ROSTSELMASH AXIAL FLOW SYSTEM

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Abstract

A modern combine harvester, or simply combine, is a versatile machine designed to efficiently harvest a variety of grain crops from the field to deliver clean grains, usually collected in the machine tank and discharged periodically for transportation and further processing or storage. The following main crops are harvested using combine harvesters: wheat, rice, barley, oats, rye, triticale (hybrid of wheat and rye), soybeans, flax (linseed), sunflower, and corn (maize). Actually, modern combines can harvest more than 80 types of grain crops, from canola seeds to beans, and from clover to corn. To harvest grain crops, a combine harvester is self-propelled and controlled (by a human operator or an automated pilot) on certain paths in the field; combine harvesters are also driven on public roads or transported with a special trailer to different fields when travel distances are long.

Key words: axial flow, cereal harvest

While clean grains are collected in the combine tank, material other than grain (MOG) that enters the combine is left behind the machine, on the field, in a continuous windrow (later to be baled), or further chopped and spread continuously on the entire width of the harvesting area. The MOG is composed of fragmented, dried stems and leaves of the crop plants.

Although the MOG has limited nutrients, it enriches the soil and changes the soil texture through chemical decomposition, or it may be used for livestock feeding and bedding.

The combine harvester combines all technological operations of grain crop harvesting: cutting and gathering of the plants, grain threshing and separating, and grain cleaning and collecting in the combine tank. Using such technology requires certain growing conditions for the grain crops, but it ensures a rapid collection of clean grains, minimizes grain losses, and clears the field of plants at a relatively reduced cost.

To harvest a large variety of crops, combine harvesters need special equipment or attachments, such as front headers, closed threshing cylinders, cleaning sieves, huskers, stalk choppers, and corresponding material conveyors. Additional equipment/features may be necessary when the machine operates on hillside fields, or for rice harvesting that requires high underframe clearance and traction aids, half-tracks, or even full crawler ground drive (Moskovsky M.N.,2018).

Combines that belong to one or more of a series developed by a manufacturer are equipped with interchangeable front headers for gathering and cutting the plants of particular crops. We distinguish the following headers: grain header, draper header, stripper header, corn header, chopping corn header, sunflower header, and pick-up header (Huzum N., 2013).

In the following, we briefly define and describe the above-mentioned processes. The processes of cutting and gathering the plants are performed by removable heads (called headers) that are designed for particular crops, harvesting technologies (e.g., corn grains vs. corn ears), or both. The header is mounted in front of the combine, usually in symmetry with the combine width. The main types of headers are standard header (platform header), draper header (for wheat, rice, barley, oats, rye, triticale, and soybeans), corn header, stripper header (for rice), sunflower header, and pick-up header (for beans).

The threshing and separating processes are the detachment of the grains from the flowery cover (panicle, ear, etc.) and the separation of grain from the MOG. These processes are performed by a threshing system that can consist of one module or a sequence of threshing modules. Since not all grains are separated by the threshing system, a conventional combine is equipped with straw walkers to shake the straw and recover the rest of the threshed grains (Leontescu M., 2016).

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In the threshing unit, the MOG becomes a mixture of long stalks, chaff, and small fragments of spikes, stalks, leaves, and husks. The combine cleaning shoe separates the grain from the MOG that is released with the soil at the back of the machine. The clean grains are collected into the combine tank and discharged when necessary.

Because the crop material follows a certain path into the combine, conventional combine harvesters work on fields with a maximum hillside slope of 6% (side-to-side or transverse direction) and 8% for the longitudinal direction (front to back). Hillsides can have slopes as steep as 45%. Working on high slopes involves leveling the machine to prevent grain and chaff from sliding to the lower side of the separating and cleaning units, while the header remains at all times parallel to the soil to cut and collect the crop properly. Leveling the body of the combine allows the straw walkers to operate more efficiently, maintaining the same machine feedrate as when working on flat fields. Leveling the separating units repositions the machine's center of gravity relative to the base area defined by the wheels' position; this improves the machine's stability against tipping on the hill (Ibanescu A., 2015). The best hillside combines have leveling on both the transversal and longitudinal planes with the following inclinations: downhill slopes of up to 12%, uphill slopes of up to 30%, and transversal slopes of up to 42%. This manner of combine harvesting is on the decline; however, big modern combine harvesters, which have axial rotary grain threshing and cleaning units with improved design allow the machine to work on transversal slopes of up to 20%; besides, these combines are much more stable on hillsides (Zhalnin E.V., 2013).

MATERIAL AND METHOD

In order to underline the advantages of the axial flow threshing system, many aspects are taken into account.

Harvesting of grain crops with combine harvesters constitutes a very important task among agricultural activities. Therefore, combine harvesters must satisfy certain technological requirements regarding the crop type, field conditions, weather, and postharvesting technologies, as well as quality performance indices of combine processing of grain crops. The importance of combine harvesting derives from many considerations:

- It is the main harvesting technology of cereals in the world.

- It is seasonal, though it has to be done at the right moment, over a short period of time (e.g., 4–6 days for wheat harvesting), and with minimal grain losses.

Optimally, harvesting of a crop starts when the quantity of useful organic substances (proteins, lipids, amino acids, etc.) contained by grains reaches a maximum.

When the weather is uncooperative, the plants fall on the ground; the machine is able to lift the plants and cut and properly process them inside the machine.

Not getting the grains inside the combine may determine a major portion of grain losses.

For a better quality and quantity of grains, sometimes it is better to modify the harvesting and storage technology, for example, first cutting the plants and placing them in windrows or swaths, followed later by threshing, separating, drying, and so forth.

The combine has to have modular construction that allows the connection of different equipment or subassemblies, such as different headers, concaves, and so forth, to be flexibly equipped and operated for a variety of grain crops. Consequently, the combine and appropriate equipment are adaptable and flexible, that is, versatile.

The combine process parameters are adjustable in relatively large ranges to accommodate technological requirements when processing a variety of grains and MOG that vary in terms of shape, size, moisture, mechanical resistance, aerodynamic properties, and so forth.

The speed of the machine varies according to the crop conditions, while the process parameters are maintained at optimum values. That implies at least two split, independent channels of power transmission from the same engine.

Operating the machine properly results in an efficient harvesting operation. This could be substantially improved by monitoring and controlling the machine processes.

Combine operator comfort (less dust, noise, and vibrations, coupled with proper temperature and humidity) in an optimally controlled cab is of great importance for machine design, manufacturing, and operation.

Increasing combine feedrate is driven by two basic requirements: increasing the production of grain crops and the necessity of grain harvesting within optimal harvesting time periods.

Self-propelled combine harvesters have already reached the limiting width of roads, so cost-effective continuous improvement of combine harvester performance will certainly be obtained through modeling, simulation, and optimization of both processes and component design, coupled with implementing a high degree of process automation, control, and improvement of grain transportation and storage logistics.

The above conditions require highly trained and skilled operators, possible implementation of autonomous vehicle guidance, and very well-planned harvesting operations involving precision farming.

The combine operating rate can additionally be improved by working in a field until the crop is fully harvested (avoiding switching between different fields), providing enough trailers for unloading harvested grain on the go and for transportation, scheduling operators in shifts with proper breaks, and performing good preventive maintenance. A proper capacity of grain storage, drying, or postharvest processing is very desirable.

The disadvantages of rotary combines are an increased power requirement and a higher degree of MOG fragmentation and separation through concaves and grates.

Because rotary combines do not preserve the quality of the straw, it is more difficult to bale or remove it from the field, though it is easier to incorporate the crop residue that results from rotary combines into the soil furrows during plowing.

Each major combine manufacturer adopted quite different rotary combine constructions.

The Gleaner combines follow the design of Allis Chalmers manufacturer; the rotary threshing/ separating unit is mounted crossways so that the material is fed tangentially into the left end of the rotor (*figure 1*). To intensify the after-threshing chaff separation process, a pair of rollers accelerates the material movement to the cleaning shoe across from the airstream blown by a fan.

New technical solutions for a threshing–separating system combine a tangential threshing system with an axial threshing–separating system, forming a hybrid threshing–separating system.

Figure 2 shows the construction of the axial rotor. The first cylinder is an accelerator of material movement that is followed by the tangential threshing cylinder and main concave; the impeller behind them divides the material into two parts for feeding two axial separating rotors that separate the remaining grains in the fragmented straw. No additional adjustment of the concave profile is required depending on the harvesting conditions of the crop.

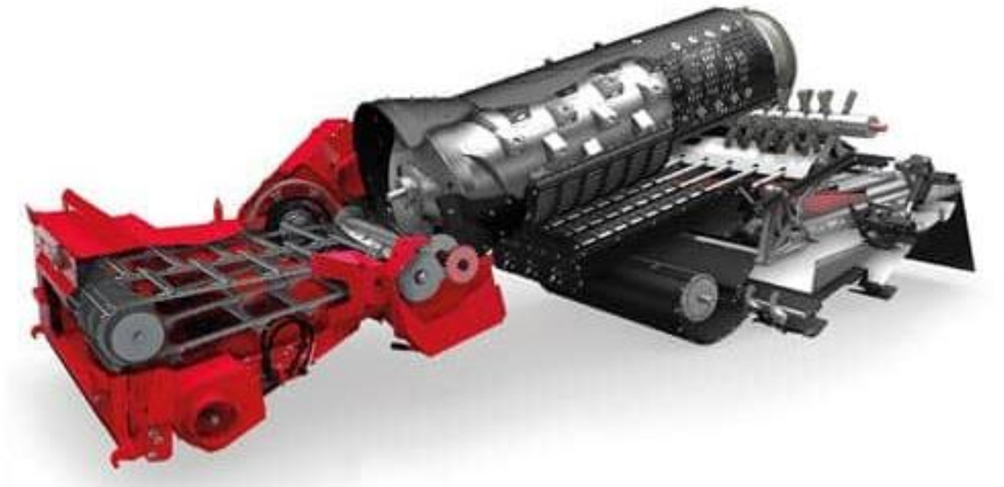

Figure 1 **Rostselmash axial rotor threshing system**

Figure 2 **General construction view of the axial rotor**

A similar threshing–separating system is used in other manufacturer's combines.

The material is fed into a large tangential threshing cylinder, and then an intermediate beater prevents material wrapping and slugging.

The following overshot beater further processes the material and pushes it to two counterrotating tine separators.

The hybrid threshing–separating systems allow the setting of a lower peripheral speed of the cylinders and beaters, whose action will be later complemented by the rotors' effect.

Such technical solutions favor a higher material throughput, lower mechanical damage of the grains, and minimal threshing and separation losses.

RESULTS AND DISCUSSIONS

The Axial-Flow advantages are: gentle but thorough threshing protects crop quality bonuses; one rotor threshes and separates – fewer moving parts to worry about; top quality grain – unbruised and undamaged – strengthens your bargaining power when selling; on-the-go rotor speed and concave opening adjustment: increased daily performance and revenue.

Cracked grain is the bane of good sample quality, not only because of the damaged kernels themselves, but also because they can be easily blown out of the back of the combine.

With the benefits of Axial-Flow threshing combines consistently deliver top quality grain samples. Rasp bars are arranged in four spirals around the rotor, for improved threshing and better straw quality in tough conditions.

The rotor compartment is accessible from either side of the combine and the interchangeable modules are easy to remove and change for different crops - a true Axial-Flow benefit.

The Threshing and Separation areas can be customized following different yields and conditions.

CONCLUSIONS

The first Axial-Flow combines stood out from the traditional straw walker design, in that threshing and separation were now performed by a rotor. At that time, the new rotary design was the first of its kind to be mass-produced and represented a giant step forward for farmers, with increased capacity translating to a significant boost in productivity. But while the principle has remained unchanged, with each range development Rostselmash engineers have utilised the very latest technology available to meet future farming needs.

Axial-Flow combines benefit from that same forward thinking, and incorporate some of the very latest concepts not only in threshing and separation, but also in areas from cleaning to unloading, from engine to transmission technology. The end result is a combine range built not just to meet today’s farming challenges – but to take on tomorrow’s too.

The grain-on-grain threshing action of Axial-Flow not only limits grain losses in the field through more effective separation, but also ensures that what goes into the grain tank is clean and high quality crop, adding revenue to your bottom line. There is no high impact conventional drum like that used in conventional or hybrid combines, and the transition from threshing to separation is completely seamless.

Centrifugal forces ensure perfect separation even in the most difficult conditions.

Centrifugal forces grain separation for gentle threshing and separation.

The impeller design and multiple rasp bars provide total crop threshing and mat control even in tough conditions.

Continual crop contact and pressure ensures positive crop control and maximum throughput.

It’s not just the rotor that makes the Axial-Flow different: the cleaning system also stands out for its efficiency and convenience. It uses the proven chevron shaped CROSS-FLOW FAN that generates a high volume of air. The result is higher cleaning capacity, with sieves adjustable from the cab. Each sieve is able to operate at an ideal stroke length, and the opposing motions of the sieves cancel each other out, resulting in a smoothly operating cleaning shoe. Short straw is virtually eliminated, resulting in a cleaner grain tank sample. A fully-adjustable pre-sieve means Axial-Flow 150 Series combines can adapt to all crops and all conditions.

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