New Combine to Header Connection-Concept for very wide platforms

Foldable header with 18m cutting width and 18m transport length including the combine

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Abstract

Rising resource and energy prices are pushing the production costs of grain from year to year. This requires a more profitable harvesting solution. All brands choose the most obvious way by extending the width of the header and increasing the power of the threshing system. They have still arrived the limits of the European traffic-licensing-regulations. New approaches to solving these problems are being sought. The following design completes the series of future-oriented grain harvesting technologies (swarm-combine and stationary thresher) designed by the Professorship of Agricultural Systems Technology in Dresden.
The study deals with this problem, and reveals the innovative potential of the combination of established foldable grain header solutions and new conceptual approaches. The best draft represents a two cabin solution for a bidirectional operating direction (differentiated in harvest and transport). An innovative extended folding head, always fixed on the combine, eliminates the time-consuming procedure of dismounting the header.
The new concept is based on a conventional combine, which provides a foldable head with a transport length of 9.2 m and a cutting wide of 17.6 m. Due to the extended folding head, the heavy weight is held up by a separated header chassis. This adjustable two wheel chassis replaces the additionally header trailer. In transport position the central part of the folding kinematics fulfill the function of the trailers drawbar. In transport mode the header stays fixed on the feeder like a normal folding head. The driver just has to change the cabin to go backwards on the street to do the transfer to the next field. The overall concept, as well as

the detailed solutions for flexible coupling, working and transport modification and the adjustable grain elevator are described and presented in detail.
The submitted paper opens a future-oriented agriculture approaches, according to the European traffic-licensing-regulations with the benefit of 11.6ha/h enhancement of area efficiency.

1. State of the Art

The farmers harvest is more and more focused on optimization and cost-efficiency [1]. No square meter of grain is left on the field, the machines are pushed to operate on maximum performance of engine capacity, to return the high investment, despite of small margin to take profits, they claim wider headers than the existing 12m [2]. The short period of 20 days [3] harvest a year forced the farmers to act always like economists.
When looking to invest in a combine, the farmer is focused on the key facts, a minimum of grain loss, grain quality, feedrate, percentage of broken grains, speed of transport and soil consolidation. All upcoming harvest concepts are measured at these characteristics and could not enter the market without matching these requirements.

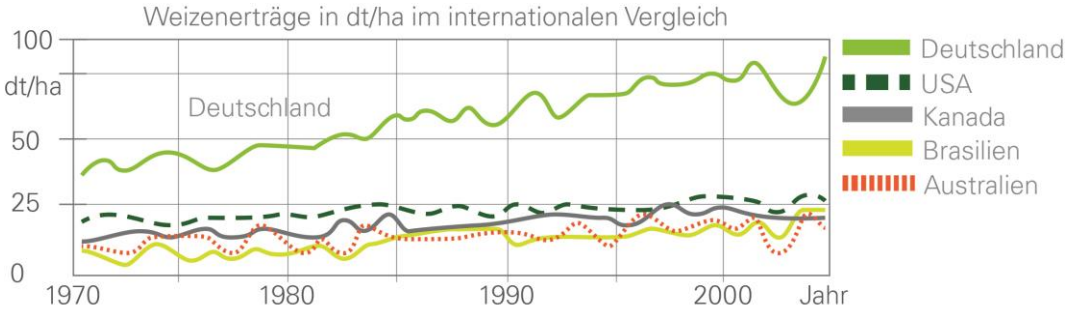

Fig. 1: Grain density comparison worldwide [4]

Farmers make a better profit when harvesting high-yield fields than low-yields ones. This is caused by the limited harvesting speed of 9 km/h despite of the rotor capacity. When evaluating figure_ 01 the dramatic range of average grain density per hectare in global comparative is noticed. The gap of 50 dt/ha is dramatic and should be addressed by implementing new concepts. Also in Europe the density of grain is not homogeneous and depends on local soil quality and the climate.
The fast development of trailed combines based on two different processes, cutting and threshing, increased the effective harvest. The self-propelled harvester supersede the trailed ones, while becoming bigger and bigger until now [5], where by the variety and feeding rate of threshing systems increases. The rotor systems reached capacities that normal header in low-yielded fields were not able to feed sufficiently. The Claas World Record show the

maximum of federate [6]. At the present situation the market has to think about new approaches, because the constant growth of headers is limited [5]. In Europe the maximum width of a header is 12m. In Australia the company MidWest offers an 18m grain header [7], the world's widest one. The wide headers in Australia and North America are necessary to feed the threshing system despite of 2/3 less yield than in Europe. To trail a 10m or longer header by combine a special permit is needed in Europe. These wide headers are often trailed by an additional truck that raises the running costs of the system. To trail a combine convoy without special permit and not inferring with the traffic, the over-all-length has to be less than 18 m [8], otherwise the special permit limits the time and route of transport regarding each province/state regulations.

New innovative concepts are required to brake the simple linear scaling of the headers width. A concept that separates the combined process of threshing and cutting, similar to the 19th Century, by using the modern technologies of engine, actuating elements and sensor technology exists, designed by Jan Wolf (TU Dresden, Junior Professorship for Industrial Design Engineering) [9]. In Addition to Jan Wolf, Hannes Wittig (TU Dresden, Junior Professorship for Industrial Design Engineering) [10] also designed a combine concept that does not increase the efficiency just by scaling the header. His unique idea was to reduce the width up to 6m, using a foldable header and three small combines as unmanned drones. A system of three drones fit on a flatbed trailer to be transported from field to field [10].

The concept of Henry Parnell provides a wide spread header with a supersized 24.000 l grain tank for long term stay on field. To reduce the floor loading the combine uses an eight-wheel-chassis instead of now a days four wheeler. The wheels are driven by hub drives in each rim with 68 hp.

Close to Henry Parnells concept the company Tribine build a 1:1 prototype of a combine with 35.000 l grain-tank-trailer using four-wheel-chassis.

The combine market is in need of new concepts to get adapted to future boundaries and gets stimulated, observing the number of new combine concepts.

The regulations of agriculture equipment are very strict, not for the use on field, but for the transport on public roads. On public roads combines have to comply with the Road Traffic Licensing Regulations otherwise the owner has to apply for a special permit for each transfer. A vehicle within the dimension of 3m (width) 4m (height) 18m (length) is allowed to drive anywhere considering road signs [8].

A combine with a trailed 10m-header excesses the maximum length of 18m [5]. Therefore each further meter of cutting-width restricts the driver in choosing the closest way from field

to field. Another side effect of long trailers are the driving performance while turning over, cornering or diving from road to field.
Besides the road restrictions, customers have their own outstanding requirements when buying a combine. Grain tank capacity, load per axle, consolidation, speed of transport and short setting periods are some of the customer's main debits [5].

2. The VENUM

Like all other competitors the harvest concept VENUM favors to enhance the efficiency by increasing the cut width. But the VENUM has 150% wider header than others in Europe without needing special permit to transfer on public roads, while still being oversized. Compared to past concepts for grain harvesting the process stays the same, based on a rotary threshing system with two cylinders, without changing parts for cutting, threshing and cleaning. The package is comparable to the one of Claas Lexion 780. This is the third conception for future grain harvest in a series of three created by co-working of *Junior Professorship for Industrial Design Engineering* and *Chair of Agricultural Systems and Technology* from the TU Dresden. The two others deal with autonomous and separated processes. The VENUM is close to the present age and should show potentials of combines without degrade the now-a-days-system.

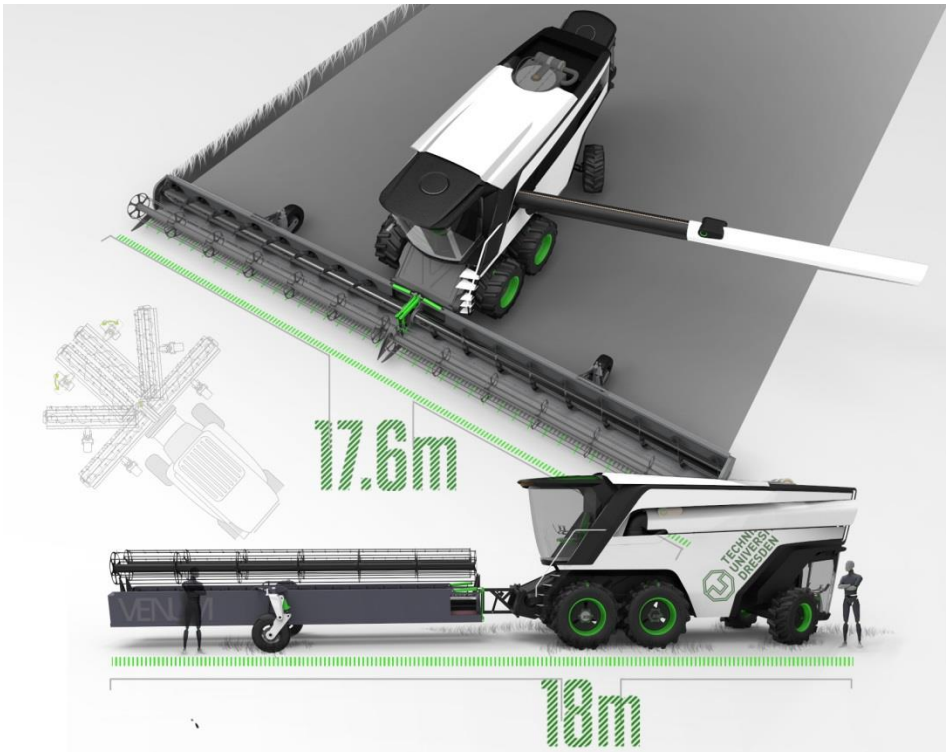

Fig. 2: The VENUM in harvest and transport configuration

Without changing the functional process for threshing and cleaning the main innovation is based on the header. Towards stiff headers up to 18m the VENUM header is foldable for transfer purposes, almost to the half of its cut width. With a cut width of 17,6m the maximum is accomplished. The combine and folded header measures 18m respectively. Compared to the foldable header H720 by Geringhoff, one of the biggest in market enables 7,2m cut width, the VENUM header is enormous evolution [5].

The mass of the 17,6m header is approximately 5t, based on a headers own chassis without loading the front axle of the combine. The vertical adjustment for cutting height is realized by hydraulic system integrated in the header chassis. The system offers the driver a mowing height from 10 to 65cm. To changeover from harvest to transport mode, the chassis extend till maximum and the electric hub drive moves each half on a circular path. At the end the chassis makes a 90° rotation around the vertical axle. Therefore the header doesn't need a trailer, the chassis build it up.

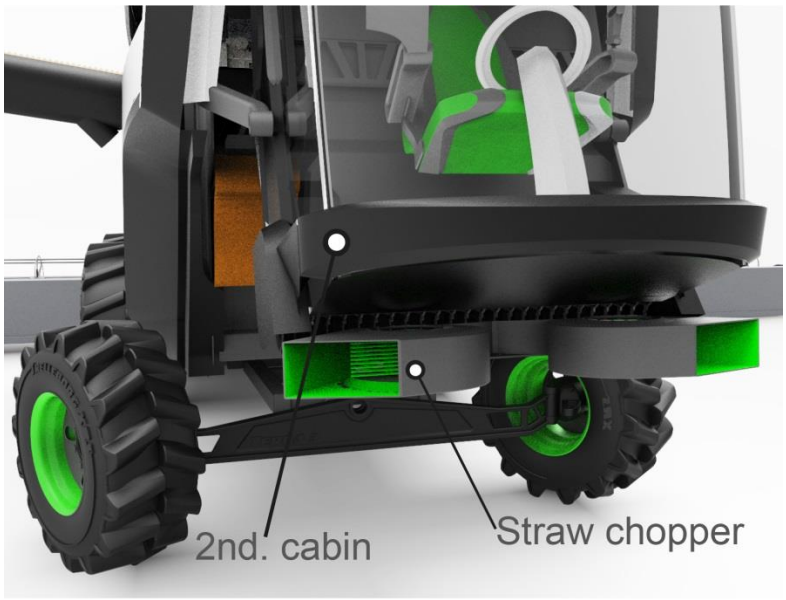

Fig. 3: Transport cabin with straw chopper

To enable a ground-based harvest the cutter bar possesses a foldable center to realize a closer ground adaption – contouring system. Sensors along the cutting bar touch the ground and the hydraulic system changes the angle, respectively.

To accelerate the changeover from field to street mode, the header stays fixed on the feeder. When folding the two half's of the header, the second cabin on the back of the combine lifts down and the driver just has to change the cabin. With the small driving cabin on the back, the combine drives in two opposite directions depending on transport or harvest. The second cabin is just equipped with one seat and the steering wheel. In contrast, the harvest cabin

has two seats and for driving a second joystick (steer by wire) instead of a steering wheel, blocking the view on the process. This missing obstacle in front of the driver's seat improves the ergonomics to current ones.

For better entry and a short design the cabin lifts down in space of straw chopper, which is just needed when working on the field. To reduce the kinematic for a moveable chopper and an adjustable cabin the two elements are connected and move together. For the harvest the cabin moves and place the chopper on his initially position. Concerning this solution the cabin does not extend the length while on-road-transport. When working on field the length is not important at all.

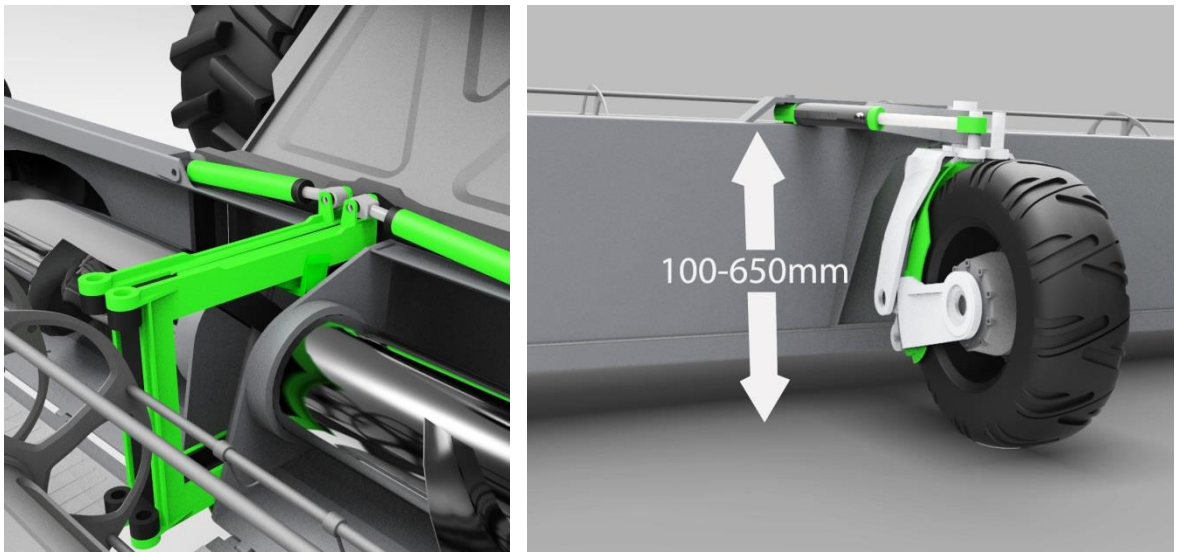

Fig. 4: Header contouring system (l) and headers height adjustment (r)

When using a header with a cutting width of 18m the system has to adapt to that size. For unloading the grain tank while driving the unloading auger has to be 2,5m longer than the end of the cutter bar. For the VENUM concept, the transport length of the auger is restricted to 6m, till the rear cover of the combine. The required auger length is 11m to guarantee the unloading process. To realize the gap of 5m a new technology was invented, a telescopic unloading auger that is constructed out of a 6m auger and a 5m pipe. The grain would accelerate by the rotating auger, thrown in the second tube where a airstream carries the grain till the unloading augers end. The airstream is generated by an axial compressor and transferred in a second canal under the grain stream of the 6m auger. To reduce the soil compaction, the VENUM uses a tandem axle instead of the commonly used single axle. Especially the fully filled grain tank enhances the load. To spread the load and to decrease the impacts are the main benefits compared to single axle and chain drive used now-a-days.

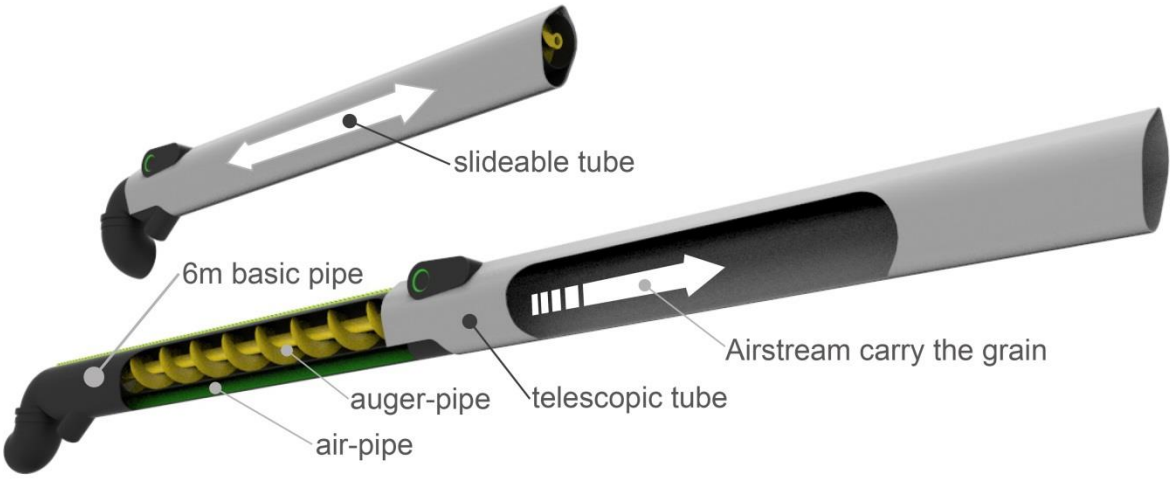

Fig. 5: The telescopic unloading auger working with airstream

3. Advantages and Outlook

In comparison to the normal headers, the VENUM is able to feed the threshing system despite of the high or low grain density on the field. The saved time for changeovers during different modes is a novelty for big headers. The benefit for the operator while driving reversed on-road with the VENUM is the front-wheel-steering instead of common combines. The handling is similar to a normal car.

The soil compaction of six wheels is comparable to the chain drives, with the big advantage of better damping the impact of road field bumpers while driving.

Summarizing, the VENUM brings the agriculture one step further to feed the world in the future and to lower the food shortages in third world countries, using a more efficient way of harvest following the strict limitations of transport and traffic. The concept is a revolutionary step in rethinking the established way of harvesting to sensitize the farmers for further innovative concepts.

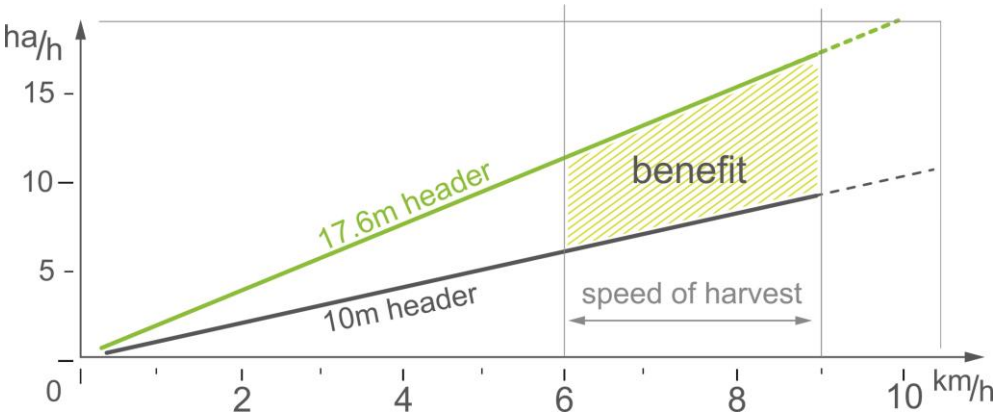

Fig. 6: benefit when using the VENUM header compared to a common 12m header

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