EVALUATION OF OPERATIONAL RELIABILITY OF GRAIN HARVESTER

VYHODNOTENIE PREVADZKOVEJ SPOĽAHLIVOSTI OBILNEHO KOMBAJNU

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The work is aimed to evaluate the operational reliability of grain harvesters. The paper describes the definitions related to quality, reliability, service, maintenance, necessary for processing of the work. The next step is a methodology of work in which are appointed all of the conditions for monitoring and evaluating the reliability of grain harvesters. Viewed grain harvesters were John Deere different type and year of production, having worked in real operating conditions. During three years of follow-up data were collected for all important, but also a marginal properties and conditions of the investigation, which were related to the literature review. After collect of data followed their subsequent processing by the methodology and based on experience during the observation. The last part is aimed to evaluate the processing results, comparison of observed grain harvesters and personal suggestions for improving the individual components.

Introduction

In the past when the market was not sufficiently saturated to produce of grain harvesters can speak as minimal competition. Reliability and quality were not even minimally close to standard as is given accent to them today. The customer had a choice only rarely. He was somehow forced to undergo a low quality or reliability of the product thus was inferior by manufacturer. The gradual rise in competition and freedom of trade, access to customers changed 360 degrees. At each site to see the billboards not only for grain harvesters but to all products and services that show their high quality and reliability.

Reliability and quality have between them strong link. People are often confused and consider it the same. In fact, it is not an option. Quality is defined as the ability to meet the requirements witch were identified by customers or their expected. If you manage to fulfill the conditions and requirements, the organization has the potential that customers will continue to use its products and to purchase new ones. Reliability can be called as an indicator indicating the likelihood that the product will perform a required function for which it was made, after a specified time in the operating conditions. In practice, it is expressed as the number of failures per unit of time called the failure rate or fault liability (Žitňák, 2008).

Reliability of grain harvester and other products is necessary in sufficiently incorporate at an early stage of development, or in the design phase. The following is the duty the object the appropriate test methods, which will confirm or disprove the correctness of the proposed solution. In the grain harvester is all new model more and more components. They serve primarily to increase automation, better monitoring, performance and ease of operation. It should be noted that the more components will include a harvester, the greater the risk of failure and may be less reliable. It is therefore important to increase the reliability of individual components .

Among the factors affecting the safety, belong immediate reliability. There is only one, quite often it is human error that is difficult to predict. For this reason, are every year before the season legally designated safety retraining.

Quality

In the normal communication between people is a word quality mostly used for view of the evaluation. In the true sense, it is given different meanings. At the same time, in most cases do not specify detailed criteria from the perspective of such treatment is perceived. And it is one of a major cause of the subjective assessment of quality in everyday life. In ongoing efforts to minimize such subjective assessments and understanding of quality to standardize in a restricted concept we provide various definitions of quality.

Quality (from lat.: qualitas = quality, characteristic sign) under the definition we understand verbal, mathematical, or other graphic description of its characteristics, which reflect its significant impact on the environment (Korenková, 2008). So it's sort of satisfying the desired requirements. All requests that customers want, and to ensure that in future re-use products or services which the mark. Quality - the degree to which a set of inherent characteristics fulfills requirements. Term quality can be used with adjectives such as poor, good or excellent. (Prístavka - Hrubec, 2009, Bujna et. al. 2010)

The glorious historical statements and definitions of quality can be classified as:

• W.E. Deming: Quality is when the customer returns, and no goods,

• Crosby - Quality is conformity with the requirements,

• Deming - Quality is when the customer returns and no goods,

• McDonald, Piggot - Quality is an effort to delight the customers by continuously improvement and satisfaction of its requirements (Kapsdorferová, 2010).

Especially in technology and economics is in present a clear solution definition of the quality according to ISO 9000:2000, "Quality - the degree, rate to which own set of characteristics fulfills requirements." Quality describes that, what distinguishes each entity. Their typical functions and characteristics in the existing environment and time. The quantity indicates the gradation of different functions and their characteristics of specific entities and multiplicity of distinguishable entities. The quality of the grain harvester can be one or more fitting characteristics describe their activity in a given environment and time (Savov –Džupina, 2007).

Collection of primary information on the reliability of harvesting must be done in real operating conditions. If we get the initial information is good to follow the rules of the test plan. The test plan describes the procedure to monitor machines, their amount, the recovery procedures of machine failure and also complete the monitoring or testing. The procedure for calculating the reliability indicators specified in test plans according to STN 01 0643rd.

Other important sub-component reliability grain harvester is life. According to STN 01 0101 is the lifetime defined as a characteristic of the product in expressing his ability to maintain working capacity under specified operating conditions and the necessary intervals required for the technical operation and maintenance (to destruction or otherwise limit state in which a further operation impossible or ineffective).

Status of the machine or its parts, in which its continued operation must be discontinued in view of the causes of deterioration of safety or decrease the operational efficiency under the tolerances that are established. Limit state threatens the lifetime of the harvester (Ružbarský et. al. 2005).

The purpose of the functions are parts divided on:

• components with their own knockout indicator with the threshold wear b_m. In case of exceeding this value can be expected emergency situation, such as fracture,

• components that represent functional pair in which the limit state, thus limit will S_m between the functional surfaces makes not emergency situation , but deteriorates economic or group technical indicators , subgroups, or even the whole machine as worn cutting tools.

Wear curve depending on the time of operation to assist in determining indicators of life (Fig. 1).

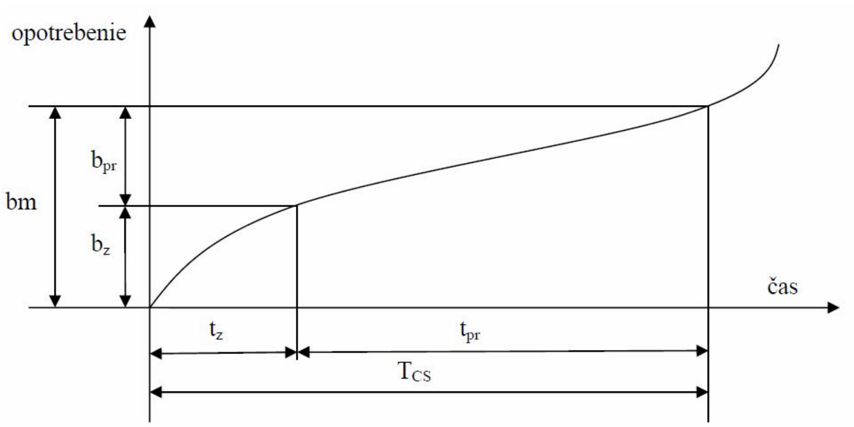

Fig. 1 The curve of wear part (Hrubec 2004)

The DTAC system- (Dealer Technical Assistance Center)

DTAC is system of John Deere company. Support technical Center of dealer is an Intranet system, is available to sellers and dealers. It provides the latest updates of product changes, inform about new solutions and innovations related to repair activities, and other relevant context.

Search the global database using keywords, sellers and dealers can get an overview of the latest information relating to the repair machinery. Customers can be confident that when began to repair the machine so in the course will use the latest knowledge derived directly from the factory (Angelovič - Jobbágy 2010).

DTAC provides especially quality improvement as it is used worldwide. If the same fault occurs on the same type of grain combine or other facilities, said the brand, the dealer of each country is doing so. evaluation sheet where is detailed described fault. These are sent directly to the factory where it produces the type. There these faults are considered, evaluated and made to measure to prevent the occurrence of the faults. Can be called a program for quality improvement.

Methodology of work

Monitoring of grain harvester

Monitoring of grain harvester was carried out in real operating conditions. Based on its test plan was followed two grain harvesters John Deere CTS9780 type and Z2264, which have worked in the service.

Monitoring began in a D-JD Chrabrany before maintenance the 2009 season and was completed after storage for grain harvesting season in 2011. Self monitoring consisted of recording and defining the following data:

- definition of the organization,
- specification of monitored harvesters,
- financial conditions,
- faults,
- downtime,
- maintenance and repairs,
- costs and revenues,
- fuel consumption.

The components of collected data from observation were evaluated using the following relationship:

relationship to calculate the costs per the year of operation

$$c_{20xx} = \Sigma c_{20xx}^{V} + \Sigma c_{20xx}^{SOÚ} + \Sigma ND_{20xx} \quad [1]$$

Example of cost calculation for the 2009 season for grain harvester CTS 9780:

$$c_{2009} = 1630{,}40 + 433{,}50 + 2798{,}33 \quad [2]$$

$$c_{2009} = 4862{,}2\ €$$

relationship for the calculation of incomes for the year of operation

$$\Sigma i_{20xx} = \Sigma ha_{20xx} . €. ha^{-1} \quad [3]$$

Example of calculation of incomes for the year 2009 for the grain harvester CTS9780:

$$i_{2009} = 407{,}6 \,.\, 53{,}2 \quad [4]$$

$$i_{2009} = 21\ 684\ €$$

relationship to calculate the profit for the year of operation

$$Z = i_{20xx} - c_{20xx} \quad [5]$$

Example of calculation of profit per year of grain harvester CTS 9780:

$$Z = 21\ 684{,}32 - 4\ 862{,}20 \quad [6]$$

$$Z = 16\ 822{,}12\ €$$

relationship to calculate the financial losses incurred by unplanned downtime:

$$cNP = V.NP.i.ha^{-1} \quad [7]$$

Example of calculation of financial losses for grain harvester CTS9780:

$$cNP = 3{,}7.63.53{,}20 \quad [8]$$

$$cNP = 12\ 400{,}92\ €$$

relationship to calculate the average fuel consumption:

$$PHM = \frac{PHM}{ha} \quad [9]$$

Example calculation of average consumption for CTS9780:

$$PHM = \frac{25\,816}{1441} \qquad [10]$$

$$PHM = 17{,}9\ \mathrm{l}$$

relationship to calculate the cost for maintenance and repair of grain harvesters:

$$c_{20xx}^{SOÚ} = \left(nR.nd.c^{OÚ}.h^{-1}\right) + \left(\Sigma h_{2009}^{OÚ}.c^{OÚ}.h^{-1}\right) + (\Sigma h^{s}.cS) \qquad [11]$$

$$c_{20xx}^{SOÚ} = c^{OÚ}.h^{-1}.(nR.nd. + \Sigma h_{2009}^{OÚ}) + (\Sigma h^{s}.cS)$$

Example of calculation of the cost for maintenance and repair the combine CTS 9780 in 2009:

$$c_{20xx}^{SOÚ} = \left(nR.nd.c^{OÚ}.h^{-1}\right) + \left(\Sigma h_{2009}^{OÚ}.c^{OÚ}.h^{-1}\right) + (\Sigma h^{s}.cS) \qquad [12]$$

$$c_{20xx}^{SOÚ} = c^{OÚ}.h^{-1}.(nR.nd. + \Sigma h_{2009}^{OÚ}) + (\Sigma h^{s}.cS)$$

Example of calculation of the cost for maintenance and repair combine CTS 9780 in 2009:

$$c_{2009}^{SOÚ} = 3{,}50\,.\,(2.24. + 33) + (10.15) \qquad [13]$$

$$\Sigma c_{2009}^{SOÚ} = 433{,}5\ €$$

relationship to calculate of the operation costs:

$$c_{20xx}^{V} = c^{V}.ha^{-1}.\Sigma ha. \qquad [14]$$

Example of calculation of the cost of operating the harvester CTS9780 for 2009:

$$c_{2009}^{V} = 4.407{,}6 \qquad [15]$$

$$c_{2009}^{V} = 1630{,}4\ €$$

relationship for calculation of grain harvester performance :

$$V = \frac{ha}{Mth} \qquad [16]$$

Example for calculation of efficiency for grain harvester John Deere Z2264 for the entire period of observation:

$$V = \frac{961{,}50}{339}$$

$$V = 2{,}8 \qquad [17]$$

relationship for the percentage statement of reliability,:

$$\omega = \left|\frac{\Sigma c}{\Sigma i - \Sigma cNP} - 1\right|.100 \qquad [18]$$

Example of calculating the percentage reliability of grain harvester CTS9780:

$$\omega = \left|\frac{21\,190{,}50}{76\,661{,}20 - 12\,142{,}90} - 1\right|.100 \qquad [19]$$

$$\omega = 67{,}16\%$$

The results of the work

Grain harvesters were monitored in a private organization D-JD Chrabrany. In 2003 took up agricultural services for small businesses with an area of five hectares of land to grain harvester

FORTSCHRITT E514. The next season, the organization decided to offer its services to large agro-companies with a grain harvester CASE 527th. In the following years tried to cooperate with other types of marks from CASE. But with relatively dissatisfied reliability and low representation of service in the region decided to go to the John Deere brand with which cooperates today. The company currently has two grain harvesters have been the subject of my tracking for the last three years (2009-2011).

Specification monitored grain harvesters

John Deere CTS 9780 .The grain harvester was developed for high-quality processing of different types of crops, and even after degraded conditions. Degraded conditions can be regarded as a wet straw, excess returns and the like. The key is the threshing drum whose diameter reaches 660 mm and twin- separation CTS Cylinder Tine- Separation. For processing large amount of vegetable matter in less time helped us also Headertrak system which allows automatic copying of the field by cutting table. For his performance has also sufficient grain tank with a capacity of 10 000 l fuel tank with a capacity of 700 liters for long days spent in the field. To ensure better stability and easier to wade in wetted field is at the front tires with a width of 800mm.

Grain harvester John Deere 2264 or also called as the council "Z" is now not produced. We can say that this series did the distributors of brand good reputation in Slovakia. This is a relatively simple standard harvester with a single threshing drum and straw shakers with area 6.4 m^2. Grain tank volume is 7,000 liters, 500 liters fuel tank and has a power of 250 hp. Like the CTS as well as here on the front axle is 800 mm wide tires, the company D-JD is considered to be a great advantage. The operator has sufficient comfort and ease of use, although the diagnostic equipment is the lower class and less user friendly than the CTS. Equipment that harvester contains the straw shredder and cutting table, ranging 6.1 meters which is colza adaptor brand Zürn with two side scythes.

Fig. 1. John Deere 9780 CTS

Fig. 1. John Deere z2264

Monitoring

In the company annually begin to prepare for the season in mid-May. The primary task was always to find out what maintenance operations with the adjustment to be made on the basis of the actual state and the owner's manual or deficiencies found during the previous season. After such a diagnosis is procured all the necessary parts and fillings, not only to prepare for the season, but also parts of the so-called reserves. These parts are easily replaceable, inexpensive and they are great potential for occurring disorders based on experience from previous seasons. For those that are grain harvester spares as follows:

• fleshing knife,
• various sizes of fasteners (bolts, nuts, washers, etc.),
• securing rings,
• removable thumbs and their holders,
• crusher knives,
• some drive belts such as scythes,
• chain and knifes for the corn adaptor,
• lubricants.

Next, was determined the approximate maintenance schedule so that the grain harvester in failure-free state at least one week prior to the performance of its primary functions thus harvesting. This date is of course heavily dependent on weather. Daily maintenance was carried out every day when grain harvester worked, and lasted about one hour.

The tables are clearly shown the individual components of observations and their corresponding description. If the Mth column is not shown the figure, it means that it is a common fault that occurs several times per season, so any breakdown failures of this kind is not important in this work.

Table 1

Summary of monitoring grain harvester CTS

	year 2009	year 2010	year 2011
number of motor hours motor/separation	174/108 Mth	178/113 Mth	232/166 Mth
number of days when it worked	24 days	25 days	32 days
number of ha	407,6 ha	451,2 ha	582,2 ha
faults, that caused more than an hour NP	2 faults	3 faults	3 faults
scheduled downtime	56 h	118 h	137 h
unscheduled downtime	25 h	49 h	16 h
maintenance and repair time	33 h	65 h	43 h
authorized service repair time	10 h	7 h	5 h
fuel consumption	7 029 l	7 174 l	11 613 l
costs for repair and maintenance	433,50 €	507,50 €	449,50 €
costs of servicing	1 630,40 €	1 804,80 €	2 328,80 €
cost of spare parts	2 798,33 €	6 574,05 €	4 664,65 €
total cost for the season	4 862,20 €	8 885,35 €	7 442,95 €
receipts for services performed	21 684,32 €	24 003,84 €	30 973,04 €
profit for the period	16 822,12 €	15 118,49 €	23 530,09 €

The performance of the grain harvester is the most objective judge of proportion Mth separation system and the number of treated areas for a given period (the larger the time of observation, the result is a more objective). Performance of the cereal harvester is calculated according to relationship 18. For grain harvester CST9780 performance was 3.7 $ha.h^{-1}$ and series Z2264 had performance 2.8 $ha.h^{-1}$.

Table 2

Summary of monitoring grain harvester Z2264

	year 2009	year 2010	year 2011
number of motor hours motor/separation	208/127 Mth	204/142 Mth	213/130 Mth
number of days when it worked	21 days	24 days	24 days
number of ha	306 ha	338 ha	317,5 ha
faults, that caused more than an hour NP	3 faults	6 faults	4 faults
scheduled downtime	43 h	75 h	58 h
unscheduled downtime	34 h	26 h	18 h
maintenance and repair time	39 h	45 h	48 h
fuel consumption	4 131 l	4 492 l	4 129 l
costs for repair and maintenance	283 €	325,50 €	336,00 €
costs of servicing	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 the season	3 637,89 €	7 934,96 €	7 505,14 €
receipts for services performed	16 279,20 €	17 981,60 €	16 891,00 €
profit for the period	12 641,10 €	10 046,64 €	9 385,86 €

Conclusion

The aim of this study was to evaluate the operational reliability of grain harvesters. In the first part we defined the most important definitions of the issues as reliability, quality, downtime, maintenance and other costs.

In the next part I chose monitoring of grain harvesters in the actual operating conditions of a John Deere CTS9780 and Z2264 in smaller organizations, which deals with the harvesting of agricultural crops. Monitoring was in the range from 2009 to 2011. While monitoring a kept records particular data, which showed studied objects with the boundary conditions. After collecting all necessary data processing followed by that of literature and its judgment based on experience during the observation period.

The last part is followed to evaluate of the processed results and compare monitored grain harvesters. In comparison, we found out, that the grain harvester John Deere CTS9780 has more comparative data with better results. As for increased planned downtime incurred long before the preparation of grain harvester to harvest corn for grain. Where it was necessary to replace the large number of components for the crop, because the supply of machines for harvesting the crop is excessively high, and because the organization did not consider it necessary to deploy a second grain combine to harvest corn for grain. Another reason was that the cost of purchasing equipment for the harvesting of the crop is expensive. Another negative statistical indicator CTS were the total costs, which can also be attributed to this problem because less general maintenance in 2010, corn Geringhoff adapter, the costs exceeded the amount of € 3 000.

The latest negatives were losses in unscheduled downtime. Although the number of hours of unplanned downtime was greater for grain harvester Z2264. The fact of greater losses in unscheduled downtime caused performance of harvester CTS9780. Average fuel consumption for this work was not essential, because throughout all the monitoring of the consumed fuel paid the customer regardless of consumption of the harvester. Therefore, consumption is indicated only for information purposes only for future research.

Percentage expression of reliability includes all relevant parameters. If the increased downtime, or in the presence of small disorder, or anything related to the reliability. The relationship will never show a value of one hundred percent. It will always be present needed maintenance, service, fuel, downtime, failures, wear and others. And these are factors that need to be able to minimize reliability as close as possible to 100%. You can clearly see the need for continuous improvement in every way.

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