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TESTING AND ANALYZING THE WORKING PROCESS OF THE HARVESTER COMBINE WITH GPS RECEIVER AND GRAIN LEVEL SENSOR

Advanced Harvesting System by using a Combine Robot
A Comparison of Three PopularYield Monitors & GPS Receivers

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In farms the combine harvesters are being used in different conditions, namely they are being used with the same working regime in low or high yield, grassy or lain down fields as well in condition that the moisture of the cereal is lower than measures. As a result, in some areas the grain loss level is reaching till 15-20 per cent, fuel expense is consisting of 35-40 kg for one hectare, and even in some situations 45-50 kg, therefore the effectiveness of the combine harvester is being low.

One of the more perspective ways of increasing effect managing agricultural production is using informative system on the base of geo-information technology. The similar systems allow solving planned agro technical operation, monitoring agro technical operations and condition of crops, prognostication the yield of the crop and evaluation losses, planning, monitoring and analyzing the used technics. Such data must be completed by an accurate position on the Earth, specifically using all modern methods: GIS digital maps, GPS, GNSS satellite systems, etc.

It is important to intrude GPS receivers and yield sensors for using GIS technologies in agricultural machines. Some works have been performed for intruding GPS receivers and sensors as well using correctly them.

Method to evaluate auto guidance systems of linear parallel-tracking applications were developed of agricultural machines that equipped with GNSS devices [Han et al., 2004]. An automatic agricultural vehicle based on low cost GPS receiver was developed for increasing the rate of using them [Keskin et al., 2006]. A robot combine harvester was developed as the aim more realizing GIS technologies during the harvesting woks. [Coen et al., 2008].

In India, an automated yield monitoring system consisting of a yield sensor, global positioning system (GPS), field computer with custom software was mounted on a self-propelled indigenous grain combine harvester for real-time crop yield mapping along with moisture data [Singh et al., 2011, 2013]. An autonomous tracked combine harvester is developed in the vehicle robotics laboratory, Hokkaido University based on Real Time Kinematic Global Positioning System (RTK-GPS) and Inertial Measurement Unit (IMU) for the harvesting of wheat and paddy [Zhang et al., 2013]. In general, a single sensor is not able to provide enough information, whereas multi-sensor integration can provide more useful information, which is more helpful and informative than what can be observed using a single sensor. This information needs to be fused in a way that reduces sensor uncertainties and the additional task of interpretation must be performed [Adla et al., 2013]. However, it can be cause combine to become complicated and expensive. Therefore, it is necessary to take important results by using less sensors than usually.

In general, main aim of using new techologies during the harvesting process is to make longer the work time of the combine harvester. [Niehaus, 2014] used spatial data to evaluate the corn harvesting operation on an Iowa grain farm and reported an overall TE of 62.4%; with 16.1% of total time spent in machine idling, 9.1% in in-field or road travel, 9.3% in turning within field headlands, and 2.9% unloading grain while not harvesting.

Crop yield affects the field efficiency of a combine when standard or typical field speeds are used to calculate theoretical field capacities, with greater yields usually resulting in reduced travel speed due to the heavier weight of grain [Grisso et al., 2002]. Agricultural machines FEs have a significant effect on the effective field capacities of machinery, which in turn impact the overall cost of production [Pitla et al., 2015]. Other scientists compared the practical collection methods of cereal harvesting costs in different agricultural holdings in order to effectively manage combine harvester fleets, make economically reasoned decisions on the exploitation of combine harvesters, reduce harvesting costs and consequently the cost price of cereals. Analyzed this information and provided assessments on the effectiveness of their combine harvester fleet [Olt et. al., 2019].

A cereal harvester combine was tested that equipped with GPS receiver and grain level indicator for harvesting the wheat as well the experiments for analyzing its work were performed by wheat's Krasnodar-99 sort. Size-mass and yield indicators of the cereal in the field were defined before experiments. Experiments were performed by cereal combine Dominator-130 (Fig. 1). For taking data about work efficiencies of cereal combine at real time regime the

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Fig. 1. Experimental cereal combine

Teltonika FMB920 GNSS/GSM/Bluetooth terminal and Escort DB-2 sensor were installed in the grain tank (Fig. 2).

Fig. 2. GPS receiver Teltonika FMB920 installed in combine Dominator-130.

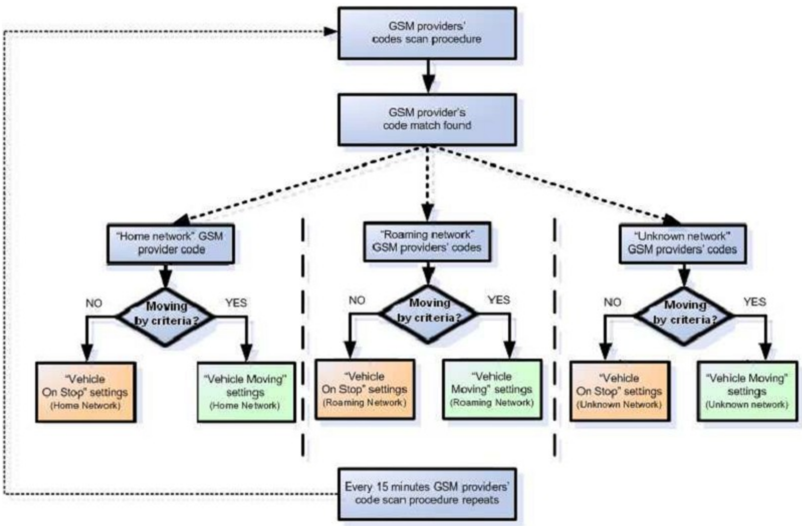

Fig. 3. Regime of GPS recording date.

Teltonika FMB920 GNSS/GSM/Bluetooth terminal collects data about position and working of moving object and it sends the data to server through GSM net-work.

Teltonika FMB920 terminal gives observing opportunity the position of combine during the work in real time regime. The technical characteristics of this device as following: Bluetooth B 3.0 micro CD card (till 32 GB) internal GPS antenna, the internal GPS antenna1, number enter 1, analog enter 1 exit were installed. Battery 170 was provided with mA / hour IP54.

Escort DB-2 grain sensor is installed on the wall of grain tank, it defines the fluctuation of every cereal and other sorts of productions that their moisture does not increase from 25 per cent and sends the data to observing system through artificial satellite. The high level of the defense (IP 67) wide temperature gap (from - 60 till +85) guarantees reliable forking of censor indicator in every climate condition and in different relief. The sensor is suitable for different types of GLONASS/GPS terminals.

During the experimental-test the work regimes and technological parameters of the combine Dominator-130 are as following: installing height of header - 20 cm; rotation frequency of drum - 1200 rpm; clearance between concave and drum: entering part - 13 mm; exiting part - 3 mm; opening angle of sieve jalousies - 30 degree; rotation frequency of fan - 800 rpm. When the influence of installing height of header to work efficiency indicators was studied, the cutting height was changed from 10 cm till 50 cm with 10 cm step. Also, working speed of the combine harvester was in diapason 4-6 km/hour according to fed cereal mass into thresher and working condition.

According to obtained data through GPS receiver, work efficiency of combine decreases while grain yield increases in work process of combine. Grain loss consisted of 1.96 ha/hour when yield became 2.62 t/ha, the rate of grain loss decreased to 1.78 ha/hour when yield became 3.58 t/ha, then with yield increased the grain loss rose too (Table 1).

Table 1. Influence of grain yield to work efficiency of combine Dominator-130

№	Work quality indicators	Grain yield, t/ha				
		2.62	3.58	4.46	5.63	6.24
1	Work efficiency in main period, ha/hour	1.96	1.78	1.63	1.50	1.30
2	Grain loss, %	2.19	2.03	2.72	3.28	3.76
	- in combine header	0.60	0.51	0.52	0.56	0.63
	- behind the combine	1.59	1.57	2.20	2.72	3.13

The grain loss in combine header almost did not change, when yield rose from 4.46 t/ha to 6.24 t/ha, losses behind the combine increased from 2.72 per cent till 3.76 per cent, and work efficiency declined from 1.63 ha/hour till 1.30 ha/hour (Table 1).

According to results of performed experiments about studying the influence of the cereal moisture to combine work quality (Table 3), at high working regimes when the cereal moisture was 20.3 per cent the work efficiency in main period made up 1.78 ha/hour, grain loss was equal to 2.10 per cent, when the cereal moisture decreased from 16.0 per cent till 7.5 per cent the work efficiency rose from 1.78 ha/hour till 1.96 ha/hour. In the same time of increasing of the work efficiency the grain loss increased from 2.10 per cent to 3.26 per cent.

Table 3. Influence of cereal moisture to work quality indicators of combine "Dominator-130"

№	Work quality indicators	Cereal moisture, %				
		20.3	16.0	12.4	10.8	7.5
1	Work efficiency in main period, ha/hour	1.78	1.73	1.80	1.81	1.96
2	Grain loss, %	2.10	2.21	2.51	2.78	3.26
	- in combine header	0.43	0.57	0.89	1.27	1.44
	- behind the combine	1.67	1.64	1.62	1.51	1.82

This situation is described that, when the cereal moisture decreased, work efficiency of combine increases as well cereal mass following rises, increasing of grain loss is described with spilling as a result its mechanical influence. It can be seen also the grain loss is being taken part mainly in combine header.

Above analyzed experiments showed that, combine harvester should be used at the suitable working regimes depending on the sort of crop, yield and grain moisture. As if like these recommendations were suggested by [Pristavka et al., 2013, 2017; Aldoshin et al., 2016].

CONCLUSION

When Dominator-130 for cereal harvesting combine that equipped with GPS receiver and grain level indicator sensor was tested by using GIS technologies, becoming its header installing height - 20 cm; rotation frequency of drum - 1200 rpm; clearance between concave and drum: entering and exiting part - 13 mm and 3 mm respectively; opening angle of sieve jalousies - 30 degree; rotation frequency of fan - 800 rpm, as cereal yield – 3.5-3.6 t/ha, moisture - between 16-20 per cent the cereal can be harvested with little grain loss. When cereal yield, moisture and weeding level change for decreasing of grain loss combine should be used by changing its work regimes.

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