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RESEARCH ON THE OPTIMIZATION OF GRAIN HARVESTING SPECIFIC WORKS BY ESTABLISHING THE TYPES OF MACHINES AND DIVERSIFIED MECHANIZATION TECHNOLOGIES IMPOSED BY SUSTAINABLE AGRICULTURE, PRODUCT DESTINATION AND THE EVOLUTION OF EARTH PROPERTY STRUCTURE

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THESIS ABSTRACT

Key words: experimentation, optimization, combiners, harvesting, grains.

Wheat and corn crops occupy the first place in Romanian agriculture. So, corn occupies the first place regarding the cultivated surface (around 34 %), and wheat is placed second (around 30 % from the cultivated area).

At world level wheat is placed on the first place in according with the total yield and corn on the second place (third place is occupied by rice and on the fourth place is potatoes).

Effectuation of harvesting work for wheat and corn in according with the request of agro-technical could be realised only by its mechanized execution. For that Romanian agriculture must have a technical-material base (self-propelled grains harvesting machines) realised at high standards and suitable from quantitative point of view to be able to harvest the cereals in the periods established by agro-techniques demands (harvesting of straw cereals claims a short perid of time, 6-10 days).

Chapter I of PhD thesis "*Actual stage of research regarding working technologies and straw grains and corn harvesting machines*" deals with problems regarding technological flows and structure of harvesting machines built by different firms, problems regarding construction and function of different types of threshing devices.

In this chapter it is shown that cereals harvesting is an important work in the assembly of production processes from agriculture, over passing 50% from the total production costs of those crops. Cereals harvesting machines and technical systems utilised in modern agriculture allow a dramatic decrease of workers number involved in agriculture and their orientation for other sectors of activity. From 19 workers on field which could assure the necessary food for another one, at the end of the 20^{th} century was reached the situation in which only one worker, equipped with the necessary tools, could assure the food for 160 peers. A modern cereal harvesting machine replace the work of thousands workers. Recent studies show that the labour productivity at cereals harvesting with modern combines increased with over 3000 times face to manually harvesting.

The main preoccupation of cereals harvesting machines designers was and is the increasing of working capacity, decrease of seeds losses and their injury, ensuring the optimal working conditions for operator (in future he will be replaced from the combine and harvesting operations will be controlled, surveyed and directed from farm headquarters using satellites).

We consider that it is absolute necessary to be built modern harvesting machines in Romania. Use of acquisition of tractors and agricultural machines from the well-known firms, which are very expensive, means that annually oven 40% from the agricultural production of Romania to be transferred to the exporting countries, fact which is equivalent with disposal of 40% of the Romania agricultural land to other countries which will not need to make exhausting agricultural works, and a consequence will be that in these countries the welfare will increase while in Romania the standard of living will decrease.

What mainly characterizes the major differences between technological flows of the actual combines is the type of gathering system of the material from cropland and the construction of threshing devices. The great majority of the combines used, nowadays, traditional threshing devices (tangential) with a single beater, but the actual tendency is to use combines equipped with axial threshing devices or with more beaters/rotors for threshing and separation, which allow the increase of working capacity.

Technological flows of the combines with tangential threshing devices. Are presented models of combines realised by different companies (firms), indicating on figures the main component parts of them: dividers, pickup reel, cutter bar, rotating auger, oscillating conveyor, tangential threshing device, straw walker, blower, cleaning system, unloading tube, engine, grain tank, cabin. The presented models are built by the following companies: LAVERDA, MASSEY FERGUSON, FENDT, DEUTZ-FAHR, VASSALI FABRIL, SAMPO ROSENLEV, CLAAS Group, CNH-CASE NEW HOLLAND, JOHN DEERE, NIVA, SEMĂNĂTOAREA S.A.

Technological flows of the combines with axial threshing devices. Are presented models of combines realised by different companies (firms), indicating on figures, commonly, main component parts of them: dividers, pickup reel, cutter bar, rotating auger, oscillating conveyor, axial threshing device, straw walker, blower, cleaning system, unloading tube, engine, grain tank, cabin.

The combines' models belong to the following companies (firms): ALLIS-CHALMERS GLEANER, GLEANER, CHALLENGER, MASSEY FERGUSON, FENDT, CNH-CASE NEW HOLLAND, CASE-IH, LAVERDA, JOHN DEERE 9880 STS, SAME DEUTZ-FAHR.

Threshing devices utilised in construction of cereals harvesting machines. Are presented two categories of threshing devices: tangential devices (with a commonly transversal placement, sometimes longitudinal) and axial devices with a commonly longitudinal placement, sometimes transversal). Are presented the tangential threshing devices from combines: JOHN DEERE (series 1100, 2200, CWS, WTS), FIAT (series L), Massey Ferguson 825, Deutz-Fahr 2780H, Sampo (series Optima), Sampo SR 2075 TS, Laverda (series L, LX), New Holland TC 55, Massey Ferguson (series 20 and 40), Claas Mega, Deutz-Fahr TopLiner 8 XL, Claas Dominator 116 CS, New Holland series TF, John Deere CTS and Claas Lexion 480. Also are presented axial threshing devices (with helicoidally flow): Allis Chalmers Gleaner, Laverda MX 300, IHC 1440, Case IH 1680, Case IH series 2100 and 9000, New Holland CR 9090, John Deere 9880 STS.

In **the second chapter** of the thesis "*Research regarding optimization of cereals harvesting specific works function of constructive types of harvesting machines*" are presented problems regarding optimization of the constructive types of combines, aspects regarding the size and the disposal of agricultural plots, ownership of agricultural lands, equipment and organization of agriculture mechanization.

At the level of year 2007 in România were 3,931,350 agricultural exploitations, with a mean surface per exploitation of 2.34 ha in familial households and 275.37 ha in agricultural exploitations with legal personality. Must be mention a very important thing which is that 99.93% from exploitations are familial household without legal personality, in other words small exploitations with an average surface of 2.34 ha (very small, with corresponding disadvantages).

Self-propelled harvesting machines are in a number of 23,900.

Automation of the agricultural production processes is a priority to be able to struggle with the fierce concurrence of the countries with a developed agriculture in the world: USA, Canada, Australia, Japan, Brazil, Argentina, China, India etc and other countries from EU, which use today tractors, combines and performance machine units.

Exist today in Romania three types of agricultural exploitations:

- individual households, in a number of 3.9 millions, in which are worked 9,182 thousands ha (79%). Mean surface per household is of 2.3 ha;

- familial associations, in a number of 7,175, managing 950 thousands ha (8%), having an average surface per association of 132 ha;
- agricultural societies, in number of 3,578, with 1,558 thousands ha in total (13%), with a mean of 435 ha per exploitation.

Could be remarked, from the above mentioned data, the high degree of fragmentation of the agricultural surfaces (72% exploitations under 3 ha and only 0.3% over 10 ha), with unfavourable implications on efficient utilisation of the financial resources, productive assests and especially on mechanization possibilities with economic means.

Regarding the concentration of the field we are far away from European Community, because the average area per exploitation is of 2.3 ha in Romania face to 16.6 ha in European Union.

Regarding harvesting machines, the load per physical combine is of around 136 ha in Romania, comparative with an average of 44 ha in EU countries and 76 ha in USA.

In the last period at world level harvesting machines were refined by improvement and optimization of the main operating parts and by application of the newest achievements from informational technology, for increasing productivity, improvement of qualitative indexes, ease of driving, ensuring of permanent control of working regime. In the current chapter are presented synthetically improvements and optimizations obtained by the most famous firms in the world which built self-propelled combines, to show the present stage in the domain.

Chapter III of PhD thesis "*Research regarding optimization of harvesting works function of required technologies by durable agriculture*" deals with the presentations of the problems connected with the optimization of cereals harvesting work with combine. First are presented general considerations regarding optimization, and then are presented the realisations in world regarding these problems. Are mentioned optimization of linear processes and non-linear optimization.

Then are presented some of the solving methods for the non-linear optimization problems: method FLETCHER-REEVES (Conjugated gradients), method DAVIDON-FLETCHER-POWELL, Geometric programming.

Is also described the determination of optimal type of a unit utilisation, which includes the following aspects: establishment of aim function annual income, establishment of aim function for the unit tractor-agricultural machine, establishment of the aim function for the case in which unit is formed by a single entity, determination of productivity matrix for cereals harvesting machines.

In **chapter IV** of the thesis "*Aims of PhD thesis*" are presented the problems which will be solved. There are also presented the importance of PhD thesis and its goals. Were establishing the machineries which will be tested, qualitative working indexes which will be determine, energetic and exploitation indexes. It will also be establishing the optimal movement speed for each type of harvesting machine and each crop. The most important aim is to establish the optimal combine for cereals harvesting.

In the **fifth chapter** of PhD thesis "*Research regarding optimization of specific harvesting works, function of ownership structure and product destination*" are presented problems regarding the size of the land plots, categories of cereals harvesting machines built in world (function of engine power), establishment of optimal combine.

Establishment of optimal combine suppose more stages: establishment of the matrix of combines which will be compared; establishment of tie criteria based on which will be determine the combine which will assure the maximum efficiency; structure of the tie criteria (maximum and minimum ones); elaboration of matrix $U_{N,M}$ for the utilities; classification of tie criteria; establishment of matrix U_{IJ} of the utilities; concretion of the total utility in exploitation for each combine; standings of possible utilized combines; establishment of optimal combine.

Chapter VI of the paper "*Material and research method to determine the qualitative working, energetic and exploitation indexes of cereals harvesting machines*" deals with the problems regarding the presentation of the combines which were tested and the calculated working indexes: qualitative, energetic and exploitation indexes.

The constructive types of harvesting machines which were tested are: SEMA 110, SEMA 140E, CLAAS Dominator 108 MAXI and LAVERDA M 305 SP. At each of those combines were presented the component parts, function and technical characteristics.

Were also presented the followed qualitative working indexes (total losses of grains, injury degree of grains, purity degree of grains, at each index being mentioned the imposed agro-technical request), energetic indexes (working speed, hourly fuel consumption, power needed for combine' drive) and exploitation indexes (17 indexes from which the most important ones are: utilisation coefficient of shift time, coefficient of safety exploitation, working capacity per 8 hour shift, specific fuel consumption in litres per grain tone).

In **chapter VII** of PhD thesis "*Research regarding determination of qualitative working, energetic and exploitation indexes of cereals harvesting machines*" are presented the experimental results obtained after determination of quality, energetic and exploitation indexes of those four constructive types of harvesting machines.

In the research carried out at wheat harvesting with SEMA 110 combine, regarding working qualitative indexes, was establish that at the same time with increasing of movement speed the total grain losses increase while injury degree of grains and their purity decrease. Taking in account the limits imposed by agro-technical demands and the values of those three qualitative working indexes was established that the optimal movement speed of SEMA 110 combine, at wheat harvesting is of 3.6 km/h. In the case of qualitative working indexes determination for corn harvesting, with the same combine, was noticed, like as wheat, that with the increasing of movement speed the total losses of grains increase; injury and purity degree of the grains collected in tank is diminished. Taking in account the agro-technical demands and the values of qualitative working indexes was established that the optimal movement speed of SEMA 110 combine, at corn harvesting is of 4.05 km/h.

Regarding SEMA 140E combine, tested at wheat harvesting was noticed that those three qualitative indexes varied with the increasing of movement speed, like in the case of SEMA 110 combine. After comparison between agro-technical demands and the values of the qualitative working indexes was establish the optimal movement speed of SEMA 140E combine, at wheat harvesting, at 4.68 km/h. When were determinate the qualitative working indexes for corn harvesting with the same combine we observe that increasing of movement speed leads to the same modifications of those three quality indices as at wheat. Having in minded the limits imposed by agro-technical demands was established that the optimal movement speed of SEMA 140E combine, at corn harvesting is 4.04 km/h.

At CLAAS Dominator 108 MAXI combine, when it is utilised for wheat harvesting was establish that the increase of the movement speed determine the same modifications of quality indices which were presented at SEMA combines. Comparing the agro-technical demands with the quality indexes values was established that the optimal movement speed of CLAAS Dominator 108 MAXI combine, at wheat harvesting is 4.2 km/h. As regarding the obtained qualitative indexes by the same combine at corn harvesting was noticed that the speed increasing leads to the same modifications of quantitative indexes which were presented at SEMA combines. Based on agro-technical demands and on the values of quantitative indexes was establish that the optimal movement speed of CLAAS Dominator 108 MAXI combine at corn harvesting is 5.1 km/h.

At wheat harvesting with LAVERDA M 305 SP combine was observed that those three quality indexes varies at the same time with speed increasing, like at the previous three harvesting machines. By agro-technical comparing with the values of the quality indexes was established that the optimal movement speed of LAVERDA M 305 SP combine at wheat harvesting is 6.5 km/h. Regarding the obtained qualitative indicators, by the same combine at corn harvesting, was noticed that the way in which those ones varies at the same time with movement speed increasing is the one which was already presented at the other types of combines. Comparing the agro-technical requests with the values of quality indexes was established that the optimal movement speed of LAVERDA M 305 SP combine, at corn harvesting, is 6.5 km/h (same as at wheat harvesting).

On based values the determined qualitative working indexes was established the optimal combine (type of harvesting machine which obtained the best results regarding qualitative indexes). In fact was established the classification of thoese 4 typer of harvesting machines, and their rank. The order was established based on the values of qualitative working indexes in according with the presented optimal speed at each type of combine and each crop (wheat and crop). At wheat crop, in the first stage was established the order of those 4 types of combines separately for each qualitative index. In the second stage was establish the rank of each type of combine, having in view simultaneously all three qualitative indexes using an own method. By using of this method was established, for wheat crop, the following classification: combine LAVERDA M 305 SP = 1st rank (the best one); combine SEMA 110 = 2nd rank; combine CLAAS Dominator 108 MAXI = 3rd rank; combine SEMA 140E = 4th rank (with the worst results). For corn crop was used the same special method and the classification is the same as at wheat (1st rank = LAVERDA M 305 SP, 4th rank = SEMA 140E).

Energetic indexes determined at wheat and corn harvesting, at those four constructive types of combines are: hourly fuel consumption and the power for combine drive. At all constructive types of combines was establish, both at wheat crop and also at corn one, that hourly fuel consumption and power for combine drive are increasing at the same time with movement increasing.

Exploitation indexes of those four constructive types of combines were determined at wheat harvesting. If are analysed the obtained results regarding using coefficient of shift time we observe that the order is as follows: CLAAS Dominator 108 MAXI (1st rank), LAVERDA M 305 SP (2nd rank), SEMA 140E (3rd rank) and SEMA 110 (4th rank). Regarding the second exploitation index, coefficient of safety exploitation K_4, was establish that the order is: LAVERDA M 305 SP (1st rank), CLAAS Dominator 108 MAXI (2nd rank), SEMA 110 (3rd rank) and SEMA 140E (4th rank). Analysing the results regarding the exploitation index working capacity per 8 hours shift the classification is as follows: LAVERDA M 305 SP (1st rank), CLAAS Dominator 108 MAXI (2nd rank), SEMA 140E (3rd rank) and SEMA 110 (4th rank). Specific fuel consumption (which is expressed in litres per grain tone) presents a remarkable importance because it is a basic criterion in appreciation of agricultural unit's performances. Taking in account the values of this exploitation index was established the following order: SEMA 110 (1st rank), LAVERDA M 305 SP (2nd rank), CLAAS Dominator 108 MAXI (3rd rank) SEMA 140E and (4th rank).

In the **eight chapter** of the thesis are presented the drawn *conclusions* in connection with the effectuated research. Below we present only some important conclusions.

At wheat harvesting with combine SEMA 110 the optimal movement speed is 3.6 km/h, and at corn harvesting the optimal speed is 4.05 km/h.

In the case of combine SEMA 140E optimal movement speed is 4.68 km/h for wheat harvesting and 4.04 km/h at corn harvesting.

For CLAAS Dominator 108 MAXI combine the movement speed is 4.2 km/h for wheat harvesting and 5.1 km/h at corn harvesting.

At wheat harvesting with LAVERDA M 305 SP combine the optimal movement speed is 6.5 km/h, and at corn harvesting the optimal speed is the same (6.5 km/h).

The optimal cereal harvesting machine, establish based on the values of qualitative working indexes corresponding for the optimal speed is LAVERDA M 305 SP.