STUDIES AND RESEARCHES REGARDING THE PRESENT STAGE OF HARVESTERS WITH AN AXIAL THRESHER ON A WORLD LEVEL

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Summary

Along the time the improvement of working technologies in agriculture was searched in order to increase the working capacity and the output.

In the assembly of the agricultural works the cereal mechanized harvesting represents an especially complex operating process, aiming the gathering of the main product - the seeds. The first models of self-propelled cereal harvesting machines built were those having a tangent thresher, but after 1970, as a result of the continuous demand of the farmers for increasing the output, there were developed the harvesters with an axial thresher permitting both the raising of the working capacity and the rate of the seeds separated during the threshing process.

The cereal harvesting by using the integral technology has known important progress lately due the ever higher requirements imposed to this process (minimum losses, reduced power consumption, optimum harvesting time).

The optimum period of straw cereal harvesting is a very short one (8 to 10 days), its exceeding leading to important grain losses. Sometimes, during the harvesting period, the climate conditions are not favourable, the plants are fallen, embedded in weeds or non-uniformly grown and the machines making the harvesting should be so designed that they should perform the tehnological process to a high quality level.

In order to do that, the harvesting machines should comply with a series of requirements:

- to ensure the plant cutting at 70÷260 mm height;
- the width of the cut and threshed straw and ear swath should not exceed 1,200 mm;
- the plant cutting should be performed without shaking the ears off;
- the losses of free grains onto the soil, after having been shaken during cutting, should not be more than 0.2g/sq.m;
- there should be ensured the plant harvesting with reduced ear losses;
- the grain quantity in free ears on the soil should not exceed 1g/sq.m;
- the losses of the grains which have remained unthreshed into the ears should not be more than 1.5% out of the production;
- the losses of grain which remained in the straw should not exceed 0.5%;
- the purity of the collected grains should be over 98%;
- the total grain losses during the harvesting process (at the optimum humidity for grains 14÷18% and for straw 12÷20%) should not exceed 2.5% out of the total production;
- the percentage of broken grains should be less than 2%;
- the straw losses should not exceed 5%.

The machines should to be possible to adjusted depending on the characteristics of the harvested plants (density, stem height, humidity, etc.), so that the harvesting operation should be satisfactorily performed. In order to avoid destroying the soil structure, the specific pressure of wheels on the soil should not exceed 0.2 MPa (2 daN/sq.cm), should have easy manoeuvrability and a small turning radius, should ensure optimum working conditions for the the next machines in the technology or for the machines from the following crops, should have high reliability, should be cheap and universal.

One of the solutions adopted by various companies for raising the harvester output and increasing the percentage of the seeds separated by the thresher was that one in figure 1, where the shakers were removed and several rotors were placed over there, the separation operation being performed by these rotors.

Figure 1 - Grain harvesting thresher CLAAS COMANDOR 228 CS [6]

The harvester threshing apparatus is a classical one, made up of a beater and a counterbeater, but the separating system is made up of 8 rotors whose rotative speed can be adjusted into two steps. The adjustment of the distance between the rotors and the grate can be performed continuously and simultaneously, depending on the harvesting conditions. The system of cleaning into cascades takes over the seeds separated by rotors and separates them off chaff and impurities and then they are transported into the harvester hopper.

In figure 2 it is presented a solution proposing a tangent thresher (type APS), placed forward, the threshed material being taken over by a postbeater APS and directed to two axial separating rotors. In this case the harvester output is very much increased, being possible also for the working speed and the header width to grow.

The APS - type threshing apparatus considerably increases the threshing flow by its constructive conception, having a material accelerator mounted on the front part of the beater accelerating the material harvested before its entrance into the beater, so that this could enter the counterbeater with higher speed. The pre-separation grate is erected under the accelerator double threshing surface: a pre-separating grate and the counterbeater Multicrop offers higher output to the machine.

The APS system scatters the harvested material layer, so that the easier separation of the grains could be performed. The CEBIS board digital computer interferes into the automatic adjustment of the threshing duty, depending on the preestablished adjustments for each crop separately. The beater rotative speed and the distance between the beater and counterbeater are automatically modified, in pre-established limits, so that the threshing process should be performed in optimum conditions.

The ROTO-PLUS separating system is made up of two helical rotors longitudinally mounted instead of the straw walkers shaker rotating inside the separating grates. Each rotor performs the separation of a half from the harvested flow, which was divided into two parts by the post-beater of the APS threshing apparatus. Due to their helical profile, the separating rotors make the material separate helically into the separating area. The centrifugal forces occuring, much more than the gravity forces, make the seeds penetrate the straw layer and the separating grates along all their circumference, the separation and retrieval of the grains out of straw being complete [2].

Figure 2 - Grain harvesting thresher CLAAS LEXION 480 [6]

The solution in figure 3 refers to a harvester where the shakers were removed and it is used a separator with double separating flow.

These harvesters represent a combination between the tangential flow and those with axial flow and the "twin flow" generation. For this type of harvester the shakers have been removed and a double flow separator has been introduced (to the left and to the right), which, together with the rotative separator performing an intense separating process before sending it to the separating "twin flow" rotor. The great advantage of this construction is represented by the counterbeater grate which is continuous from the beater up to the "twin flow" rotor, in this way the threshing and separating process being performed also by the postbeater and the rotary separator.

Figure 3 - Grain harvesting thresher NEW HOLLAND TF 78 Elektra Plus [6]

Massey Ferguson 8560 (figure 4) has achieved a self-propelled harvester with a longitudinally mounted rotor, threshing and separating counter - rotor and a cleaning shoe. The rotor with a closed tube has a feeding auger, three initial elements for threshing and three pairs of bars with rasp, three longitudinal separating flutes and three rows of rotor knives. The threshing and separating counter-rotor is a typical construction of bars and wire, the cleaning fan being a classical fan with 5 blades. The chaff sieve with an adjustable basis and the cleaning sieve displace by a movement which is opposite to the displacement sense of the material.

The harvested material is sent to the rotor entrance by a transversally mounted drum which also throws the stones and other hard objects into a device for gathering the stones, which is settled under it.

The auger in the rotor feeding area moves the harvest to the threshing elements.

The threshing initially starts when contacting the threshing elements and continues along the whole counter - rotor. The material displaces on a spiral - shaped trajectory to the rear of the rotor through its case, being helped by the ribs of the rifled bar disposed on a certain angle and by the stationary blades on the upper side of the rotor case. The grain separation out from straw is performed along the whole counter-rotor, the grains passing through the concave being transported by a grain chute to the hopper. The grains are cleaned by combining the pneumatic and sifting action, those which remained uncleaned coming back to the rotor entrance.

The distance between the rotor and the concave, as well as the sieve openings for chaff and those of the cleaning sieve are easily modified on this type of harvester [1].

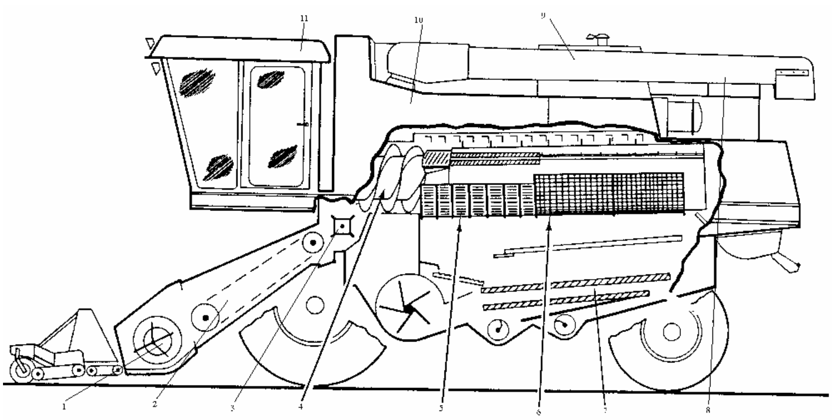

Figure 4 - Grain harvesting thresher Massey Ferguson 8560 [1]

The solution proposed by SIBIRIAK KOLOS with the model SK - 10 has a longitudinally settled thresher where the material enters the feeding area 1 and passes through the threshing area 2, the separation area 4 and the cleaning area 5, the straw being removed through the exhausting chimney 7 and the seeds being transported into the hopper 8 near cabin 9. The harvester is also endowed with a system for copying the ground transversally and longitudinally, the cutting apparatus being with a double-bladed (one fixed and a mobile one) type on which the cutting plates are fixed. The harvester mass is approximatively 15,400 kgs and the hopper capacity is 8,500 litres.

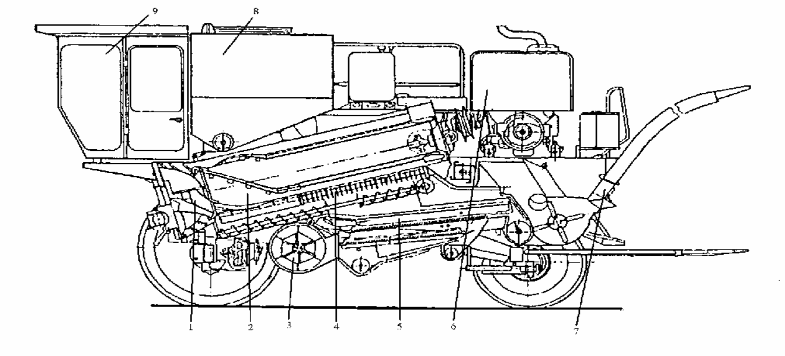

Figure 5 - Grain harvesting thresher SK - 10 [6]

The American company WHITE has proposed a model of a harvester with a high-capacity axial thresher, WHITE 9700 (figure 6), the working width of the header 1 being 7.3 m, the material being transported through the agency of a central conveyor 2 to the longitudinally settled thresher 3, 5, 6. The chaff and the chopped straw are thrown away by a fan 4, the seeds being transported into a hopper 9 which can be emptied in the moment of filling through an exhausting basket 7. In cabin 10 there is the control desk of the motor 8, as well as of the other working elements, the harvester being also provided with a ground transversal copying device. Both the thresher having 4, 267 mm length and 800 mm diameter, and the impurities separator are manufactured under the form of a rotor with a sieve concave. The hopper capacity is 6,900 litres.

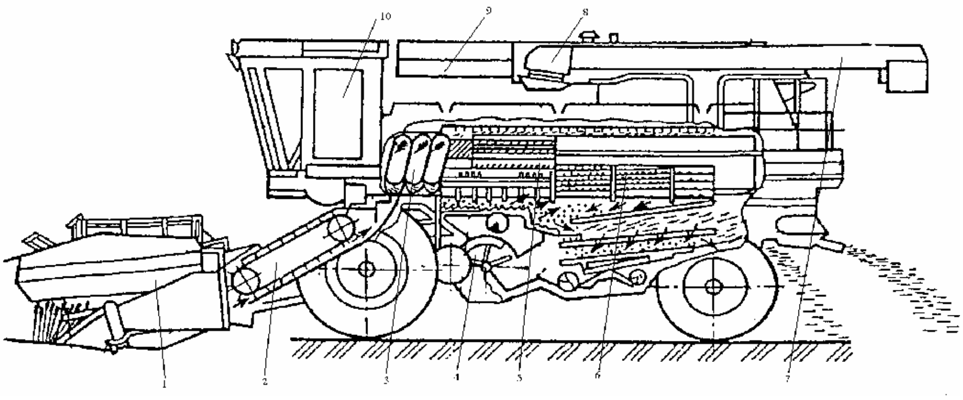

Figure 6 - Grain harvesting thresher WHITE 9700 [6]

The company "ALLIS CHALMERS" has also manufactured a high-capacity harvester - Gleaner N7 (figure 7), equipped with an axial thresher with cage - type concave, but having the flow sheet different from the other axial flow harvesters because for the farmer the axial thresher was settled transversally to the harvester displacing direction. The plants cut by the cutting device are supported by the inclining device paddles and directed to the header auger from 1, where they are sent to the central part, to the central elevator 2. From here, the material is taken over by another conveyor 3 feeding the thresher through a window on the right side of the concave and it is introduced into the threshing area of the thresher 5, an area provided with straight rails with rifled surface, the rifles being inclined in one single direction for helping to the material axial displacement.

The cage - type concave has the separating surface under the form of some square orifices. In the lower part of the concave there are fixed some helical rails.

The active separating area of concaves is provided with a cleaning system having an alternating motion along the axis. The feeding is performed on a perpendicular direction to the axis of the thresher. In the area of plants entering the thresher there is a trap which automatically opens if alongside with the plants there are entrained some stones or other hard objects, permitting their removing.

The threshed grains pass through the orifices of the separator, the straw and the chaff being thrown by a fan 4 outside and upset by the blades of an exhausting rotor which directs them through a tube to the rotating thrower which spreads them onto the soil.

The seeds passing through the separator, due to the centrifugal force given by the rotor, are taken over by the collecting augers and transported to the accelerating rolls and from here into the hopper.

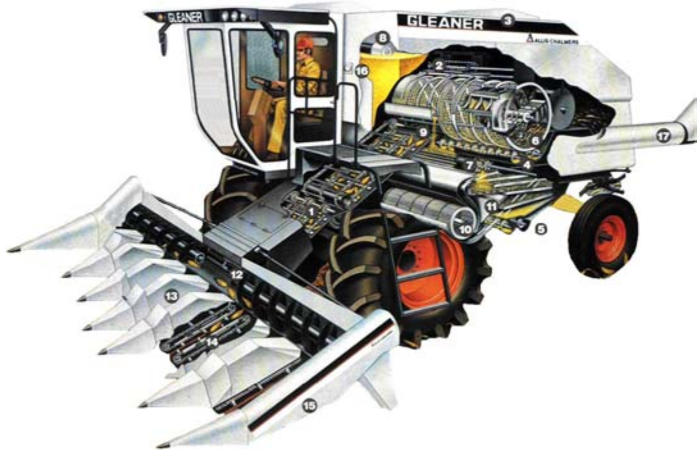

Figure 7 - Grain harvesting thresher ALLIS CHALMERS Gleaner N7 [6]

LAVERDA MX 300 is a model of a high-capacity Italian harvester, its threshing and separating system being a novelty in the domain. The plants are cut by the cutting device 1, supported by the inclining device paddles 2 and directed to the header auger 3, from where it sends them to the central part of the central conveyor 4 and they are introduced into the thresher 5, transversally settled.

The system is made up of a rotor - stator (fixed coil) assembly where there are distinguished two various areas: the threshing area and the area for separating the seeds and removing the straw.

The front settling of the thresher and the shakers removing have permitted the use of the space inside the harvester for enlarging the cleaning elements 9, 10 and the hopper.

Figure 8 - Grain harvesting thresher LAVERDA MX 300 [6]

The studies and the researches performed in the latest years by the specialists from countries having an old tradition in the field of agricultural machines (USA, Italy, Germany, the former URSS, etc.) have been materialized in manufacturing some axial flow threshers which perform the separation of the seeds out of the ears in a percentage over 99%, increasing the working capacity when being reported to the same gauge, reducing the losses, etc.

The first axial flow threshers have been manufactured since 1903 by HIXXON&HIXON and they were performing only the cereal separation, while in 1910 the HOLLINGWORTH Company produced an axial machine which made only cereal threshing. In 1930 ALLIS CHALMERS Company manufactured the first harvester with an axial flow thresher, which was doing both the threshing and the separating of seeds from the ear, having the rotor laterally oriented. The Company CATERPILLAR TRACTOR Co. has also produced, starting since 1934, a harvester with an axial flow thresher which was performing both the seeds threshing and their separating, the thresher being laterally obliquely oriented [3].

The first modern harvesters with an axial flow thresher were manufactured in 1975÷1977. An axial thresher (figure 9) is mainly made up of:

- a mobile rotor with rotative motion;
- counter - rotor + case, totally winding the rotor.

The rotor of the axial thresher used in the construction of cereal harvesting machine has, as a rule, a cylindrical shape, its form and construction depending from one building company to another.

The counter - rotor winds the rotor according to an angle which is usually smaller than that of the tangent threshers. On the other hand, in order to increase the area of seeds separating, the case has been completely or partially provided with orifices.

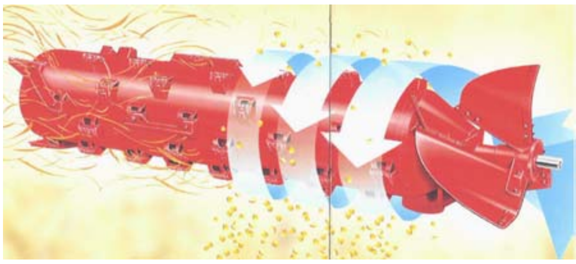

Figure 9 - Rotor of an axial thresher Case IH [6]

In the construction of the axial thresher four areas can be distinguished (figure 10):

- material feeding area - the rotor is provided with feeding blades mounted on a conical surface, the case having a tapered shape, without orifices;
- threshing area, marked out by the construction of the cylindrical case and which at its lower side is under the form of a bar grate;
- seed separating area - the case is fully or partially covered with orifices in order to do a better separation of the seeds;
- exhaust area for straw parts.

In the space between the rotor and the counter - rotor + case, also called threshing space, the processed material is displaced according to a helical trajectory.

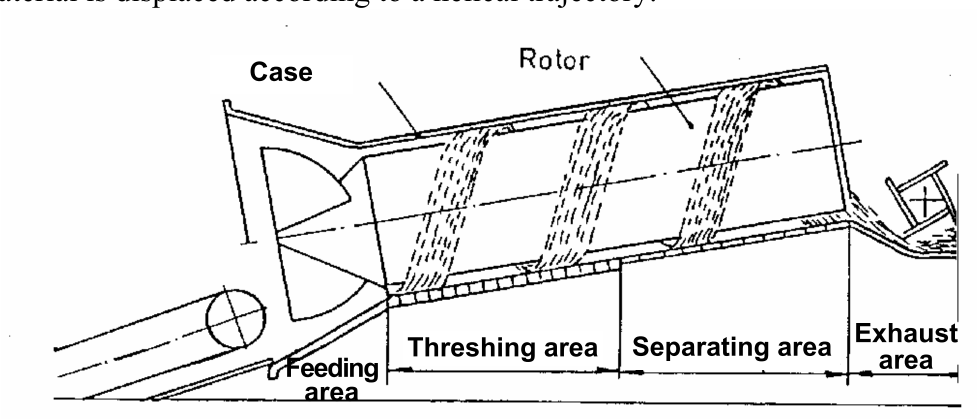

Figure 10 - The material flow in an axial thresher [4]

As compared to the conventional threshers, having a tangent thresher, the axial threshershave the following advantages:

- seeds more reduced damage;

- versatility: the axial threshers can be used with very good results both for maize and for straw cereal harvesting, without making any constructive modification;
- less seed losses;
- the graph of seed losses when increasing the straw flow presents a plateau, due to the reduced sensibility to the variation of the volume flow;
- high efficiency in the case of humid seeds;
- raising of the seeds threshing and separating rate (over 99%);

Although the power consumption within the axial thresher is higher by 16 - 20%, the working capacity is higher, too, by 60÷90% than that of the conventional threshers at the same overall dimensions.

The main disadvantages of these threshers as compared to the tangent ones are:

- higher power consumption;
- increasing of the rate of crumbling the straw parts, during the threshing process which leads to rendering the cleaning operation more difficult.

Taking into consideration that the resistance when detaching the seeds from the flower cover varies between very large limits when harvesting the same crop, the seeds detach themselves out from their support at different efforts, which makes difficult to establish an optimum working mode of operation of the thresher. In order to ensure a complete threshing of the material it must be used an intense mode of operation which determines the increasing of the rate of seed damaging and the decreasing of the working intensity results in increasing the unthreshed seeds quantity. The solution for solving this problem is the manufacturing of some threshers with a variable radius by which there can be obtained a variation of the rotor peripheral speed along all its length.

The American Company CASE IH (figure 13) is the indisputable leader of the manufacturers of harvesters with axial flow thresher. This model is a high- capacity harvester, the engine power being 245 HP. The cutting width of the header it is equipped with is 5.5 m, the threshing and separating rotor with 610 mm diameter having 2800 mm length. The total bounding surface is 4.2 cu.m and the hopper capacity is 6,300 l. By using this type of a thresher the threshing and separating surface is increased, resulting in a good separation for the seeds - over 99% [5].

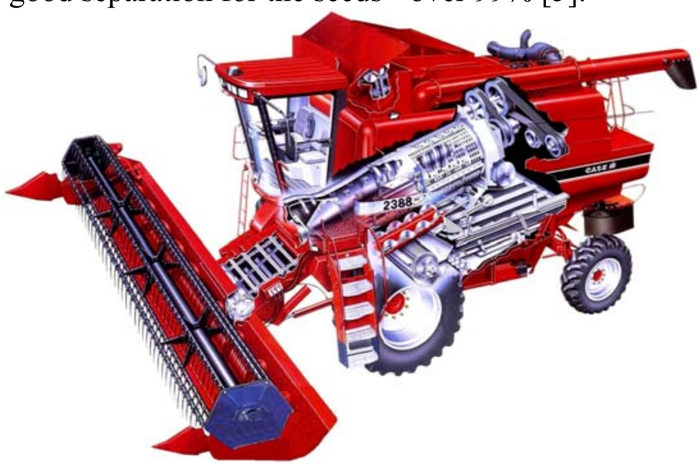

Figure 11 - CASE - IH Harvester, front view [6]

In this regard the tendency of developing and implementing the axial flow threshers is more stressed in the measure in which this type of threshers suit very well to high and very high working flows because the length of the thresher can increase very much, the threshing surface being three times bigger than in the case of harvesters with a tangent thresher.

Further more, in the case of harvesters with an axial thresher, the shakers occupying a large surface and introducing vibrations are removed.

The percentage of seeds separated within these harvesters is over 99.5%, the damaging rate being much lower due to the fact that the detaching of the seeds into the ear is mainly performed due to friction and centrifugal forces and not due to hurting, as with the classical harvesters. That is why these types of threshers can also be used with good results for harvesting cereals with higher humidity rates.

The main indexes influencing the threshing process are:

- seeds humidity and straw humidity;
- rate of weed encroachment of the field;
- field density;
- seeds detaching resistance;
- speed, shape, length and type of the rotor;
- shape, type of counter - rotor;
- feeding angle;
- number of rotors in the process of mechanized harvesting.

The final aim is to gather the harvest as soon as possible, without any seed losses or damages and without impurities.

This can be achieved only when it is very well-known the influence of the above-mentioned indicators on the threshing process.

In order to obtain the required quality indexes after the harvesting process, it should be taken into account the effect of these indicators and the thresher modelling and optimizing will be sought in order to perform a rapid harvesting, without losses, damages and impurities into the seed mass.

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