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Combine Harvesters – State of the Art

Securing the world food supply with a rapidly growing world population necessitates further efforts to produce, harvest, process and distribute increasing quantities of food, in spite of limited agricultural areas. Due to limited time, a fast, low-loss harvest is especially important. Also in developing countries, increasing harvest mechanization is necessary in order to increase capacity levels and reduce losses. For this reason, combines are being improved and optimized by the manufacturers. Progress in separating- and threshing technology, cutter bars, drives, and chassis, as well as in operation and automation is reported on below.

Even though the development has already reached a high level, the combine manufacturers continued to raise output and operating comfort last year. The new or improved products which will be presented at the Agritechnica 2007 are interesting. Three manufacturers (Claas, CNH, and John Deere) supply more than 90 % of the German market, and five other brands (Deutz-Fahr, MF, Fendt, Laverda, and Sampo) share the rest. In Germany, approximately 90 combine models ranging from 75 kW to 398 kW are offered (*Fig. 1*). In the past 50 years, the lowest engine output increased approximately three-fold to 75 kW. In the upper power segment, engine output grew almost 10-fold to 398 kW. Engine power is going to keep increasing in the future so that throughputs can grow even further. More and more engines meet the exhaust standard Tier III and reduce fuel consumption as well as noise both at the driver´s place (better cab design) and in the environment. Oil consumption was reduced, and oil change intervals were extended. In 2006, a total of 2206 units were sold in Germany, i.e. only 22 combines less than in the previous year.

Combining Costs

The production costs of grain vary significantly not only worldwide, but also within Europe. Different cost structures for production in Germany, France, the Czech Republic, and Canada were shown using several farms as examples. In Canada, in particular the expenses for labour and machinery amount to only one third of the costs in France and Germany, which is a result of the different intensity of cultivation.

In certain cultivation techniques, the combine could be used for direct drilling, which would allow one pass and, hence, costs to be saved.

The stabilization of the grain prices is being supported by the growing market for energy grain (bio-ethanol, biogas, combustion) and for industrial use (starch).

More and more often, the growing size of combines is confronting the buyer with the question of whether he should buy one larger machine instead of two. Due to the lower personnel expenses, the use of a more efficient combine provides considerable advantages. In practice, repair costs vary greatly and mainly depend on local and individual circumstances.

Performance-based cost calculation, which is discussed frequently, is used only rarely in practice because evaluation is more difficult than in area-dependent cost calculation. Haulage is a very important cost factor and contains additional optimization potential. During transports over large distances, for example, it is worthwhile to use trucks more frequently. On large farms, more and more grain carts are used on the field. Larger operations are also increasingly considering grain storage instead of direct sale again. This requires large combine output so that the grain can be stored dry and in high-quality condition. In addition, the grain must be cleaned, and storage space must be provided.

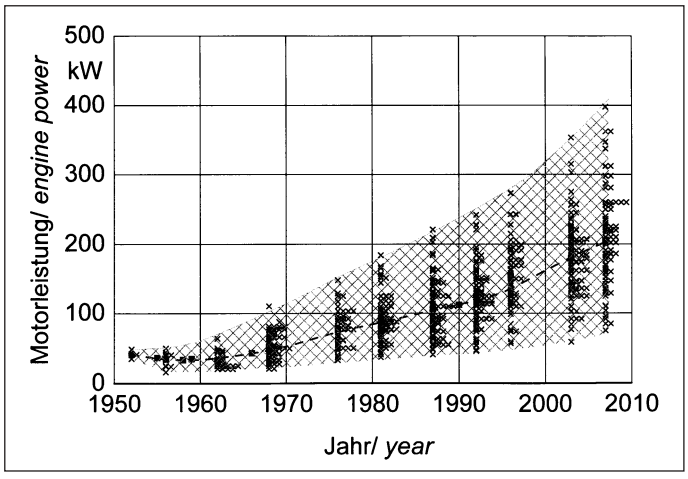

Fig. 1: Increase of combine engine power

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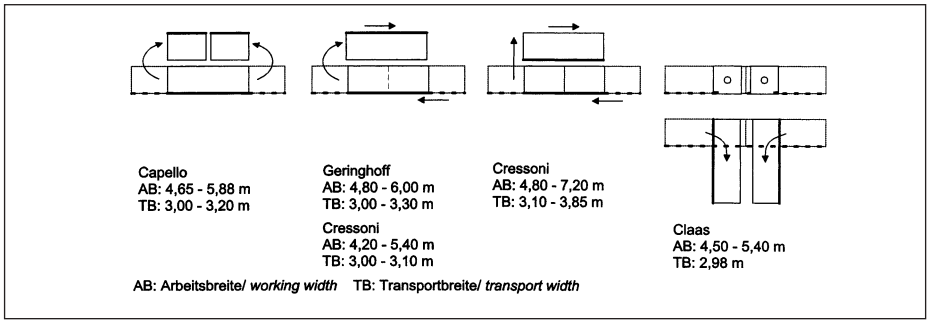

Fig. 2: Foldable cutter bars

The advantages of intermediate storage on the farm are reduced waiting times for unloading, which leads to a reduction of the required transport capacity, and the sale of larger lots at the most favourable time.

Threshing and Separating Systems

The threshing and separating systems available today are being improved in detail. Principally new systems have not been introduced on the market for a long time. Several companies, however, are developing new threshing systems with separating rotors for large combines. The high-cut technique for the reduction of the straw load on the combine is being discussed more intensively again. However, the user must find out whether the high stubble can be incorporated or whether an additional pass is necessary at a later time. A newly presented retrofit underfloor chopper for the combine opens up new possibilities here. Nevertheless, sufficient threshing capacity must be available for unfavourable harvesting conditions, such as laid grain. Investigations have shown that the advantages of the high cut are mainly given under moist conditions and decrease when it is dry.

Kernel damage is often underestimated as a cause of losses because some damaged kernels are overblown by the cleaning system in addition to the visible kernel damage in the grain tank. These fine, damaged kernels usually cannot be detected on the field, but they can account for as much as 3% of the entire grain.

Consumers are showing an increasing demand for alternative grain varieties. This requires other settings and setting possibilities of the combine. Normally, combines are suitable for special crops, such as dinkel. In these crops, however, they need to be driven more slowly.

Cutter Bars

The adaptation of the cutter bars to different harvesting conditions is simplified by the manufacturer (control of the rotational speed of the reel, automatic reel lowering). Almost all manufacturers meanwhile offer cutter bars which allow the distance between the cutter bar and the gathering auger to be adjusted from the driver´s seat either steplessly or in steps.

After 1960, Lely introduced foldable cutter bars into the market. The centrally divided cutter bar had a working width of 4.2 m. Since the two parts were able to be folded up by 90° each, a transport width of 2.9 m was able to be reached. Foldable cutter bars reduce set-up times significantly. This advantage particularly manifests itself in smaller-structured regions with a large percentage of cooperatively used machines. Under these conditions of use, these cutter bars have a constant market share. The current range of cutter bars offered with their various folding concepts is shown in *Figure 2*. Only one combine manufacturer offers a self-produced foldable cutter bar with a working width of 4.5 and 5.4 m, which reaches a transport width of 2.98 m because both halves are swivelled in the direction of travel. The other manufacturers offer their cutter bars for all combine brands. In these solutions, the parts of the cutter bar are swivelled or pushed one above the other. Therefore, transport width depends on the individual cutter bar width. Only in the best case does it reach 3.0 m.

Drives and Chassis

Hydrostatic travel drives and hydrostatic drives for different elements of combines and other harvesting machines are widely used. Alternative electric drives are being discussed and must compete with existing solutions.

With regard to their dimensions, combine chassis are reaching the limits of the Motor Vehicle Safety Regulations. For this reason, one must make sure that machines wider than 3 m are exempt from Section 70 of the Motor Safety Vehicle Regulations and apply for the permission of the local authorities for the operation of the machines according to Section 29 (3) of the Motor Vehicle Safety Regulations. With regard to soil pressure, sufficiently dimensioned tyres are required. As a result, however, the machine widths allowed even with an exemption permit for transport on public roads are easily exceeded. For this reason, the use of tracks is recommended. At a machine width of less than 3.5 m, they provide slightly lower soil pressure values than low-pressure tyres, which are considerably larger. However, costs are higher.

Operation and Automation

Future legal requirements with regard to permissible vibrations at the work place are favouring the use of cab suspensions, which are being examined by the manufacturers and will improve comfort in the future. To a growing extent, the driver is freed from routine tasks and has more time for control- and optimization work. Examples are automatic steering systems as well as the control of the driving speed depending on throughput and grain losses.

Precision Farming

Yield maps have been improved using different statistical methods. It is already possible to include the dynamics of the material flow in the combine in the data recorded on the machine. The quantity of tailings and its influence on the material flow are taken into account with the aid of another baffle plate throughput sensor for tailings.

More and more sensors for quality measurement on the combine are being developed. Experimental systems on the combine meanwhile determine the protein and gluten content as well as the falling number during work. The increasing contamination of grain with fusarium poisons (DON) also requires early detection and selective harvesting depending on the extent.

Beyond precision farming, the combine is an important link in the production chain which provides information as well as proof of quality and supports traceability. One possibility is data storage during the harvest on RFID and the adding of the chips to the grain.