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# Reduction in plough material wear through improved steel quality

Greater area performances in cultivations can be achieved through wider working widths, higher operational speeds or also through less downtime during the work in progress. A possibility for decreasing downtime is the coating of implement wearing parts with extra material layers and so slowing wear progression. This approach is already followed with soil cultivation implements. A further possibility in this respect is the use of harder types of steel, an approach already used for components in feed mix wagons and recently also applied by the company Lemken to reduce wear on its ploughs. The improved steel qualities involve a higher degree of hardness, offering a longer working lifetime because the surface is thus more wear resistant. The use of harder steel in this respect in own trials resulted in a 61% reduction in wear. Working time, as opposed to downtime in the field, increased by a factor of 2.5.

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**Abstract**
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Alongside harvesting operations, field cultivations and sowing represent major cost blocks in cropping with over 30 % of total labour costs [1]. In addition to climate and growth, cultivation is an important factor in forming soil structure. It influences the ratios of the larger and the finer soil ingredients and through this has an important impact on the growing medium. Cultivation methods influence soil structure in the upper layers, field surface relief and habitat for soil flora and fauna as well as the rhizosphere. In farming, various soil cultivation systems [2] have become established. Especially the intensive inversion of soil via ploughing leads to high wear in the implements applied. For this reason, soil cultivations have already been investigated to determine the effect of applying additional layers of material in reducing wear [3].

Figures for metal hardness depend on the actual testing method used and respective measurement technique. For softer metals (aluminium) through to fine-grained steel the Brinell hardness scale is used. This system is often insufficient for harder metals where techniques such as the Rockwell Test can be more efficient (HRC hardness testing via Rockwell according to scale C) [4].

For the plough, the company Lemken has developed new soil-moving parts using substantially harder steel (**Figure 1**) [5]. The higher degree of hardness (62 HRC) used for DuraMaxx parts gives improved wear resistance on the material surfaces. The tool steel used so far for the Dural model range represents a hardness of only 57 HRC [6].

The attempt to establish a generally accepted definition for wear according to [7] can result in the following: Wear indicates the process of increasing loss of material on the surface of a body caused through contact with, and relative movement of, a solid, liquid or gaseous counter body.

## Materials and methods

Used in the trial was a 5-furrow Juwel 8 plough equipped with conventional Dural wearing parts on the one side and the new DuraMaxx parts on the other, so that uniform wear on both sides could be expected.

Fuel consumption in each ploughing direction was measured in volume terms using a VDO-Kienzle oscillating piston meter with GPS positioning documenting movement on the field via data logger [8]. Additionally, speed over the ground was determined via GPS tracking.

Further recorded values via data logger over CAN-Bus interface were positions of the lower link arms, draught forces acting on the lower linkage attachment bolts, engine rpm, exhaust gas temperature and transmission speed.

## Results

The trial commenced in spring 2011 and is still ongoing. Firstly, all starting weights of the wearing parts under observation were documented (**Table 1**). Then, ploughing as cultivation op-

Fig. 1

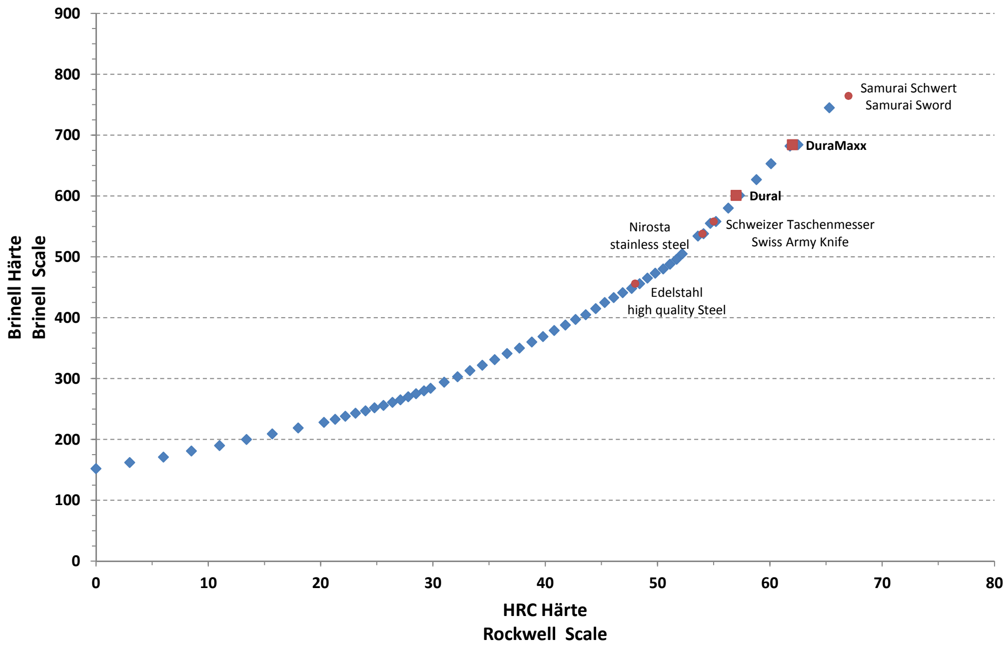



*Fig. 1: Brinell and Rockwell hardness scales, after [5] expanded*

eration for establishing maize was started with all conspicuous characteristics during the operation documented by the tractor driver. Soil-moving parts including points (lace) were reversed or changed by farm staff in uniform routine. Additionally, at first every 100 ha every part involved was re-weighed so that weight reduction could be documented.

The new DuraMaxx tool steel is used only on the mouldboard slats (E to H), the share point triangle C and the skimmer (**Figure 2, Table 1**). Alongside the advantage of higher quality steel, the DuraMaxx wearing parts could be replaced faster and easier, in that no spanner-work is required for these operations (**Figure 3**). The parts are attached using only a clip-on system. Hereby mouldboard parts and slats are supported completely by the plough body and have no longer a load-bearing role in the design. The mouldboard parts and the slats are without attachment bolts and at the same time free of tension loads being hooked onto the plough frame, or frog. Hereby the mouldboard shin serves as locking component for the mouldboard slats. In this system the mouldboard point attachment is reduced to a single bolt, meaning less time requirement for replacement (downtime) can be assumed.

Through reduction of bolts required for affixing components as illustrated in (**Figure 3**), repair time (downtime) with the DuraMaxx version compared with the Dural version could be substantially reduced. Timed replacement of components showed a difference of 15 minutes per plough share to the advantage of the DuraMaxx model where a compressed air spanner was used, (Dural with 24 minutes to DuraMaxx with 9 minutes). With a ratchet spanner the replacement time increased by 17 % for the Dural model. The points and landsides were not included in these timings because these parts were made of the same type of steel in both variants and therefore had to be unbolted and replaced the same number of times.

Alongside the advantages of reduced downtime the DuraMaxx parts also offered substantially reduced wear. This was measured through weighing the parts to determine weight loss in grams. For further analysis, the mouldboard slats were taken as an example for observation because the initial weights of the two types are almost the same, despite the different steel qualities (**Figure 4**).

Table 1

*Initial weights of all parts of Dural and DuraMaxx series on the first plough bottom*

| **Pflugkörper** ***Plough bottom*** | | | **Dural** | **DuraMaxx** |
|---|---|---|---|---|
| | | | **kg** | |
| I | Spitze/*Lace* | A | 2,8 | 3,1 |
| | Schar/*Coulter* | B | 5,5 | 5,6 |
| | Dreieck/*Triangle* | C | 1,9 | 3,9 |
| | Streichblechkante *Plough body stripe* | H | 4,8 | 6,1 |
| | | G | 4,1 | 3,8 |
| | | F | 3,5 | 3,4 |
| | | E | 3,7 | 4,2 |
| | Anlagen/*Apendices* | I | 1,0 | 1,0 |
| | | J | 4,6 | 6,1 |
| | Vorschäler/*Skimmer* | D | 11,1 | 11,6 |

Fig. 2

*Description of the individual components of a plough bottom in the test (Photo: Reckleben)*

Fig. 3

*Comparison of DuraMaxx (left) and Dural parts (right) (Photo: Reckleben)*

The DuraMaxx components out of harder steel showed 61 % less wear than the Dural ones. On the mouldboard middle slats, F, wear is substantially more than that on the outer slats because there is a higher friction force at that point.

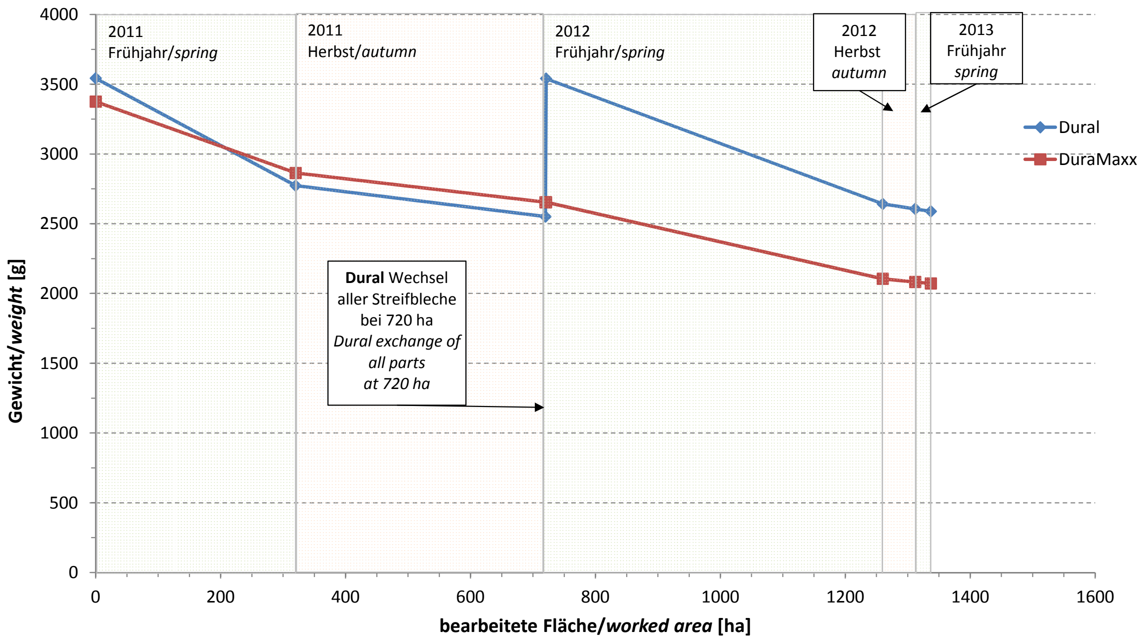
The greatest wear was identified at the beginning of the trial with less recorded in the subsequent weighings (**Table 2**). The higher wear at the start could be attributed to the dry spring in 2011 as well as to the slightly reduced hardening of the treated metal surfaces. In autumn 2011 and 2012 much less weight loss of the parts was recorded. On the one hand, this could be attributed to the work having been carried out later in the autumn and, on the other, to varying soil conditions because of climate-caused changes in soil moisture prevalent during the respective seasons. Especially higher rainfall in the latter part of the years in consideration had the effect of reducing wear. The Dural parts were completely replaced after 720 ha because the material on the points was paper-thin and breakage danger consequently greatly increased. The same tendencies were observed in all the parts of the trial with regard to the proportionality of wear of individual mouldboard slats. Reduced fuel consumption through using DuraMaxx components has not been able to be established in this trial.

Respective area performance prognoses were calculated with the following equation 1 [9]:

$$\text{Max. area} = \frac{\text{(Usable material thickness)}}{\text{(Material loss after 350 ha)}} \times 350\ \text{ha} \qquad \text{(Gl. 1)}$$

According to own investigations an operational area of maximum 1 800 ha is currently calculated when DuraMaxx components are used, thereby assuming a component residual

Fig. 4




*Weight loss and change interval using the example of the plough body stripe F*

Table 2

*Material thicknesses and rates of wear after 350 ha*

| | Dural | DuraMaxx |
|---|---|---|
| | mm | |
| Dicke der Neuteile<br>*Thickness of new components* | 11 | 10 |
| Minimaldicke der Teile vor Wechsel<br>*Minimum thickness of components before replacement* | 5 | 2 |
| Nutzbare Verschleißdicke<br>*Usable amount of wear* | 6 | 8 |
| Nach 350 ha/*After 350 ha* | | |
| Materialdicke<br>*Thickness of material* | 9 | 8,5 |
| Materialabnahme zum Neuteil<br>*Material wear on new components* | 2 | 1,5 |

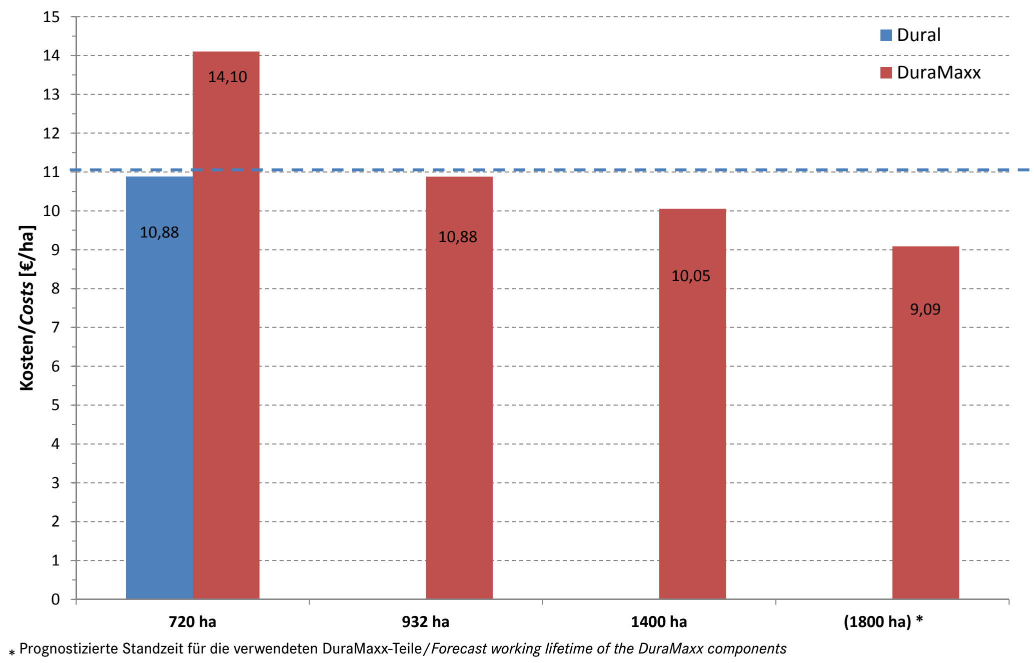
material thickness of 3 mm. Applying equation 1 gives an expected operational area for the Dural components of 1 050 ha. This area could not be achieved in the trial because the Dural mouldboard slats became badly worn at the edges and this had a negative effect on the work result. On the other hand, a ploughed area for the DuraMaxx components of 1 860 ha was calculated, assuming a remaining component thickness of 1.5 mm. The measurements were repeated at 720 ha, 1 050 ha and 1 400 ha. Based on the results, a theoretical performance of 1 800 ha and assumed remaining DuraMaxx component thickness of 3.00 mm is currently calculated [10]. The limits with regard to ploughed area for the Dural components were already reached at 720 ha (**Figure 5**), so that for the DuraMaxx components in own trials would result in a 250 % higher ploughed area, if the forecast area performance was achieved.

Looking into the economics of the two systems involved comparing the cost of a VariOpal 8 plough with Dural components with that of a Juwel 8 plough with DuraMaxx components. Decisive here are the purchase prices of both ploughs as well as the costs of the wearing components. The Dural components had to be replaced in own trial work after 720 ha. At this point the total costs for the DuraMaxx were higher by 3.22 €/ha. With a ploughed area of 932 ha the costs for the Juwel 8 plough with DuraMaxx components were the same as those for the VariOpal 8 plough with Dural components. This value was already exceeded in own trial work. The 1400 ha performance so far of the DuraMaxx components currently gives an advantage of 0.83 €/ha for the new material. If one calculates this advantage for the forecast DuraMaxx components area performance, this results in an advantage of 1.79 €/ha. For the total area performance of 7 000 ha representing a working lifetime of 14 years annual ploughed area of 500 ha, an advantage of 12,530 € is calculated for the new plough with the DuraMaxx wearing parts.

## Conclusions

Through selection of newer and harder metal for plough wearing components, a 250 % longer working time was able to be calculated from the results of own trials. Downtime (for repairs)

Fig. 5




*Cost comparison 5 furrow reversible plough: total of fix costs (AfA 14 years, interest 4 %, annual hectares performance 500 ha, resale value is equal) and variable costs (wear parts and replacement costs)* is greatly reduced by reducing the number of bolts required for attaching wearing components onto the frame. The cost comparison shows that the new material DuraMaxx already works out cheaper than the standard material Dural after 932 ha.

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