Horst Neuhauser, Karl Wild and Johann Mitterleitner, Freising

Durability of forage harvester cylinder knives

It has been proved that the durability of self-propelled forage harvester cylinder knives working in grass under practical conditions depends on the quality of knife coating. Investigations with knives established a variability in periods between sharpening of up to 90 hours. During harvesting operations knife sharpening by the driver was found to be insufficient resulting in blunt cutting edges. Also not taken account of in practice was the requirement for increasing duration of the sharpening action for knives that have been working for longer periods.

Dr.-Ing. Horst Neuhauser is manager, Dr. agr. Karl Wild and Dipl.-Ing. (FH) Johann Mitterleitner staff members of the Bayerischen Landesanstalt für Landtechnik, Vöttinger Str. 36, 85345 Freising

Keywords

Grass silage harvesting, knives for cylinder cutters, stability, self-propelled forage harvesters

For satisfactory chopping in harvesting of forage (wilted crop, maize) the leading role is played by the quality of the knives and contra-blades used and also the gap between contra-blade and knife cylinder.

In order to reduce costs, long periods between knife sharpenings and short sharpening times are aimed for. Additionally, efforts are made to prolong the interval between knife replacement, especially so that replacement can be avoided during peak labour spells.

In connection with this it is assumed that through high-quality coating of the cutting edge, the blade stays sharper longer thus allowing a reduction in power requirement during harvesting and subsequent drop in fuel consumption to be achieved.

Analysed in these investigations are the durability of various forage harvester cylinder knives on self-propelled forage harvesters working under practical conditions during grass silage harvest.

Material and methods

The investigation was carried out with three similar Claas 860 self-propelled forage harvesters. The trial organisers gave no special instructions to the forage harvester drivers so that the operation of the machines was according to normal practice. All investigated knives were made available from the firm Busatis GmbH and two knife types used in the trials were manufactured by the firm with one type coming from another manufacturer.

The three self-propelled forage harvesters were each equipped with a cutter cylinder with attachments for 24 knives. In that during grass silage harvesting in practice normally only every second attachment is fitted with a knife, this practice was also followed in the trials.

The knife inspections took place after defined operation periods and the knife wear, the gap between knife and contra-blade and also the wear on the contra-blade (radius) was measured. The sharpening of the knife during harvesting was done by the driver of the harvester and it was also left to the driver himself to decide on the timing and length of each sharpening operation. The driver recorded the time of sharpening and the cylinder operating hours.

The investigations took place within two trial series with in each case new-condition knives and the trial ended when the knives were worn down. In the first trial series two different knife types (knives A and B) from different manufacturers were tested on a single cylinder with one half of the cylinder fitted with A knives and the other with B knives. This trial arrangement was chosen to achieve a treatment of the tested knife types uninfluenced by differences in driver, harvested material, ground conditions and mud/dust.

In that with these conditions reduced wear of a knife type, during sharpening for instance, would be relativized, the second trial series had 12 knives of the same model fitted in each forage harvester. Here, the investigations with the two types of knife (A knife and B knife) from the first trial series took place along with a new development from one of the manufacturers involved (C knife). In this way results depicting possible working duration were aimed for.

Results and discussion

The material wear in the region of the cutting edge determined the time between knife sharpening. Hereby three phases of knife wear can be identified.

Sharpening wear

During the sharpening of the knife after fitting and adjusting it was apparent that, because of the different knife forms, different sharpening times were required in order to ensure a matching of knife and contra-blade. Before the sharpening, a gap difference of up to 0.4 mm per knife was determined with A knives whereas with C knives this gap was only 0.1 mm. This had the result that when sharpening the knives that matched more exactly in the first place, a longer grinding time and unnecessary material loss was involved and with this, wear over the whole breadth of the knife. This was also reflected in the resultant grinding phase breadth of the knife which with the matched knives ranged

from 0 to 5 mm, whilst the knives that matched even more exactly only varied from 1 to 1.5 mm.

Harvest wear

During the harvesting processes, wear is to be seen on the cutting edges, through the reduction of coating thickness and also the wear on the end of the coating.

The wear on the cutting edges results in the point of the cutting edge being rounded-off during harvesting. During the trial phase it was indicated that in all inspections of the cutting edges in the three forage harvesters the cutting edges were markedly rounded-off. From this it was assumed that during grass silage harvesting in practice no great emphasis was made on having a sharp cutting edge of the knives.

Marked differences emerged in the wear of the coating thickness. The coating distinguished itself with its high degree of hardness and was responsible in the main for the durability of knife sharpness. This could be very definitely demonstrated within the framework of the first trial series through direct comparison of the knives. Thus it was that with the knife type with the lesser time between sharpenings a marked wear of the coating could be seen with the naked eye after just 30 working hours. In many cases the coating no longer reached as far as the cutting edge, was partially already worn down and indicated also extreme wear of coating end compared with the other knives.

In *Figure 1* the changes in the breadth of knives during the second trial series in connection with the working hours for the three investigated knives are presented. The trial with knife A was ended after 45 working hours because the wear of the coating of knives on one side of the cylinder was too far progressed. Marked differences in the periods between sharpening also appeared in the comparisons between knives B and C with respectively 97 and 131 working hours.

Post-sharpening wear

Further wear on the knives took place during the sharpening process. In this case, grinding-off the basic knife material on the side opposite that coated was carried out until a sharp knife edge had been formed with the coating reaching right to the cutting edge. In this case, the types of knives with coating more subject to wear required that more material be ground-off during sharpening towards a sharp and durable cutting edge.

Questioning the drivers and evaluating their records revealed that on average the knives were sharpened about every four to five hours. Sharpening time during harvesting was given as about one minute per sharpening operation.

In each case, a complete sharpening of the knives was undertaken by the trial organisers after about 30 to 40 cylinder working hours. Here, the knives were ground down until they were all ground over the total breadth. The investigations indicated that markedly longer times were required to reach this condition than those needed by the forage harvester drivers in the field operations. In *Table 1* are listed the sharpening times in connection with the working hours based on the performance of knives C (the longest period between sharpenings in the second trial series).

It is shown that with increasing knife working hours the need for sharpening rose markedly and that a significant discrepancy existed compared with the usual sharpening time in practice. Why the negative results from the short sharpening times were not recognised in practice was probably due to the following main reasons:

Table 1: Required grinding time of all knives for knife C in the second test series

Working hours	**[h]**	35	54	82	131
Sharpening time	**[min]**	15	18	33	51

- In practice, the swath is normally not of sufficient bulk to achieve full load for the forage harvester at the driving speeds achievable in practical terms. Because of the high engine power available this means that enough reserve is available to cope with the higher power requirements caused by the insufficiently sharpened knives.
- A worse cutting quality is optically not so apparent in grass as it is with maize where unchopped lengths really stand out.

Conclusions

For the moment, it cannot be estimated whether a further marked increase in the period between sharpenings is possible through further developments on the basis of the current systems. Through a better matching of knife and contra-blade geometry sharpening wear and the up until now necessary time involved can be reduced. Also, the current sharpening equipment should be given a critical examination. Here, it should be investigated whether, through automatizing of the sharpening process, an increase in efficiency is possible.

The results presented have to be looked at in the light of the trial factors and surrounding conditions. On cost grounds it was not possible to repeat the trials so that deviations from other trial results arepossible.

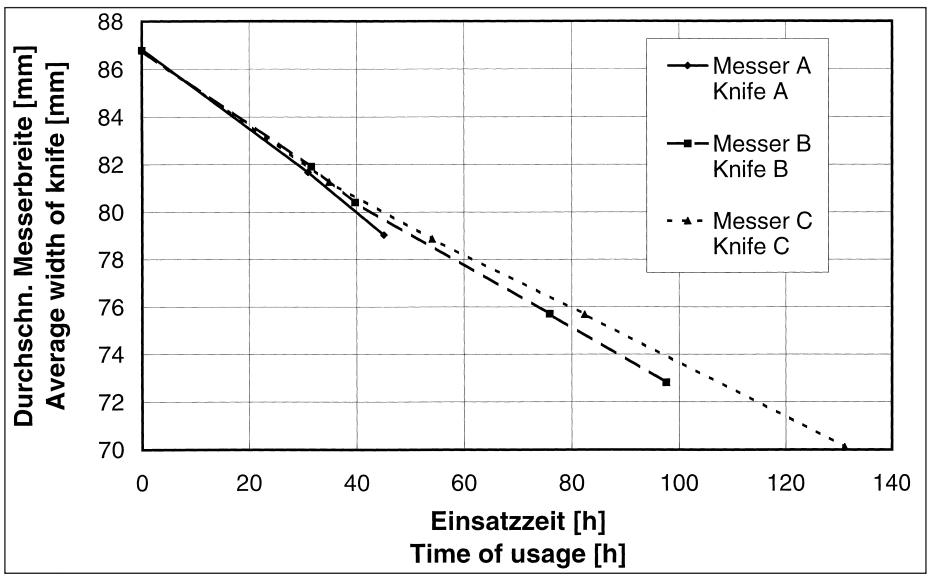

Fig. 1: Wear and time of usage of different knives for cylinder-cutters in grass harvesting for silage