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Tyre Inflation Pressure Adaptation of Sugar Beet Harvesters with Hoppers

In Germany, the one-stage multi-row harvesting system for sugar beets has prevailed. Increasingly SP-harvesters with hoppers are being used, which are able to collect the beets up to a field length of 800 m and to bring them to the headlands. The consequences are high machine weights with high wheel loads. Their negative effect on the soil can be lowered through tyre dimensioning and adjusting tyre inflation pressure.

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Keywords

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Developments in the harvest technology for sugar beets have led to machines, which cause a severe strain on the soil because of their high weights. Structural soil damages caused by harvesting machines cannot be ruled out, because sugar beets are harvested at a time when seasonal weather conditions lead to increased soil moisture and to a decline in the load-bearing capacity of the soil.

Reacting to the threat, which the industrial society poses to the natural resource soil, the legislature has passed the Federal Soil Preservation Act. Among other items, the Soil Preservation Act demands as „good agricultural practice" that

- soil compaction shall be avoided as far as possible, especially by taking the relevant soil type and soil moisture into account, and by controlling the contact, exerted on the soil by agricultural implements,
- the soil shall be tilled site-specifically, taking wheather conditions into account,
- the soil structure shall be conserved and improved.

Tyre Dimensions

The manufacturers of beet lifters have reacted to the requirements of soil preservation by increasing the dimensions of tyres, particularly their width. The tyres of self-propelled six-row tankers (KRB 6) are between 800 to 1,050 mm wide, mounted on 30.5 or 32 inch rims. Because of the space between the tyres taken up by the conveyor chain, the front axles of KRB 6 are usually equipped with the smaller tyres. The rear axles usually have bigger tyres that are 1,050 mm wide and mounted on rims with a 32 inch diameter. High-volume tyres are also used for trailed lifters, with widths of up to 600 mm and rim diameters of 26 to 30 inches.

Wheel loads of self-propelled tankers (KRB) and lifter-loaders (KRBL)

Figure 1 details the wheel loads of trailed and self-propelled tankers (KRB) as well as lifter-loaders (KRBL). Covering a range from two-row KRB to six-row KRB with three axles and including lifter loaders, the data reflect the trend of technical development towards higher gross weights. Germany's sugar beet harvest has come to be dominated by the one-phase technology of six-row KRB, which is used on more than 70 % of Germany's sugar beet cultivation area (Merkes, 2001). As the illustration shows, the distributions of axle loads and wheel loads differ for all harvester types.

Tyre Inflation Pressure

The wheels of self-propelled harvesters are inflated to 1.7-2.5 bar and those of trailed harvesters to 1.9 - 2.5 bar (Rodertest Seligenstadt 2000). High wheel loads resulting from a full tank require high inflation pressures adjusted to the load capacity of the wheels determined by the wheel manufacturer. Another reason for high inflation pressures is that on sloped ground high-volume tyres with low pressures yield sideways due to lateral forces. Drivers and operators also argue that the higher speeds on the road require higher inflation pressures than operations on the field. Moreover, on most machines the tyres on the front machines were found to be inflated to higher pressures than those on the rear axles. The reasons for this are, first, that the front axles are usually equipped with the smaller tyres and, second, that the lifting-out of the topping-lifting device causes high wheel loads. Moreover, higher inflation pressures may be assumed to have a positive impact on the steering behaviour, because the lateral yielding of the tyres will be lower in bends and during corrective steering movements.

Apart from that, it is worth mentioning that, because of the cyclic load on the tyres arising from the loading and unloading of the tank, manufacturers of tyres tend to admit lower inflation pressures than indicated for the maximum wheel load in tyre tables.

Figure 2 details the required inflation pressures for the operating conditions of full and empty tank and for operating speeds below 10 km/h during lifting and up to 30 km/h on the road. The data were taken from the respective manufacturer's tyre tables.

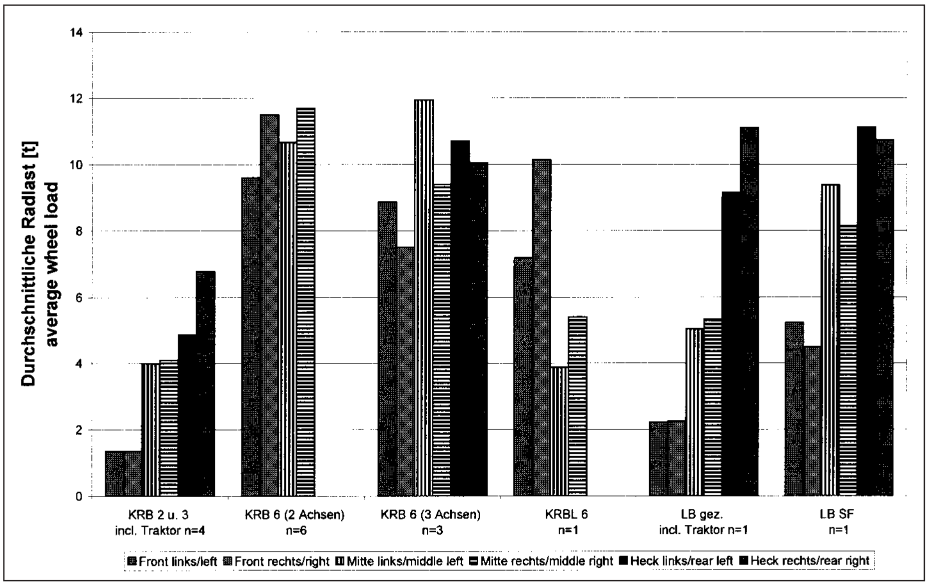

Fig. 1: Average wheel load of beet harvesters - loaded hoppers

The data outline that the highest inflation pressure is required not for road driving but for operations with full tank, even though speeds are low in that case. Accordingly, it is not the main task of inflation pressure control systems to adapt the inflation pressure to the requirements of road and field missions. Instead, they must adjust the tyre inflation pressure to the changing weight of the beet tank while it is being loaded or unloaded.

Requirements for Tyre Inflation Pressure Control Systems

Therefore an inflation pressure control system must be able to lower the inflation pressure of up to six tyres during the unloading of the tank and to raise the inflation pressure during lifting until the tank has been filled. For six-row tankers, which have tyres with volumes between 1,300 and 1,700 l, substantial amounts of air must be released and pumped through the valves. For harvesters with an unloading time of 1 or 1.5 minutes, the release of pressure could in the simplest case be effected by means of an electrically-controlled valve in the wheel rim.

Tests with a 1050 R 32 tyre have shown that an inflation pressure adaptation from 0.8 to 2.7 bar (tyre table equivalents of wheel loads for full and empty tank) can be effected by a vehicle compressor pump (200 l/min, power: 0.6 kW) within 8 min, provided that valves and air pipes with adequate diameters are used (12 to 15 mm). With contemporary tank volumes and average yields, a six-row tanker operating at speeds of up to 8 km/h will be filled after a period of 9 to 16 min, which is the equivalent of a lifting length of 1,200 to 1,600 m.

By means of the same air tubing, tyre inflation pressure can be reduced from 2.7 to 0.8 bar within one minute while the tank is being unloaded. The unloading takes between 1 and 1.5 min. Wheel load plays only a negligible role in both cases. If the compressor is equipped with an adequately sized main receiver tank, inflation can be speeded up. A size 1050 R 32 tyre requires a main receiver volume of 400 l at 9 bar to raise the inflation pressure from 0.8 to 2.7 without further operation of the compressor pump.

An inflation pressure adapted to the wheel load will result in an optimum flattening of the tyre and, consequently, in an even distribution of the wheel load throughout the contact area. If the inflation pressure is too low, the distribution of the wheel load will be uneven, which results in higher contact pressures towards the edge of the contact area. On the other hand, the result of inflation pressures of 2.7 bar will be that the lifter's tyres will for the greater part of the lifting cycle exert a higher contact pressure in the centre of the contact area than on its edges. Optimal flattening is attained only for a very short period of time; the load on each wheel of a six-row tanker with two axles must be assumed to rise by 600 kg per min if the yield is assumed to be 650 dt/ha.

Thus, if inflation pressures are adjusted to wheel loads, the wheels are not only used according to their technical specifications, i.e. in a way that spares the tyre, but also in a way that spares the soil.

Adequate inflation pressure control is not only made difficult by additional costs, but also by additional technical problems which need to be solved. For instance, to avoid inordinate wear of the sealings in the leak-proof joints, they must only be pressurised during standstills of the wheels. Moreover, as illustration 1 shows, there are great variations in axle loads as well as in wheel loads. Therefore, adequate inflation pressures cannot be determined with recourse to gross machine weight only. Instead, axle load, and ideally wheel load, must be known for each stage of the harvesting process.

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Fig. 2: Wheel load and tire inflation pressure of a 6-row harvester, conditions: road, vehicle structural weight, 30 km/h; field, vehicle structural weight and with loaded hopper < 10 km/h