**Step by step**

Does it really work, to thresh a thousand hectares farmland area with only three workers and without being pressed for time during harvesting, storing, processing and strategically marketing? Does the so called compact harvesting represent a concrete alternative to conventional threshing processes?

Despite some freak weather in the 32th calendar week, winter wheat could now be harvested using the converted combine harvester at the agricultural cooperative's farmland in Bornum, Germany.

The picture shows the application and the current machine design as well. It is easy to see that the development of the harvesting method has now reached the next level.

From the technical perspective, the collecting thrower and blower unit has been modified. During preliminary studies in 2013, this unit was just hooked-up at the combine harvester. In the current version, the whole thrower and blower unit is on board the harvester and could be integrated into the existing shaft rotor system. In such a case, the test harvester operates without the integrated cleaning process. The grain-chaff mixture enters directly the baskets of the two axial rotors. The straw leaving the rotors is split into three fractional material flows at the end of a chopper unit. The middle fraction (25%) is admixed with the material passing the thrower and blower unit. The remaining 75% of chopped straw goes to both sides of the chopping unit and leaves the combine by use of distributing rotors sideways down to the stubble field.

The new approach is to use a collecting trailer for chopped straw in line with the combine instead of collecting onboard hopper. It is intended to hook-up this trailer permanently at the combine's rear axle avoiding an interchangeable system. This has significant advantages:

- Well adapted to the harvest situation, it is possible to have different and very large hopper volumes (in this example: 38 m³),
- The hopper size is not a problem anymore, but a solution in terms of traction, because the more lightweight harvester is additionally charged by the hydraulic drawbar at the rear axle,
- A steering axle on the trailer allows to control its tail in parallel to the across-loading mode and also for wider cutting units when the distances to the receiving vehicle are very short,
- Since the chopped straw trailer is a series vehicle, it can also be used independently as a "half combine" throughout the year.

Thus a testing combine harvester has been created that still ranges in upper class performance of cutting and threshing (throughput of the original machine is about 50 tons/h, tested by The German Agriculture Society / DLG e.V.). With the total weight of 12 tons, the harvester is far less heavy than a large tractor of comparable performance. This is partly also the case because of the load generated by straw leaves the combine already after 3.5 m seen from the shaft entry. However, the compact harvester is to be a high performance combine. Short wheelbase, wide drive wheels and front axle steering give the traction and handling characteristics of a modern tractor.

This is a unique feature that could be greatly enhanced by adaptations on the rear axle, e.g. trailer and equipment coupling, powerful hydraulic, pneumatic, electric and electronics, and above all by further imagination of the practicians.

**What has been achieved technologically?**

Benefits of the harvesting procedure are born e. g. by lower operation costs, reduced $CO_2$ emissions, additional benefits, soil fertility and sustainability. In order to verify this, material has been recovered, analyzed, transported, stored and recycled, all tangible, measurable and thus comprehensible.

Technology was developed, tested and improved. The compact harvester has been tested in field operation to demonstrate the practical use. The recognized effects promise significant increases in efficiency for the entire harvest method.

The compact harvest target mixture consisting of 8 tons/ha of grain and each 1.5 tons/ha of short straw and chaff gives many advantages:

- With its 250 kg/m$^3$ for transportation it is nearly ideal self-compacting. This allows payloads of truck trailers to be better exploited.
- It can be stored at achievable press densities of 550 kg/m$^3$ in only two meters of hose per hectare (diameter 2.7 m). This is very cost effective and strategically valuable.
- When it has been compacted, it reaches densities of 200 kg/m$^3$ of separated straw chaff. The material keeps not only the crumbly texture during relocation, but also half of the density, which makes it ideal for large-scaled technical storage.
- The straw handling costs can be reduced to at least 45% compared to baling lines. With additional sales of chaff in a more cost effective way it could increase the operational earnings by six times using a fully sustainable recycling of residues (see table).
- The containing amount of weed seeds can reduce the use of herbicides, which also implies phytosanitary effects.
- When used in biogas plants, 80% of the grains and straw chaff respectively are downsized simply by chopper cracking so that the methane output increases by about 16%.

This all together are very obvious effects of a new technological approach that can convincingly be rated as correct and feasible after only two years of trial.

**Cost comparison straw harvesting**

| **Costs [€/ton]** | **SCHINDLER** | **Compact harvester** |
|---|---|---|
| Nutrient value | 23.89 | 12.00[1)] |
| Pressed straw | 13.73 | 7.00[2)] |
| Straw bale loading | | |
| - telescopic loaders | 4.88 | - |
| - tractor and trailer | 5.90 | - |
| Transport 5 km | 8.02 | 6.00[3)] |
| Unloading | 3.90 | - |
| Pre-cleaning | - | 1.00[4)] |
| Storage 6 months | | |
| - Hall | 35.08 | 8.00[5)] |
| - Field edge | 16.26 | 8.00[5)] |

according to basic data SCHINDLER (dlz agriculture magazine, July 2013, p 117)
1) 50% as only 30% biomass removal; 2) stationary at cleaning, AKr. proportionately, electric drive; 3) average KTBL as grain transportation; 4) estimation, conservative; 5) mixture incl. grain, silage analog x 1.2

**The future has begun yesterday**

In the last two years, visions for 2050 were published for many areas and so also for the combine harvesting. Facing the development of economic resources, the climatic conditions and political consequences, it can be assumed that concrete problems and challenges need to be addressed much earlier. Two recent examples make this very clear. First, the youth talent and labor situation now is becoming more difficult. Regarding agriculture and its technologies, it has to be done a pragmatic approach to develop technologies. Related labor needs and specific fuel consumption are good evaluation criteria. But if the marginal conditions are weak only additional costs and burdens remain for all parties being involved in such projects. The Compact Harvesting method is a technological approach to manage the harvest-to-market products with absolutely less labor and less technical resources. In the shortest option "Combine harvester – storage tube - product (grain plus chaff straw)", this process could even be accomplished with much less absolute effort.

**Positive signals from the industry**

Secondly, the Quality Association for Wooden Products (Holzwerkstoffe e.V.) has installed new quality tests and conditions for products made of wood-polymer compounds. The important aim is to minimize large variations in quality of the wood fractions by allowing an admixture of 30% other natural fibers. A driver of this production process is the company NOVOTECH in Aschersleben, Germany (www.megawood.com). Early in 2012, they already extruded decking boards made from straw chaff on a trial in a very successful manner. The product range is large. In Aschersleben they stand with the claim "Like wood, but better." which represents the beginning of new qualities and quantities. The straw chaff out of the compact harvester has good prospects as an admixture component. The test capacity should be at 5,000 tons of milled straw chaff per annum. Due to the fact that the straw chaff never touches the ground during the entire growing and production process from combine harvester to finished products, high quality requirements should be met. The scientists of the Thünen Institute of Agricultural Technology Braunschweig want to get involved as accompanying partner institute developing the new material.

**Future tasks and new priorities**

To harvest the first 50 tons of straw chaff next year, the following has to be completed:

- Development of a new over-loader device going to the harvest wagon in order to feed the material mixture during threshing.
- Development of a new lateral straw distributer with residual grain recovery and safety function.
- Development of a high performance pre-cleaning system for the mixture combined with a new rotation principle aiming at a throughput of 150 tons/h.

The developments are made by the University of Applied Sciences Schmalkalden in collaboration with Anna Burger Commercial Vehicles GmbH, MMZ Zerbst and Bautec Zerbst (all in Germany).

The technological chain is planned as follows: Compact harvester – Over-load Grain Trailer – Truck Trailer – Pre-Cleaning System- Hose Storage / Straw Chaff - Removal / Treatment – Silo Tanker-trailer – Silo / Production Warehouse. Such an operation chain makes any other material use of straw chaff possible and with high quantity, quality and cost efficiency. The next step is to convert the compact harvester as a key engine for chaff straw harvesting into a practical development stage by using previous technical experience. For this purpose a group of students at the Otto-von-Guericke-

University Magdeburg (Germany) takes over the design of a modular combine harvester according to the requirements of the Compact harvest method for a concept combine harvester. We are eagerly looking forward to the results, because this will not only be a drawing from previous work. What begins as a realistic basis for a prototype is expected to continue in detail and module developments. In this case, there will be next stage modules which might allow the compact harvester a far greater range of applications compared to the state-of-the-art technology. The concept combine harvester has the required installation space; students and researchers in Magdeburg have the expertise.

**A lot of bags in the field**

With the ability to hook-up a chopper wagon or other equipment to the compact harvester, the idea of Field-bag System was born. This is actually a short tube in which the harvested mixture is compressed, higher portioned, and stored continuously in the field. This is a well-known approach for grain that fits much better to the compact harvester product. The picture above shows the "handmade" prototype during the presentation at the DLG Field Days 2014. The practical implementation of the short tube has already begun. It has the following figures and offers several advantages, for instance:

- Diameter 1.2 m; length 2.5 m, volume until 3 $m^3$
- Minimum density 400 $kg/m^3$; weight 1.3 tons
- 8 units/ha; storage distance approx. 120 m
- 19 units/truck
- Recovery: storage and retrieval mechanized
- Storable and stackable outdoors or under roof
- Joint storing of different consistencies and crop types are possible.
- In the case of fire, water is used for extinguishing without jeopardizing the complete stock.

Applying this new method it is not a utopia far from practical use to harvest a 1,000 ha threshfield with only three workers and without being pressed for time during harvesting, storing, processing and strategically marketing. However, the special attraction of this technology consists in the fact that it could be implemented efficiently and highly practical for much smaller fields because of the simplicity of the resources, the low labor costs and the low storage required. What is achievable and meaningful shall be as soon as possible examined and simultaneously tested.

CONCLUSION:

The compact harvesting method represents a novel method for harvesting grain. In addition to the grain the removable sustainable biomass per hectare is harvested as a straw-chaff mixture. By 2014, the technical feasibility of this method has been practically demonstrated by experiments and the start line was set for the implementation of the process concept. The results confirm the correctness of the conceptual approach, including the expected benefits and the strategy for large-technical application of a compact harvesting method. This development allows and requires follow-up tasks in new dimensions. The concept is feasible in aspects of structural design, power consumption, space, weight and price.

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