change of cutting-edge radii. For example, after harvesting an area of approximately 3.3 hectares on 13 May 2009 and 20 May 2009 respectively, the radii were 0.45 mm and 0.72 mm respectively, which is a difference of almost 0.30 mm.

The 2009 results for silage maize showed much smaller radii as well as narrower size ranges. On one occasion (11 September 2009) a total of eight sections were measured on four knives. These 176 single measurements yielded radii of 0.06 to 0.27 mm (mean value, 0.12 mm; standard deviation, 0.032 mm).

Figure 3 shows the mean cutting-edge radius on four knives after operating times of varying duration.

These results exposed an entirely different pattern than in grass silage, where the cutting-edge radii do not increase over time. The radii are within the same range as those measured directly after grinding. This proves that the chopping action produces no substantial change in knife sharpness.

Fig. 3



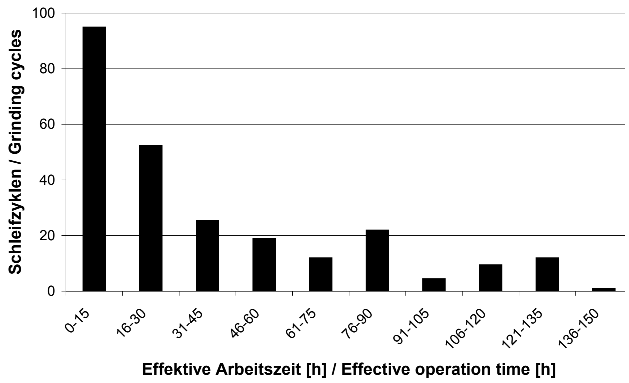
Mean cutting-edge radius as a function of effective operation time during maize silage production in 2009

Conclusions

Although the body material and the coating of the knives are identical for both knife types, there were significant differences in wear between the grass and maize knives examined in the test. This discrepancy in wear behaviour can be explained by the percentage of dirt and stones that comes with each of the foraged crops. The lower debris content in maize and the design of the knife have a self-grinding effect: the highly wear-resistant coating is slower to wear out than the knife body material. This causes the coating to protrude from the body material and to form the cutting edge.

Today, forage chopper drivers calculate knife sharpness and, consequently, the optimum point for grinding from indirect parameters such as fuel consumption, engine noise and chopping quality. The interpretation of these values requires a great deal of experience. In addition, they are heavily subject to personal perception. Therefore, drivers have no chance of knowing exactly which point on the wear curve the knives have reached, particularly because the operating conditions (e. g. sand in crop) may change quickly and dramatically. In order to determine the actual sharpness the driver would need applicable technology, which at present is not available. The only remedy in this case, to a certain extent, is for the driver to perform regular checks on the chopping unit (at least once a day). The visual inspection and a finger check of the cutting edge enable a rough estimation of the knife sharpness. **Figure 4** shows the possible effects of this method.

Fig. 4



Change in number of grinding cycles during maize silage production in 2009

At the start of the maize harvest, the trial forage chopper's driver performed experience-based grinding of his knives in approximately 30 cycles a day (one day = approx. 5 hours of effective operating time). This grinding intensity corresponded to the mean value calculated from a survey of over 100 drivers [5]. Based on his visual inspection of the knives (**figure 5**), the driver continued to reduce the grinding intensity over the course of the harvesting season.

Fig. 5

Drivers control of forage chopper knife (photo: HTW Dresden)

This did not entail a deterioration of fuel consumption or chopping quality, which was confirmed by parallel measurements taken during the process of the trial. Requirements for the use of this method include easy access to the knives, which is not always the case.

Despite the steady sharpness in the knives under examination, the grinding process proved to be indispensable. The inconsistent knife wear occurring on the edges and in the centre of the knife drum had to be compensated through a series of grinding cycles. This enabled the shearbar to be positioned closer to the knives along the full width of the drum. Generally, the grinding effort today is often exaggerated. Reducing the grinding routine to the actual requirements would achieve significant savings.

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