DEVELOPMENT TRENDS IN CEREAL HARVESTING

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Summary
Cereals represent the most important food for people. Almost a half of the world population live by feeding with rice, and a third of it-with wheat. Preparing a large quantity of cereals according to the permanent population growth has become an important requirement. The question "How many people the ground can feed" depends also on the surfaces which can be used for the cereal crop, on the output and on the harvesting and storing losses [1]. In the industrial countries, it has been imposed the utilisation of the harvesting machines for the cereal harvesting. After many failures, painful experiences, but also resounding success, it has been arrived to the cereal harvesting machines with minimum losses, high quality and high capacity of work through a single passage.

HISTORICAL DEVELOPMENT

Cereals occupy an important place in the people's and animals' food due to the nourishing substances which they contain, their harvesting representing an important problem for the world agriculture. About half of the Planet inhabitants feed on rice and more than a third-on wheat.

Thus one of the urgent requirements has become the finding of new modalities for increasing the cereal amount due to the continuous increase of the population. The number of people the Earth can feed also depends on the areas used for the cereal crop, on the increase of cereal production, both by variety amelioration, by improving the works of preparing the crop germinating bed and maintaining, but especially also by improving the harvesting technologies in order to reduce losses and to limit the necessary time for harvesting and storing, due to the specific environment conditions [5].

Cereal harvesting was and still it is in some regions of the Globe a very hard physical work. It lasts for long periods of time and it highly depends on the weather conditions, at the same time needing a great number of workers involved in this operation. In the case of manual harvesting, the plants are cut by sickle, gathered and tied into sheaves, which are then arranged into hayricks and left in the field for drying, after which they are transported to the threshing machine.

An important facilitation in these hard works was obtained by introducing the reapers pulled or pushed by animals. In 1826 Patrick Bell manufactured the first reaping machine in the world (fig. 1), a horse - pushed reaper which replaced the manual work of several people, the reaping operation costs, in this case, by using Bell's machine, being reduced to one third.

Figure 1 - The first reaping machine in the world (Patrick Bell) [2]

In 1836 Briggs and G.C. Carpenter manufactured a horse-drawn machine, performing, besides the reaping operation, the threshing one, too (figure 1).

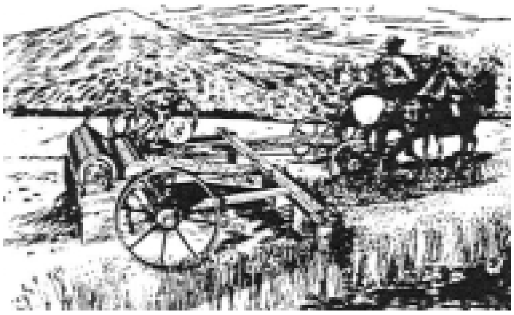

Figure 2 - The first reaping and threshing machine in the world [2]

In 1885 in Stockton (USA) Holt Bros & Brothers manufactured the first cereal threshing harvester (three-wheeled, one tractor-trailed) which used "the gearings" for transmitting the power from the driving wheels to the flywheel of the threshing and separating rotor, as well as V-type belts and chains (fig. 3). The results obtained with this harvester were very good, so that there appeared numerous requirements for producing this harvester in a greater number, both from the part of the farmers in USA, and from those in Europe and Australia.

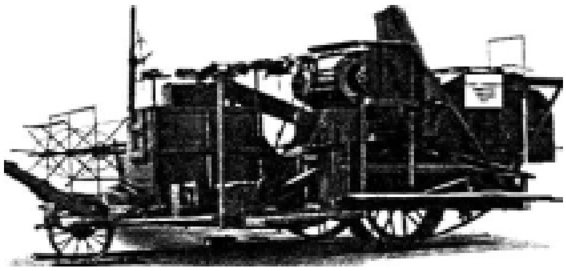

Fig. 3 - The first trailed cereal threshing harvester [2]

In the next year, 1886, in Sacramento Valley, a farmer, G. Stockton Berry, manufactured the first self-propelled harvester in the world, which was displaced by using a steam motor (fig. 4).

This was the best harvester manufactured up to that date, also establishing some records, as:

- the first self - propelled harvester;
- the first steam harvester (it used the straw resulted from the threshing and harvesting process for producing steam);
- the first tractor which could move in both directions: in front and behind;
- the biggest header of that time: 12.2 m in 1888;
- the first machine which threshed over 40.5 ha daily and which used the artificial lighting to work after getting dark, too.

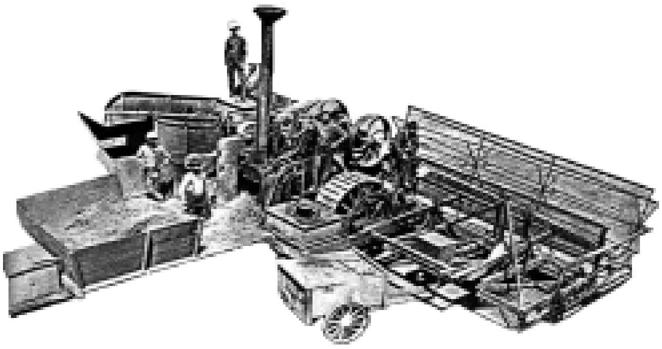

Figure 4 - The first self - propelled harvester in the world [2]

The year 1938 has also represented the moment of appearing the Massey - Harris model no. 20 (fig. 5) which was the first self-propelled harvester manufactured by "Massey-Harris" Company, being endowed with a Chrysler motor of 65 HP and a header 16 ft. (4.88 m) wide. After testing these machines in Argentina and obtaining the required performances, they passed to the series production, only during the year 1938, 925 such units being built.

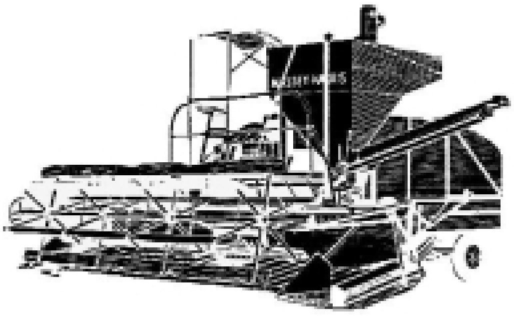

Figure 5 - Self - propelled harvester Massey - Harris no. 20 [2]

In 1940 the first self-propelled harvester IHC model 123 was manufactured. In the same year the production of the second model, a self-propelled harvester, IHC no. 42 (fig. 6) started. This type was also equipped with a grate in order to intensify the threshing process, for the first time the metal teeth beater being replaced.

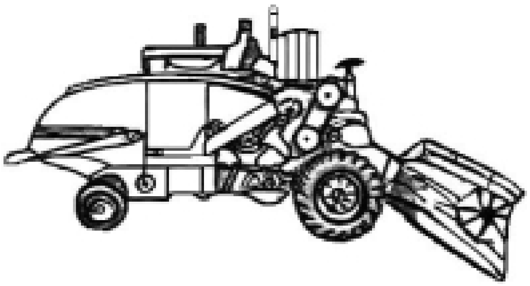

Figure 6 - Self - propelled harvester IHC no. 42 [2]

As a result of the pressures from the competitors, in 1945 "John Deere" Company started the manufacturing of the first self-propelled harvester, model 55 (fig. 7). After numerous researches performed between 1945 and 1946, in 1947 they started the manufacturing of this series model, continuously for 22 years, period when there have been built not less than 84,000 units. Model 55 was provided with a threshing rotor 1,400 mm wide and a header 3.66 m or 4.27 m wide.

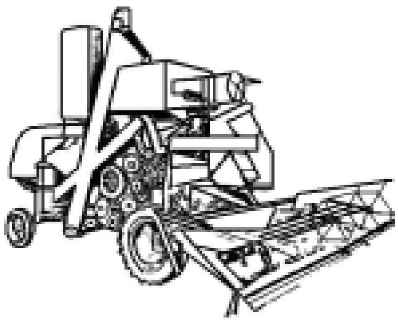

Figure 7 - Self - propelled harvester John Deere 55 [2]

In the same year in Klimarnock (Scotland) it was started the series manufacturing of the first harvester made in Europe: the self-propelled harvester Massey Harris 726 (fig. 8). Four years later in Marquette (France) it started the manufacturing of the model 890, and in 1954 in Eschwege (Germany) - the model 630.

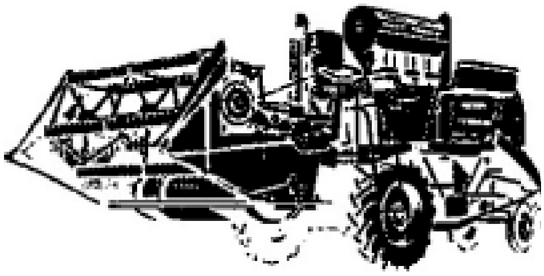

Figure 8 - Massey - Harris 726 (the first self-propelled harvester built in Europe) [2]

In 1953 the Claas Company manufactured the first self-propelled harvester produced by "a European company - Claas Hercules". Two years later, in 1955, it started the production of "Claas SF" model (figure 9), which was also equipped with a hopper platform for storing the straw (by pressing).

Figure 9 - Claas Herkules (the first self-propelled harvester made by a European company) [2]

THE NOWADAYS AND FUTURE DEVELOPMENT

The increasing of the output per unity of surface remains an important subject for the grain harvesting. Further on we must notice that in the last 15 years the price of the grains has been lowered at about half and, that's why it would be more difficult to manage a profitable entreprise. In order to make the entreprise income grow we should produce a higher quantity of grains, through greater yields and greater surfaces on each exploitation. Both these trends must be observed during the last decades. The output has constantly increased, for example for wheat, with about 2,5% / year, reaching the top productions of about 13÷16 t/ha. The enlargement of the private farm surfaces leads to the well-known decrease of the number of entreprises. Although, the available period of time for harvesting can't be extended so that same, a large quantity of harvesting has to be performed in the saine time.

The output increasing per surface unit

We can obtain an effective increasing of the output per surface unit by using different solutions: power, working capacity, separating surface, cleaning area increasing, etc.

The effective output per surface can be performed through an efficient utilization of the machines, by improving the management or introducing new methods as the stripping, procedure by which only the ears are pulled out, remaining the straws. A good management means a good arrangement of the machines, as little wasted secondary times as possible and an efficient management that should remove the frictions during the transport of the harvesting material. For obtaining a big output reliable machines of high capacity can be used, by utilizing efficiently the working conditions, adjusting the machines in the best way and, at last, by using well-trained harvester operators.

- **Arrangement of the Machines**

In a near future the machines arrangement and the transport organization will be considerably facilitated by using the modern communication system and the information about the position of the machines, obtained through GPS. For example, the harvesters working stages, the most important data and the position of the harversters will be comprised in a board computer and transmitted through the radio to a service computer. By this way, each machine could be represented on a screen and introduced in a card cataloque. Further on, through this system it would be easier to solve the problems at the harvesters level or due to the lack of capacity. Nowadays, this system is utilized by same of the users.

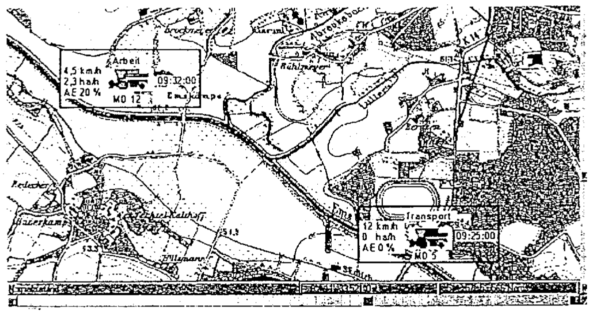

Figure 10 - Reprezentation of the position and working state of the harvester (Claas) [1]

During the harvesting, the effective running time, so the main time, can be prolonged through the diminishing of the idle time or of the standing time. In this way the yield on the field and the output on the surface unity will be increased. We must take into account the fact that the mounting and the dismounting of the cutting device lead to frequent changes of the field and to waste of time. These idle times can be considerably reduced by using reversible or folding blanking tools. We can also obtain some time sparing by performing an automatic adjustment of each separating device in the harverster through the previously stored values.

- **Working capacity**

The growth of the working capacity can be performed by:

- getting larger the working elements;
- improving the working elements;
- new working elements;

Getting larger the working elements and implicitely the whole harvester represents the main problem to be solved, because you shouldn’t exceed the maximum admitted outer dimensions. For about 15 years the 6 shaking devices harvesters have already reached the maximum admitted width (3 m), Deutz-Fahr introducing an shaking equipment with 8 elements.

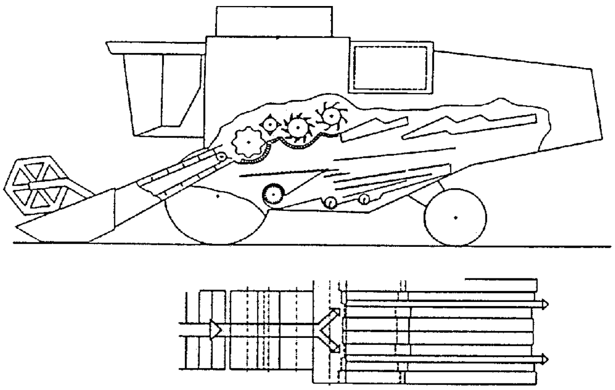

Figure 11 - Harvester with 8 shaking elements [1]

Some other solutions which can lead to the increase of the working capacity of this construction are the harvesters with several threshing and separating rotors. By means of these machines, the seed productions of 40t/h should become possible. As an example, for improving the working elements, it is worth mentioning the the threshing implements with supplementary separation (fig. 12).

The introducing of the MCS system ("multi crop separator") on Laverda New Holland and Massey Ferguson" harvesters has appeared as a necessity because the harvesters working capacity continuously increased and the straw walkers couldn't separate the amount of 15÷25% seeds out of straw and chaff. Thus a further beater, MCS, was introduced, having both the role of a thresher, and especially that one of intensifying the separation.

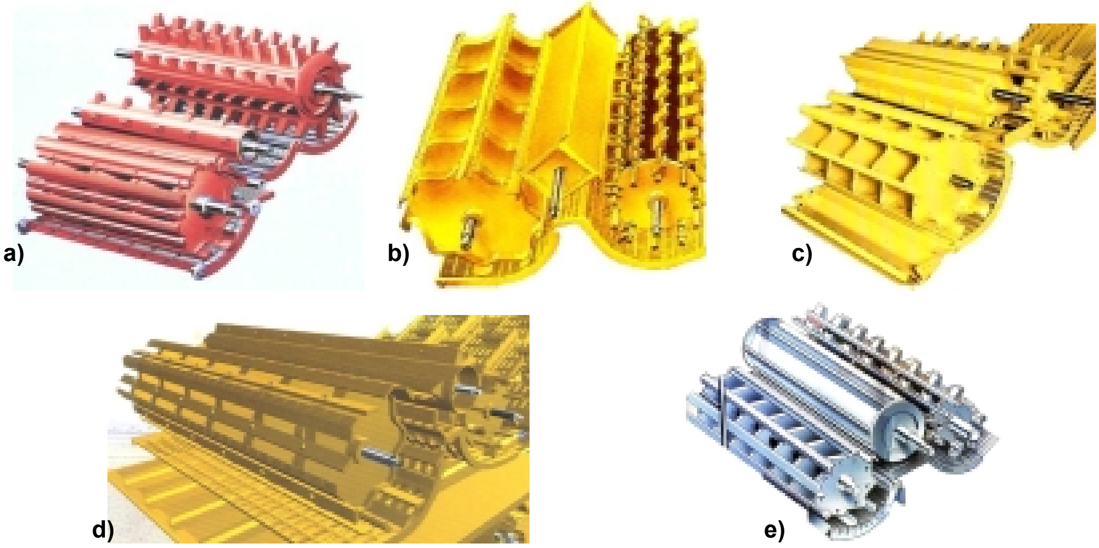

Figure 12 - Tangential threshing apparatus with a rotary separator (MCS) [6]
a) Laverda series L, LX and Integrale (MCS); b) New Holland TC 55, 57; c) New Holland 8080 and TC 59;
d) New Holland series CX; e) Massey Ferguson

The APS system introduced by Claas Company has the same role as the MCS system (from Laverda harvesters), namely to intensify the process of seed separating through the grate of a multicrop concave. The threshing system APS is a classical one, made up of an accelerator mounted on the frontal side which accelerates the harvested material before entering the beater, so that it should enter the concave with higher speed. The pre-separation grate is mounted under the accelerator, here being separated all the seeds falling on the route between the cutting apparatus and the accelerator, as well as those having lower detachment resistance (the seeds in the middle of the ear). For the threshing apparata with APS system the threshing surface is double, the material being at the same time dispersed so that it can be performed an easier seed separation.

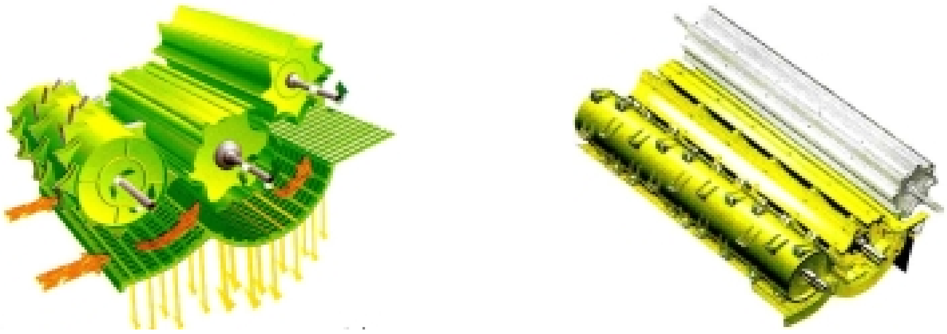

Figure 13 - Threshing apparatus with acceleration pre-beater (APS), Claas Medion/Mega [6]

This type of threshing apparatus resembles the system APS (Claas), but especially MCS (Laverda, New Holland and Massey Ferguson), the only difference being the existence of two rotary separators instead of one. The necessity of using two separators has also occured because of the fact that this type of threshing apparatus equips a very high-capacity harvester working with headers with widths between 7.2 and 9 m, performing working flows over 12 kg/s and having a 408 HP motor.

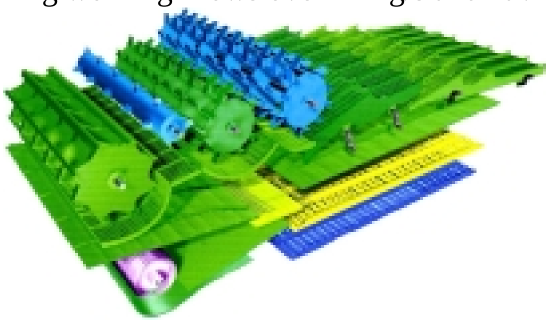

Figure 14 - Threshing apparatus with beater and intensive separators Deutz-Fahr Top Liner 8 XL [6]

The construction of this type of threshing apparatus manufactured by New Holland is very resembling to that of the threshing apparatus equipping the Deutz Fahr 8XL harvester, the solutions being alike also due to the characteristics which are somehow the same: very high capacities, high working flows, high motor powers, etc.

This threshing apparatus is also made up of four rotors, their setting being different from that for "8XL", namely: after the beater there is mounted a rotor having the same diameter as the beater, with five blades and two-thirds from the beater rotative speed, provided with a grate with large surface permitting the seed separation out of the already threshed straw and the loosening of the material layer in order that when this is taken over by the rotary separator, the seeds could be easier separated. This solution, as in the former case, permits the separation of the biggest amount of seedds in the threshing apparatus, although the working flows are very high, so that the straw walkers should separate the rest of the seeds out of straw.

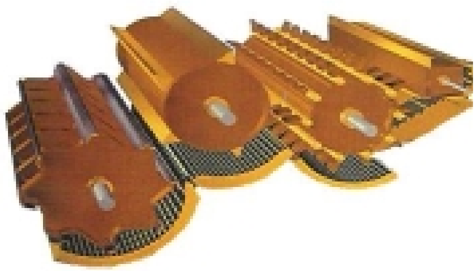

Figure 15 - Threshing apparatus with beater and separating rotors, New Holland TX [6]

Because of the fact that the separating intensity on the straw walkers is low and the output ratio when separating is low, too, many companies have looked for solutions in order to replace these working component parts with some others having a higher efficiency. That is also the explanation of replacing by Claas the classical shaking system with one made up of multiple rotors (fig. 16) and using some rotary separators by New Holland Company, TF series (fig. 17).

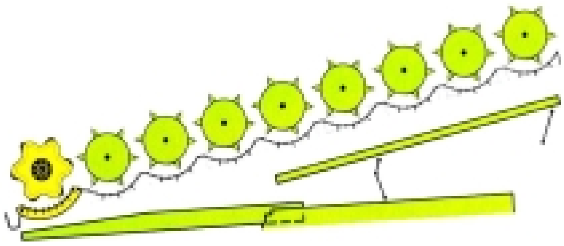

Fig. 16 - Threshing apparatus with multiple rotors Claas Comandor 228 CS [6]

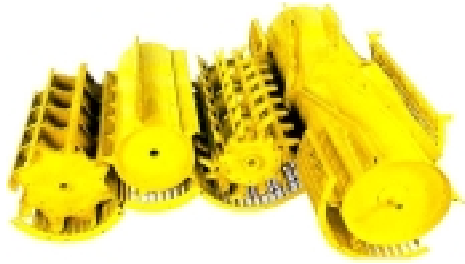

Fig. 17 - Threshing apparatus with multiple separators ("Twin Flow Rotor") TF 42 [6]

The threshing apparatus equipping the harvesters of "Sperry New Holland" company, respectively the models TR 70, 85, 95 and 96 and John Deere CTS is made up of a classical threshing apparatus, crossways disposed (arranged) and two axial, parallel and inclined rotors. Each rotor has the diameter 450 ÷ 500 mm and rotates itself at a rotative speed between 650÷1500 rpm. The advantage of this threshing apparatus consists in the existence of an overall bigger threshing and separating surface, the vibrations being limited by the reciprocal balancing of the rotors. The beater and concave working elements are standard-type. Thus the rotors are provided with two series of striated and fluted rails placed with 180° between them on the rotor. Such a threshing apparatus with two rotors rotating in opposite senses needs a balanced distribution when delivering the material.

In the case of the threshing apparatus of the Claas Lexion 480 harvesters (fig. 18) there are distinguished two parts: one made up of rotors crossways settled on the harvester performing mostly the threshing operation and less the separating one and another one made up of two axial rotors, longitudinally placed, performing especially the intensive separating operation.

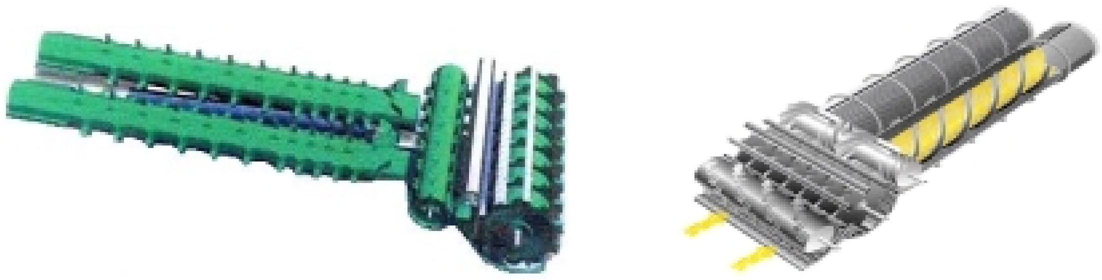

Figure 18 - Threshing apparatus with two axial rotors [6]
a) John Deere 9780 CTS; b) Claas Lexion 480

The limited perspectives of the shaking system finally led to the integral transfer to the threshing apparatus of the seeds separating function out of ears by using the axial threshing apparata.

The rotor of the IHC and base IH harvester (figure 19) is inclined by a 10° angle to the horizontal, with the end side placed into an upper position. This inclining permits a better delivery of the material and a constant flow in the apparatus.

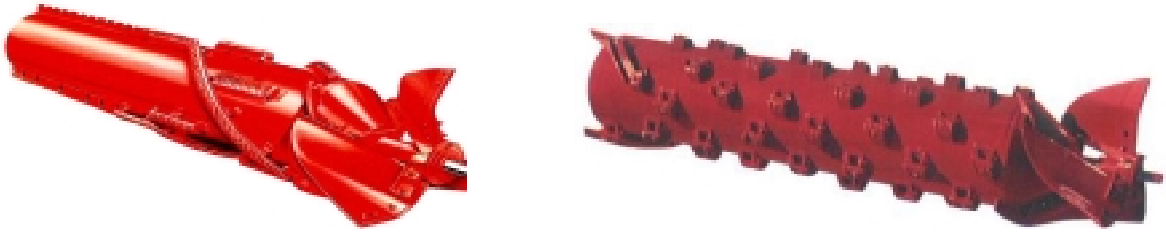

Figure 19 - Harvester axial rotor [6]
a) IHC 1440 and Case IH 1680; b) Case IH 2388

In order to ensure a complete threshing of the material an intense working duty (run) should be used, determining the increasing of the seeds damaging rate and the diminishing of the working intensity results in increasing the amount of unthreshed seeds. The solution of solving this problem was the performing of a threshing apparatus with variable radius by which it could be obtained the variation of the rotor peripheral speed along its whole length (figure 20).

The STS System (Single Time Separation), an axial rotor longitudinally settled which performs together both the threshing operation, and the separating one of seeds out of ears and straw.

The axial rotor represents a real revolution in the domain, being designed with a variable radius for each of the three zones of the axial threshing apparatus: feeding, threshing and separating, the rotor radius increases into jumps, so that there are three diameters and, thus, three peripheral working speeds, its rotative speed being adjustable. In the threshing section the rotor diameter is 750 mm (27 threshing elements) and in the separating section 834 mm (24 separating elements).

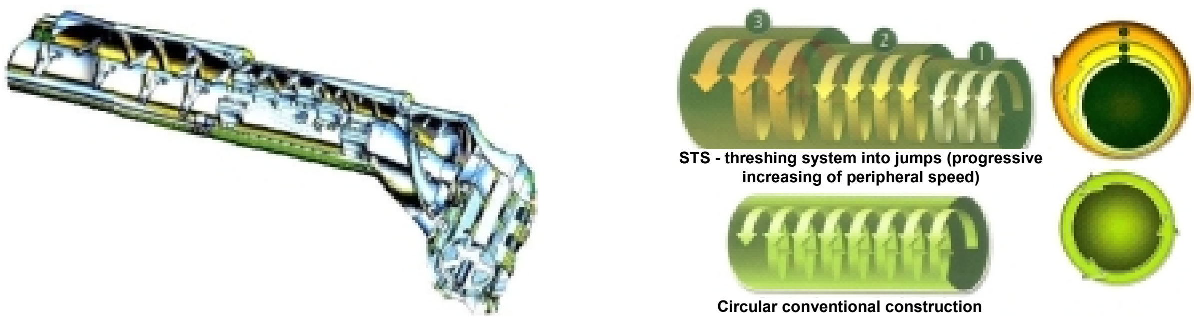

Figure 20 - Rotor combina John Deere 9880 STS [6]

SYSTEM OF ADJUSTMENT AND INFORMATION

The operator of the harvester has not only to drive the harvester along the field, but also to observe the work of each working element and to adapt them continuously to the crop conditions. The harvesters are implemented with sensors for the seed losses, for the supervision of the rotation speed operation and for the filling of the seed tank. In time, the standard equipment has also included the automated heave at the corn harvesting machines. At the same time, the harvesters are implemented with electronic devices for taking over some of the driver's tasks [4].

The Global Positioning System has revolutionized positioning concept, though it started primarily as a navigation system. Today, the Global Positioning System (GPS) has become an international utility. In addition to its ease of use and worldwide all-weather operation, GPS owes its popularity to the dependable high accuracy with which position, time and direction can be determined. As a tool of precision Agriculture, Global Positioning System satellites broadcast signals that allow GPS receivers to calculate their position. This information is provided in real time, meaning that continuous position information is provided while in motion. Having precise location information at any time it allows crop, soil and water measurements to be mapped. GPS receivers, either carried to the field or mounted on implements allow users to return to specific locations to sample or treat those areas [3].

Specific Management of the Partial Surfaces

Once the satellite navigation system GPS NAVSTAR (Claas) being implemented, for a couple of years a free service for the position determining has been made available. If the harversters are additionally implemented with sensors for measuring and determinating the density, the output maps (or income maps or field maps) can be made. In these output maps it is represented the local output for each position. The digitally stored output maps represent an important background for the specific management of each surface by the computer-aided system (figure 21). Knowing the local outputs due to the utilization of the ground maps and starting from the experts knowledge, we can draw a conclusion about the local differences of the ground within a certain field, from the field point of view. Thus, having got this knowledge and reporting to the position, we can influence the quantilies of seeds and fertilizers so that for every part of the surface these should be applied the suitable quantities for the potential growing.

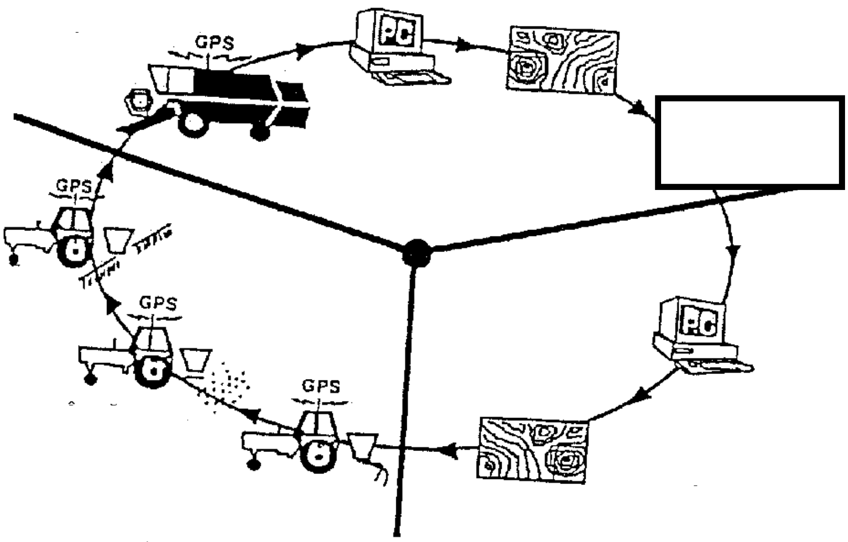

Figure 21 - The specific agricultural management of the partial surfaces [1]

In this way, we can avoid an overfertilizing followed by a superpollution of the environment and additional costs. These systems of output maps will be extended in the future, for the control against weeds, and in order to collect the necessary data about ground and plants.

Agriculture Management System (A.M.S.) - New Generation of Farming (John Deere Greenstar Systems)

This modern day cycle acts as a decision support system. This aids the difficult and complex decisions required within today's agricultural environment to operate an efficient and profitable business. There are 3 levels of decisions that can be taken on the farm. Namely: a strategical, practical and an operational one. The A.M.S. assists the modern Farm Manager in making effective decisions on each of these areas. The concentration of this system identifies four cornerstones, namely: Precision Farming, Vehicle Communication, Agronomic Management and Enterprise Management. Each of these sub-systems has an interaction with one another. The A.M.S. diagram gives a clear picture of this global strategy.

Figure 22 - A.M.S. System [6]

Advances Farming System (A.F.S) - Case IH

Full success with the AFS system **-** The precision agriculture is embraced nowadays by a growing number of farmers, the information offered by it being as important as a machine. By its Advanced Farming System or AFS, Case IH is the pioneer in the field.

Equipped with only 4 elements (an humidity sensor, a flow sensor, a GPS receiver and its aerial on a screen switchboard) AXIAL FLOW will perform the output maps of your lots. The 12-channel - GPS receiver intercepts both the ground correction beacon signals and those emitted by a geostationary satellite DGPS. It is so precise that it can offer the latitude and the longitude with one meter or less precision. During your harvesting process, the switchboard keeps registering the humidity and the output measurements joined every time to a certain position (latitude, longitude, altitude).

These data are also recorded on a transfer floppy disk PCMCIA for being used subsequently on your microcomputer. In this way you'll be able to create output maps for each of your lots. The precision supplied by the switchboard AFS is the best available at present as the error margin is below 1%.

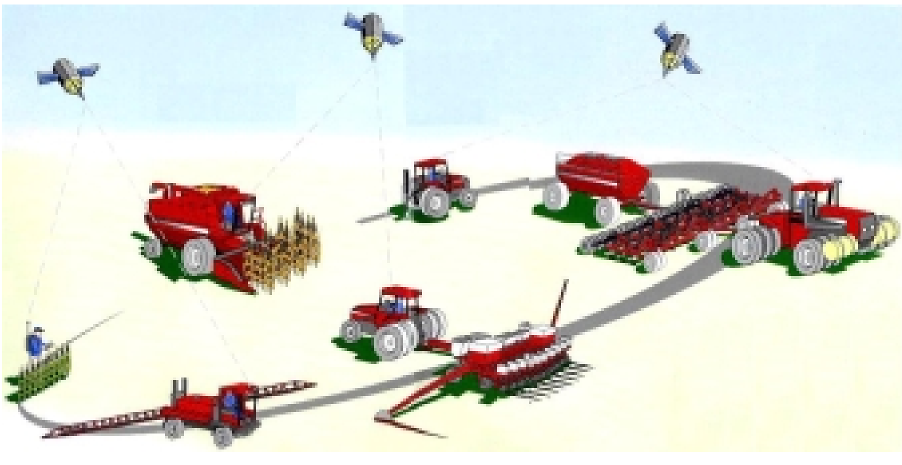

Figure 23 - A.F.S. System [6]

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