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Forces acting on different types of plough shares

Despite the increasing establishment of non-inversing cultivation methods the plough remains the most important implement for primary cultivations. Tight margins in agricultural production mean the plough has to be applied as efficiently as possible. The target must be minimising of draught requirements whilst maintaining work quality. Different types of plough share points and mouldboards as well as welded-on wearing parts can considerably influence draught requirements.

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Keywords

Plough, wearing parts, pulling power requirements, fuel consumption

Literature

Books are marked thus •

[1] • *Soucek, R und G. Pippig*: Maschinen und Geräte für Bodenbearbeitung, Düngung und Aussaat. Verlag Technik GmbH, Berlin, 1990

Forces acting on a ploughshare are mainly from the shearing action, lifting and accelerating of the earth mass as well as work and progress frictions [1]. Important parameters influencing average draught requirement are here the working depth, width and speed, soil type and plough body form.

Different types of shares are offered for the same plough. As standard, there are complete shares but also ones comprised of share point and mouldboard with separate replacement possible. Shares are available in different sizes, thickness and with various coatings.

To minimise wear on working components and thus save costs many wearing parts in the share point and landside areas are welded on to the original material by farmers. These wear parts are generally of old metal.

The aim of this investigation was to determine the draught requirements of different plough share variants.

Material and methods

Draught requirements of different wearing parts were measurement with a Lemken 4-furrow plough (Vario Opal 84N90) on the second and third body directly at the upper plough leg.

Investigation site was a flat area (soil: sandy loam) after stubble cultivations. Soil moisture was 12% (wt.).

To create comparable conditions, all measurements were conducted at a normal ploughing speed of 8 km/h with 28 cm working depth and a furrow width of 42 cm.

Tab. 1: Technische Daten und Abmessungen der verschiedenen Scharvarianten

Fig. 1: Technical data and dimensions of different ploughshare variants

Var	Mouldboard Manufacturer	Mouldboard Condition	Mouldboard Length [mm]	Mouldboard Thickness [mm]	Share point Manufacturer	Share point Condition	Share point Length [mm]	Share point Thickness [mm]	Rate of change [mm]
1	Lemken	Standard new	480	9,0	Lemken	Standard new	235	18,5	
2	Mölbro	Standard new	470	9,0	Lemken	Standard new	235	18,5	
3	Lemken	Standard used	470	6,5	Lemken	Standard new	190	12,0	
4	Lemken	Standard used	470	6,5	Lemken	Standard new	250	19,5	
5	Frank	Standard used	470	12,0		used	180	24,5	
6	HTU	coatet new	500	4,5		new	280	23,5	
7	HTU	coatet used	475	8,2		used	230	22,0	
8	Lemken	Standard new	480	9,0	Lemken	new	235	18,5	Flatplate I: 200•50•8
9	Lemken	Standard new	480	9,0	Lemken	new	235	18,5	Flatplate II: 300•60•6
10	Lemken	Standard new	480	9,0	Lemken	new	235	18,0	Doubled point: 28
11	Lemken	Standard new	480	9,0	Lemken	new	235	18,0	Doubled land side wedge: 20
12	Lemken	Standard new	480	9,0	Lemken	new	235	18,0	Landside: with steel plate: 240•180•8
13	Lemken	Standard new	480	9,0	Lemken	new	235	18,0	Landside: with 2 flatplates: 360•65•6

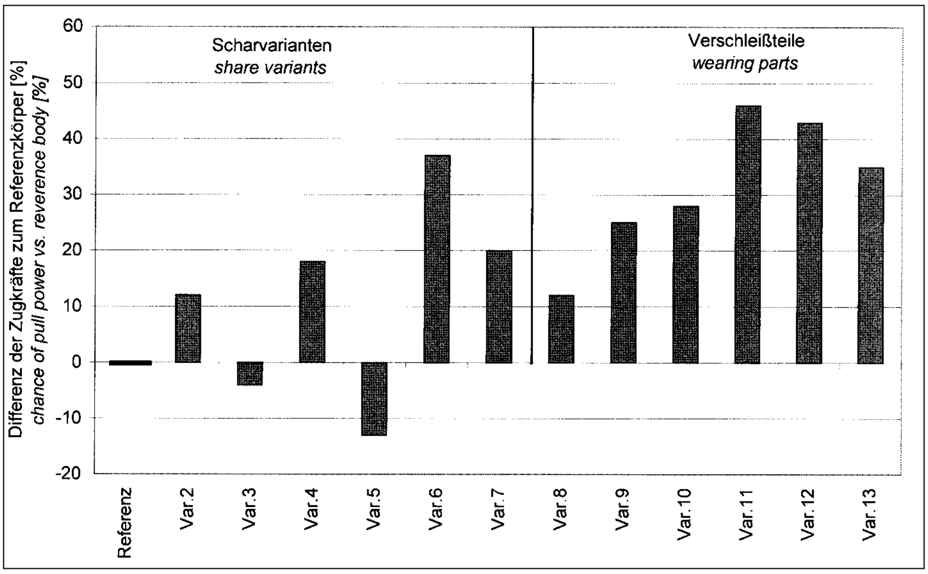

Fig. 1: Technical data and dimensions of different plough share variants

Shares were chosen for the investigation that differed in construction, form, thickness, coating and degree of wear (variants 1 – 7; *table 1*). In addition to the standard commercially available shares, landsides and mouldboards were reconditioned with wearing parts of older metal (variants 8- 13).

Results

Measurement data was collected in the form of a stress-time function. From this function average time-based values were calculated. The differences were applied as relative values to standard body draught requirements (*fig. 1*).

The draught requirement of the reference share was 4.1 kN as average value from all variants.

Analysis of data from variants 1 – 7 took place with a multivariant regression analysis with the proof links length and thickness of share point or mouldboard.

Under the given conditions a highly significant influence of the share point length on draught requirement could be determined. A longer share point increased the undergrip. On a single body basis, this caused the draught requirement to increase by 20 daN per cm of share point length increase. When altered by different setting angles the undergrip returned an absolute increase of only around 4 mm per cm longer share point. This explains the low draught requirement s of variant 3 and 5 with respectively 4.5 and 5.5 shorter share points.

Despite having almost the same measurements as the standard mouldboard, the variant 2 mouldboard had a 12% higher draught requirement, attributable to the rougher surface of the coated mouldboard. Variant 7 showed a similar result where additional influence of the recorded values came from the thickness of the share point.

The successive modifications of the different wearing parts in the variants 8 to 13 had a clear influence on draught requirement. The welding of two flat plates on the lower mouldboard in variant 9 increased the power requirement by 25%. Where a second used share point was welded onto the existing one, draught requirement was only increased by 3% (variant 10). An additional landside wedge increased draught required compared with the standard variant by 46%.

The additional landside wedge was replaced on the landside by other wearing parts in variants 12 and 13. The draught requirement rose compared with variant 10 by 15% with variant 12 and 7% with variant 13. Compared with the reference body, this represented a substantial difference of 43 and 35% respectively.

The main reason for the increase in draught requirement lay in the poor transitional surface between the original and the welded-on wearing parts. Resistant angles are created on such surfaces and soil sticks to these resulting in a strong resistance to the soil flow. The earth clods sticking onto surfaces thus led to a strong soil-soil friction with respectively higher draught requirements.

The rising power requirement had an effect on tractor fuel consumption. This was calculated for a 107 kW tractor on the basis of the available results. For measured draught power at the reference share there resulted a draught power requirement for the 4-furrow plough of 46 kW/m working width. If the ploughshares were replaced by the variant 2 ones, the draught power requirement increased by 6kW/m working width. For this plough, that meant an increase in fuel consumption by constant area performance of 3 l/ha (*table 2*). Still greater is the difference where additional wearing parts were welded on. These caused the draught requirement to rise to 64kW/m and brought the diesel consumption up to 8.2l/ha.

On average, all measurements with welded on wearing parts when compared with original parts resulted in an increased diesel consumption of 6l/ha, representing an extra cost of 4.80 €/ha. The increased fuel requirement represented 40 to 50% of the up until now usual wear costs under the specific conditions in Schleswig-Holstein.

Table 2: Power requirements and fuel consumption with a four-bottom plough (computed results, working speed 8 kph)

Variant	Plough draught requirement Absolute [kN]	Specific [kN/m]	Required tractor power* [kW/m]	Diesel-consumption** [l/ha]	Costs [€/ha]
Reference	17,2	10,2	46	20,2	16,2
2	19,8	11,8	52	23,2	18,6
3	16,7	9,9	44	19,6	15,6
4	21,8	13,0	58	25,7	20,5
5	14,2	8,5	38	16,7	13,4
6	24,1	14,4	64	28,3	22,7
7	21,2	12,6	56	24,9	19,9
8	20,0	11,9	53	23,4	18,7
9	21,5	12,8	57	25,3	20,2
10	23,0	13,7	61	27,0	21,6
11	23,2	13,8	61	27,2	21,7
12	24,2	14,4	64	28,4	22,8
13	22,2	13,2	59	26,0	20,8

*Efficiency of 50% with 5% wheelslip, ** specific consumption of 233 g/kWh – density 860 g/l – fuel price 0.80 €/l