Grain Waste Post-Harvest Deep Processing Strategy

M V Zapevalov1, N S Sergeev1, G V Redreev2

1Chair of FSBEI HE South Ural State Agrarian University, 454080, Russia, Chelyabinsk, 75 Lenin Ave.
2Chair of FSBEI HE Omsk State Agrarian University, 644008, Russia, Omsk, 1 Institutskaya sq.

E-mail: gv.redreev@omgau.org

Abstract. The article identifies the problematic situation in plant cultivation during the grain crop production, which consists in significant losses of biological harvest with the implementation of combine harvest technology and undeveloped cleaning technology with the threshing process at a station. There is shown the relevance of solving the problem of deep crop processing. There is the resource-renewable technology scheme for grain crop processing. In addition to the commercial and seed grain production, the technology also provides for the feed pellet, thermal and electric energy and organic-mineral fertilizer production. The advantages of the proposed technology are disclosed: compliance with optimal agro-technical harvesting terms, refusal to maintain an expensive combine harvester, complete exclusion of grain loss during harvesting, energy cost reduction for harvesting, high-quality marketable grain and seed production, rational straw use, cheap thermal and electric energy production, effective organo-mineral fertilizer production and high-quality grain feed production for animals.

1. Introduction
The priority orientations and Food security Doctrine of the Russian Federation until 2020 provided for strengthening the stability of the domestic production market [1]. Russia has a unique agricultural potential that allows not only to fully provide itself with food but also to become one of the main exporters of agricultural products on the world market [2] with 9% of the world productive arable land, 20% of fresh water reserves and 10% of mineral fertilizer production. In this case, the special attention should be paid to crop production - the main raw material basis of all agricultural production. The intense competition in crop production market poses a priority task for agricultural producers to increase the crop cultivation efficiency. This problem can be solved by increasing soil fertility, reducing crop losses, using technologies of entire biological crop processing [3-4].

2. Problem description
In Russia, until the 30’s of the last century, agriculture was a self-supporting industry. Farmers became increasingly dependent on other industries with the industrialization process. This dependence has reached a critical state by now, when the equipment cost began to be millions and tens of millions of rubles. A kilogram of diesel fuel is about ten, and fertilizer is five to six times more expensive than the cost of a kilogram of grain. According to Rosstat, the electricity cost has spiraled. It is increased by more than 8 times for agriculture from 2000 to 2011, which is more than 2 times higher than for...
transport and industrial consumers, and it continues to grow [5]. At the same time, the grain purchase price practically does not change and fluctuates from 5 to 7 thousand rubles/ton. At the same time, the weather conditions prevent the high-quality grain production from year to year (for example, dry summer and rainy autumn). Not every agricultural enterprise in such conditions can carry out sustainable production activities. The way out of this situation is primarily the use of new energy-saving and resource-renewing technologies [6-9]. In recent years, due to insufficient availability of combine harvesters and adverse weather conditions, two-phase harvesting is practically not used, which is the guarantor of higher quality grain production [10-13]. No more than 40% of the biological crop is harvested with the combine technology of grain crop harvesting. The remaining 60% are either lost or (chaff, straw) are not effectively used [14]. At the same time, after a certain processing, chaff can serve as a valuable animal feed, because the forage properties are not inferior to high-quality hay. Straw corresponds to wood in its energy capacity. It is possible to avoid significant losses of biological crop while using the grain threshing technologies at the station.

The method of grain threshing grain at the station was used since ancient times, when there were no combine harvesters. The bread mass was removed in sheaves, which were taken to the farmstead, laid in stacks and threshed after the field work completion. The work was mainly carried out manually. Scientists of the Kuban State Agrarian University, All-Russian Research Institute of Agricultural mechanization of the Russian Academy of Agricultural Sciences, Siberian Research Institute of Mechanization and Electrification of Agriculture, South Ural State Agrarian University etc. [15-16] made a great contribution to the development of grain and leguminous crop mechanized threshing technology and perennial pericarps at the station. However, for a number of objective and subjective reasons, the developed technologies have not found a wide practical application. Currently, there are renewed research on this issue, since conditions of crop cultivation are exacerbated by changing climatic conditions, machine and tractor fleet, and increasing in the cost of combines, energy, etc.

3. Research data
In order to increase the grain cultivation efficiency, the resource-renewable technology scheme for grain crop processing has been developed at the Chair of Operation of Machine and Tractor Fleet, South Ural State Agrarian University (Fig.) [17–18].

The proposed technology provides for the bread mass roll formation [19-20]. Then it is finally dried at the station under a canopy to a conditioned humidity by actively ventilating dry air from inside to outside and then it is threshed in a stationary installation. The grain heap is fed to the cultivation from a threshing mill to obtain commercial grain, calibrated both in size and seed density, as well as grain waste with chaff [21]. The grain waste together with chaff goes to the processing for the high-calorie animal feed production [22]. All technological operations for the bread mass processing are carried out in flux& It doesn’t depend on weather conditions and time of a day. The fuel briquettes are made from straw, the combustion of which produces heat and electricity. As a result of straw thermal conversion, ash remains, which is used for the organic fertilizer production [23–26].

In contrast to the well-known technologies for the grain crop threshing at the station, the proposed technology contains new rational elements, such as: the roll formation of a certain shape, which makes it more convenient to work; the grain is not damaged; the deep processing of the entire non-grain crop part with the heat and electric energy production; organic fertilizer. According to the energy capacity, while processing 1 ton of straw, it is possible to produce up to 1 MW of electric and 1.5 MW of thermal energy. The thermal energy can be used to dry the bread mass in the process of active roll ventilation, as well as the heating of industrial and non-industrial premises. The electric energy will ensure the operation of all processing lines for the crop processing. It can also be spent on other on-farm needs.

This technology, as any other technology, has its advantages and disadvantages. The main disadvantages are: the additional costs for the roll formation and its transportation to the forage area, the additional space allocation for the roll storage, the need for initial costs of funds for engineering structures, machinery and equipment.
Figure 1. Resource-renewable technology scheme for grain crop processing.

Advantages:
- the cleaning process is carried out in the optimal agrotechnical terms around-the-clock (it doesn’t depend on weather conditions);
- there is no need to maintain an expensive combining park; all field work is carried out by the trailed machines;
- completely eliminated grain losses during the harvesting prevents the secondary contamination of fields with weed seeds;
- the soil compaction is reduced by the running system of harvesting and transport units;
- the reduced energy costs for harvesting and post-harvest grain processing;
- it provides the high-quality commercial grain and seeds;
- the rational straw use is provided with cheap thermal and electric energy production and effective organo-mineral fertilizer [27-31];
- the high-quality grain feed production for animals is provided.

4. Conclusion
Thus, the proposed technology can find its rightful place in the grain crop production and completely or partially replace the grain crop combine harvesting technology. The harvesting of the entire biological crop allows to use its non-grain part for the renewal of thermal and electric energy resources, as well as the return of some nutrients into the soil in the form of mineral fertilizers.

References
[1] https://www.garant.ru/products/ipo/prime/doc/56641501/
[2] 1969 Physiology of agricultural plants: 12 volumes vol 4 wheat physiology MSU 554 p
[3] Uraimov T U 2015 The use of industrial waste as organomineral fertilizers and its impact on the growth and development of winter wheat Report collection of the IV International Scientific Ecological Conference «Reclamation of household, industrial and agricultural waste problems» (Krasnodar) Kuban State Agrarian University Part II pp 40–43
[4] Sendetsky V N 2015 Straw and other plant residues as a valuable fertilizer to increase the soil fertility Report collection of the IV International Scientific Ecological Conference «Reclamation of household, industrial and agricultural waste problems» (Krasnodar) Kuban State Agrarian University Part II pp 51–55
[5] Rosstat website www.rosstat.ru
[6] Filatov V I, Bazdyrev G I, Obyedkov M G and others 1999 Agrobiological basis for crop product production, storage and processing edited by Filatova V I (M.: Kolos)742 p
[7] Plaksin A M and others 2018 Agriculture production potential: Development stages, condition, modernization problems (Chelyabinsk) 240 p
[8] Sergeev N S, Paleckov E N, Zolotykh S V 2006 The unity of energy and technological foundations for the design of industrial and agricultural technologies Achievements of science in the implementation of the national project «Development of the agro-industrial complex»: Materials of a scientific-practical conference (Kurtamys) pp 17-24
[9] Stekolnikova N V 2015 Use of secondary resources in agroecosystems Report collection based on materials of the IV International Scientific Ecological Conference «Reclamation of household, industrial and agricultural waste problems» (Krasnodar) Kuban State Agrarian University Part I pp 307–312
[10] Lovchikov A P 2014 The rationale for improving the direct cereal crop combining process Bulletin of Orenburg State Agrarian University 6(50) pp 68–70
[11] Lovchikov A P 2015 The methodological approach to the development of direct cereal crop combining with a double stem cut Bulletin of Orenburg State Agrarian University 2(52) pp 87-90
[12] Zhalnin E V 2011 Calculation of the combine harvester main parameters using the harmony principal in its design (M.: VIM) 104 p
[13] Konstantinov M M, Lovchikov A P, Lovchikov V P and others 2011 Design and organization of an effective process of grain crop harvesting (Ekaterinburg: Institute of Economics, Ural Branch of the Russian Academy of Sciences) 144 p
