Journal of Central European Agriculture, 2013, 14(4), p.1436-1443 DOI: 10.5513/JCEA01/14.4.1374

Reliability monitoring of grain harvester in operating conditions

Sledovanie spoľahlivosti obilného kombajnu v prevádzkových podmienkach

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Abstract

Reliability and quality are strongly linked between each other although people are often confused and consider these to be the same. Quality is defined as the ability to satisfy requirements that customers had determined or expected. If an organization manages to fulfill preconditions and requirements, it has a potential that customers will continue to use its products while buying new ones. Reliability can be named as an indicator expressing the probability that a product will perform the function it was made for and for a period specified in given operating conditions. In this work, we have focused on monitoring the specific parameters in two types of grain harvesters in operating conditions.

Keywords: grain harvester, quality, organization, reliability

Abstrakt

Spoľahlivosť a kvalita majú medzi sebou silnú väzbu. Ľudia sa často mýlia a považujú ich za to isté. Kvalitu definujeme ako schopnosť uspokojiť požiadavky, ktoré si určili zákazníci alebo ich očakávali. Ak sa podarí predpoklady a požiadavky naplniť, organizácia má potenciál, že zákazník bude pokračovať v používaní jej výrobkov a zároveň kúpe nových. Spoľahlivosť môžeme nazvať ako ukazovateľ vyjadrujúci pravdepodobnosť, že daný výrobok bude vykonávať požadovanú funkciu, pre ktorú bol vyhotovený, po dobu stanovenú v daných prevádzkových podmienkach. V práci sme sa zaoberali sledovaním konkrétnych parametrov u dvoch typov obilných kombajnov v prevádzkových podmienkach.

Kľúčové slová: kvalita, obilný kombajn, organizácia, spoľahlivosť

Introduction

Nowadays, many organizations that deal with growing special-purpose crops use mainly service at harvest. When buying a new grain harvester, providers of these services are taking risk in some way as they are expensive and their failures result in large financial losses (Findura, 2010). An unplanned downtime occurs, and the season time is shortened due to competition and weather conditions. For these reasons, buying a new harvester from a manufacturer or distributor requires not only high quality and reliability but also warranty and post-warranty service (Gejdoš, 2010). Each new grain harvester is characterized by more and more features, primarily used for better automation, monitoring, performance and operating comfort (Savov et al., 2011). It should be remembered, the more features a harvester contains, the greater is the risk of a failure, and thus the reliability of a machine is reduced. (Hrubec et al., 2009). Another important aspect that increases the reliability of equipment in operation is operator's professional competence (Žitňák, 2012). Besides operating reliability, an efficient operation of the grain harvester is closely related to the work efficiency of the grain harvester as a whole. Increasing operational reliability in vegetable production can be positively influenced by the use of automatic navigation systems working on the principles of sensors or global navigation systems (Macák and Žitňák, 2010).

Materials and Methods

The aim of this work is to observe grain harvesters in real operating conditions and to evaluate and compare the observed parameters. Based on a test plan, we have monitored two John Deere grain harvesters, the types CTS9780 and Z2264 that worked in service. Monitoring started before the 2010 season, prior to maintenance, and was completed after the storage of grain harvesters (after the 2012 season).

Monitoring consisted of recording and defining the following data:

- defining the organization;
- specification of monitored harvesters;
- financial conditions;
- failures;
- downtimes;
- maintenance and repairs;
- costs and incomes.

Individual components of collected data were evaluated by observing the following relations:

- ✓ **annual operating costs of the machine (total costs) can be expressed as:**

$aCo = aCc + aCv$, €*year^{-1} **[1]**

aCc – constant annual costs, €*year^{-1}

aCv – variable annual costs, €*year^{-1}

$$aCc = aCa + aCc + aCvt + aCLi + aCi + aCoi + aCg$$ **[2]**

where:

aCa – amortization annual costs, €.year^{-1}

aCc – annual costs of capitalization of funds, €*year^{-1}

aCvt – annual costs of vehicle tax, €*year^{-1}

aCLi – annual costs of insurance according to law, €*year^{-1}

aCi – annual costs of bank interest, €*year^{-1}

aCoi – annual costs of optional insurance, €*year^{-1}

aCg – annual costs of garaging, €*year^{-1}

$$\mathrm{aCv} = \mathrm{aCm} + \mathrm{aCe} + \mathrm{aCmw} \qquad [3]$$

where:

aCm – annual costs of repair and maintenance, €*year^{-1}

aCe – annual costs of energy, including fuel and lubricants, €*year^{-1}

aCmw – annual costs of manual work, including levy, €*year^{-1}

- ✓ **ratio of calculating income for the year of operation:**

$$aI_{20XX} = LC_{20XX} \cdot HA_{20XX} \text{ , €} \qquad [4]$$

LC_{20XX} – labour costs, €*ha^{-1}

HA – harvested area, ha

- ✓ **ratio of calculating profit for the year of operation:**

$$\mathrm{aP}_{20XX} = aG_{20XX} - aCo \text{, €*year}^{-1} \qquad [5]$$

aG_{20XX} – machine gains for the year, €

aCo – annual operating costs, €*year^{-1}

- ✓ **ratio of calculating financial losses incurred by unplanned downtime:**

$$\mathrm{aCdw} = \mathrm{aP}_{20XX} \cdot \mathrm{DW} \cdot \mathrm{LB}_{20XX} \text{, €} \qquad [6]$$

aP_{20XX} – annual performance, ha*year^{-1}

DW – unplanned downtime, h

LB_{20XX} – labour costs, €*ha^{-1}

- ✓ **ratio of calculating the cost of operation:**

$$aCoc = \left(R_{hr} + \frac{R_{hr} \cdot \sum LVY}{100} \right) \cdot EW \text{ , €*year}^{-1} \qquad [7]$$

R_{hr} – hourly rate, €*h^{-1}

∑LVY – total percent of levy corresponding to R_{hr}, %

EW – extent of work, h*year^{-1}

- ✓ **ratio to state reliability in percentages:**

$$\omega = \left| \frac{aCo}{aG_{20XX} - aCdw} - 1 \right| \cdot 100 \qquad \textbf{[8]}$$

aCo – annual operating costs, €*year^{-1}

aG_{20XX} – machine gains for the year, €

aCdw – annual costs of downtime, €

Results and Discussion

Fig. 1: JohnDeere CTS 9780

JohnDeere CTS 9780 (Fig. 1) has been developed for a high quality processing of various types of crops, even in worse conditions, as for example wet straw, excessive returns, etc. A key is a threshing drum (Fig. 2), the diameter of which is 660 mm and a twin-separation CTS Cylinder Tine – Separation. To process larger amounts of vegetable mass in less time, a Headertrak system is used, which allows automatic terrain copying by the cutting table.

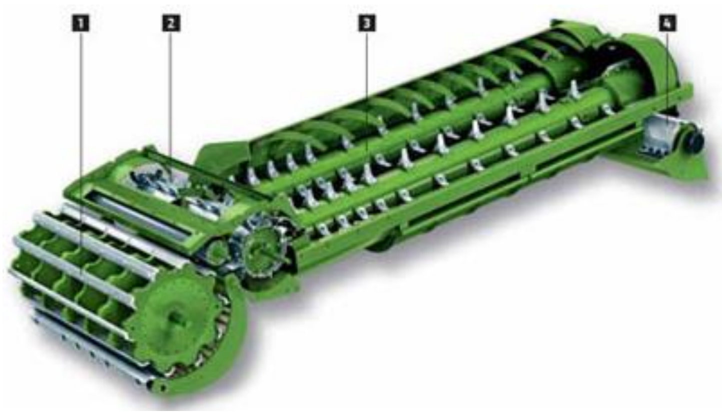

Fig. 2: Threshing mechanism CTS 9780

1 – main threshing drum, 2 – cylinder beater, 3 – rotors, 4 – accelerating roller

Fig. 3: John Deere Z2264

JohnDeere Z2264 grain harvester (Fig. 3), also called a “Z“ series, is no longer in production. We can say that the series mentioned above has done well in Slovakia. This is a relatively standard and simple harvester with one threshing drum and shakers’ flat of 6.4 m^2. The operator has sufficient comfort and ease of use even when the equipment diagnosis is lower class and less user friendly than the CTS.

During the observations, the average price per hectare of treated area was € 53.20. It is important to note that this price already includes the cost of diesel.

Tab. 1: The parameters and values of JD CTS 9780 grain harvester monitoring

	year 2010	year 2011	year 2012
Number of motohours engine/separation	174/108 Mth	178/113 Mth	232/166 Mth
Number of days when in operation	24 days	25 days	32 days
Number of ha	407.6 ha	451.2 ha	582.2 ha
Failures that caused more than an hour of downtime	2 failures	3 failures	3 failures
Planned downtime	56 hrs	118 hrs	137 hrs
Unplanned downtime	25 hrs	49 hrs	16 hrs
Time of maintenance and repair	33 hrs	65 hrs	43 hrs
Time of repair in authorized service	10 hrs	7 hrs	5 hrs
Diesel consumption	7,029 l	7,174 l	11,613 l
Costs of repair and maintenance	€ 433.50	€ 507.50	€ 449.50

Costs of operation	€ 1,630.40	€ 1,804.80	€ 2,328.80
Costs of spare parts	€ 2,798.33	€ 6,574.05	€ 4,664.65
Total cost for a given season	€ 4,862.20	€ 8,885.35	€ 7,442.95
Income for services	€ 21,684.32	€ 24,003.84	€ 30,973.04
Profit for the year of operation	€ 16,822.12	€ 15,118.49	€ 23,530.09

Tab. 2: The parameters and values of JD Z 2264 grain harvester monitoring

	year 2010	year 2011	year 2012
Number of motohours engine/separation	208/127 Mth	204/142 Mth	213/130 Mth
Number of days when in operation	21 days	24 days	24 days
Number of ha	306 ha	338 ha	317.5 ha
Failures that caused more than an hour of downtime	3 failures	6 failures	4 failures
Planned downtime	43 hrs	75 hrs	58 hrs
Unplanned downtime	34 hrs	26 hrs	18 hrs
Time of maintenance and repair	39 hrs	45 hrs	48 hrs
Diesel consumption	4,131 l	4,492 l	4,129 l
Costs of repair and maintenance	€ 283	€ 325.50	€ 336.00
Costs of operation	€ 1,224.00	€ 1,352.00	€ 1,270.00
Cost of spare parts	€ 2,130.89	€ 6,257.46	€ 5,899.14
Total cost for a given season	€ 3,637.89	€ 7,934.96	€ 7,505.14
Income for services	€ 16,279.20	€ 17,981.60	€ 16,891.00
Profit for the year of operation	€ 12,641.10	€ 10,046.64	€ 9,385.86

The most objective assessment of grain harvester performance is to assess a proportion of motohours worked and the treated area during the given period. As for the JD CTS 9780 grain harvester, the performance was 3.7 $ha*h^{-1}$, and the performance calculated for JD Z2264 was 2.8 $ha*h^{-1}$.

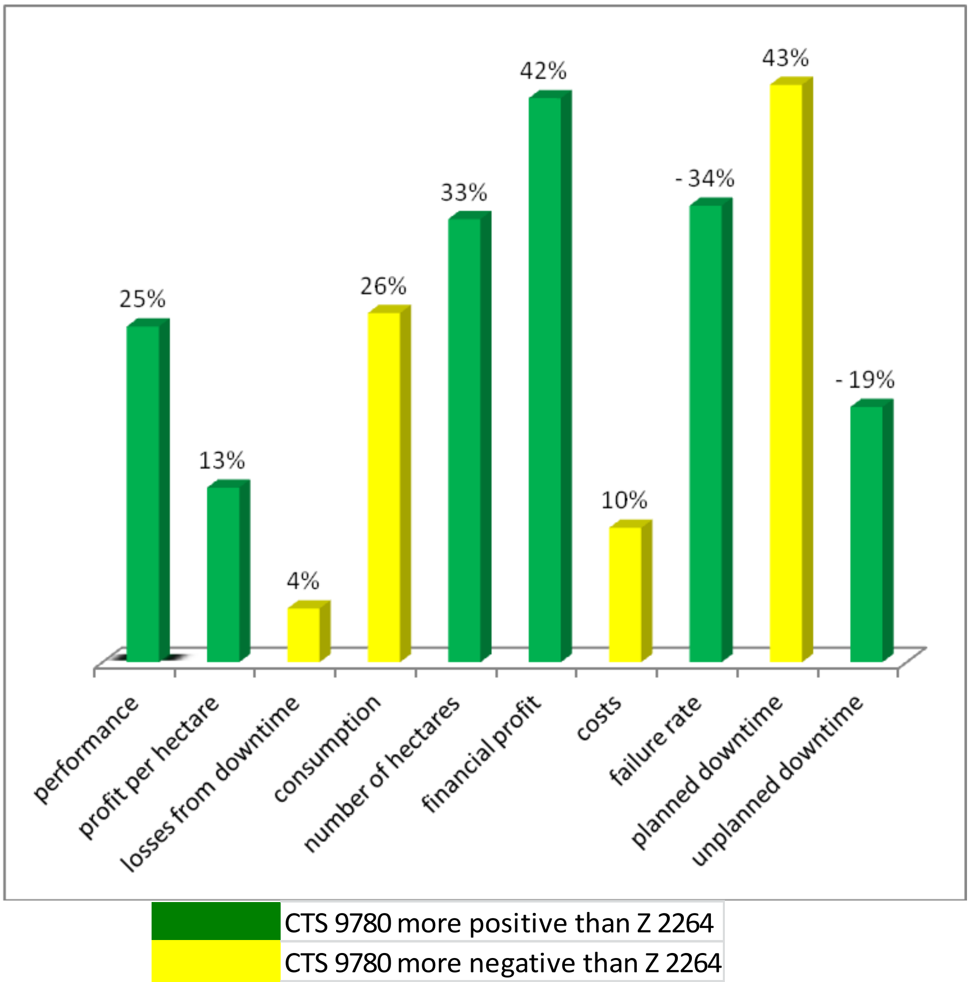

Fig. 4: Comparison of selected parameters in the grain harvesters

Conclusion

The aim of the work was to monitor grain harvesters in real operating conditions as well as the evaluation and comparison of their parameters.

We have monitored the John Deere CTS 9780 and Z2264 grain harvesters from 2010 to 2012. During the observation, we recorded individual data that showed the studied objects with boundary conditions. After collecting all the necessary data, we processed them, evaluated the results and compared the monitored grain harvesters. In comparison we found the JD CTS 9780 grain harvester had better results in more data that have been compared; except for the increased planned downtime being caused by a long grain harvester preparation before and after harvesting. Another reason was a fact that the cost of purchasing the equipment to harvest this crop are demanding. Another negative statistical indicator were the total costs that also can be attributed to this problem due to a smaller overhaul of the Geringhoff adapter in 2010, the cost of which exceeded the amount of € 3,000.

The losses in unplanned downtimes were the last negative thing. The unplanned downtimes of the JD Z2264 grain harvester were of a greater number of hours. The average fuel consumption was not so significant because it was paid byt the customer, regardless of the harvester's consumption during the whole time of observing. The percentage of reliability includes all the essential parameters such as maintenance, servicing, fuel, downtime, depreciation, etc. It is necessary to minimize these factors so that reliability could be as close as possible to 100 %.

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