Agricultural, Forest and Transport Machinery and Technologies (ISSN: 2367 – 5888)
Volume I – Issue 1, 2014

Qualitative Analysis of the Combine Harvesters Production

Renata Stasiak-Betlejewska, Miroslav Prístavka, Hristo Beloev

Abstract: *Contemporary production of machines and equipment for the modern agriculture farms should meet current production trends that enable production in accordance to qualitative requirements providing the high level of the machines and equipment applying in the agriculture industry. Production course realization should be matched to the level of quality expected by the customer/user. According to this assumption in the production process there is necessary appropriate quality control with quality management tools applying. The article presents quality level analysis in the production of the harvester combines at high level producer in Germany production company.*

Keywords: *harvester combines, quality, Ishikawa diagram, Pareto-Lorenz diagram*

INTRODUCTION

Quality is the crucial element of the production course realized in all kinds of industries including production for agriculture equipment. The main challenge for the contemporary production is the process of quality problems identification and applying appropriate quality management tools that enables solving problems related to quality identified in the machines production.

MATERIAL AND METHODS

Kaoru Ishikawa, a professor at the University of Tokyo wondered what are the causes of failures, which often face different types of companies. In 1962, professor Ishikawa published assumptions of own diagram, which is called the graph of causes and effects, and because of the distinctive appearance – it was called a fishbone diagram. The scope of this quality tool application was initially limited to the industry, but in a short time it was proved to be useful in many other areas. Ishikawa diagram of causes and effects allows to rank the causes of abnormalities and interrelatedness of these reasons, using the chart. Its essence is a graphical presentation of the analysis of the specific problem causes interrelation [16, 13, 6]. The diagram performance should be result of the workers group effort since the causes of failures usually have its origins in different fields of action. Therefore, the workers team should consist of people with high expertise who will also have to disclose the reasons for the deficiency, including problems caused by themselves. Using heuristic methods during the scheme construction is very useful. Chart consists of arrows and descriptions, connecting in this way that the main arrow indicates the result, which is a description of the failure, which is studied. This is shown in Figure 1.

Categories of reasons shown in the figure 1 are usually chosen in accordance with the principle 5M + E [1] that concerns 6 factors: man (M), machine (M), material (M), method (M), management (M), environment (E) [4, 1, 8].

There can be also used other categories (e.g. procedures, equipment, materials, information, people) depending on the area in which the diagram is used. Each category of causes is extended by a further cause of details. If necessary, it be accompanied by a secondary cause. Expansion of the diagram ends when the phenomenon is fully identified. Graphical analysis of the problem is an ordered transfer of information, which is focused on the data hierarchy, locating and eliminating the problem causes and it facilitates the systematization of the possible causes of failure. Ishikawa diagram enables easy introduction of new proposals for the problem solving process. It is also the basis for further action and data collection in the quality improvement and production problems solving [15, 12, 10].

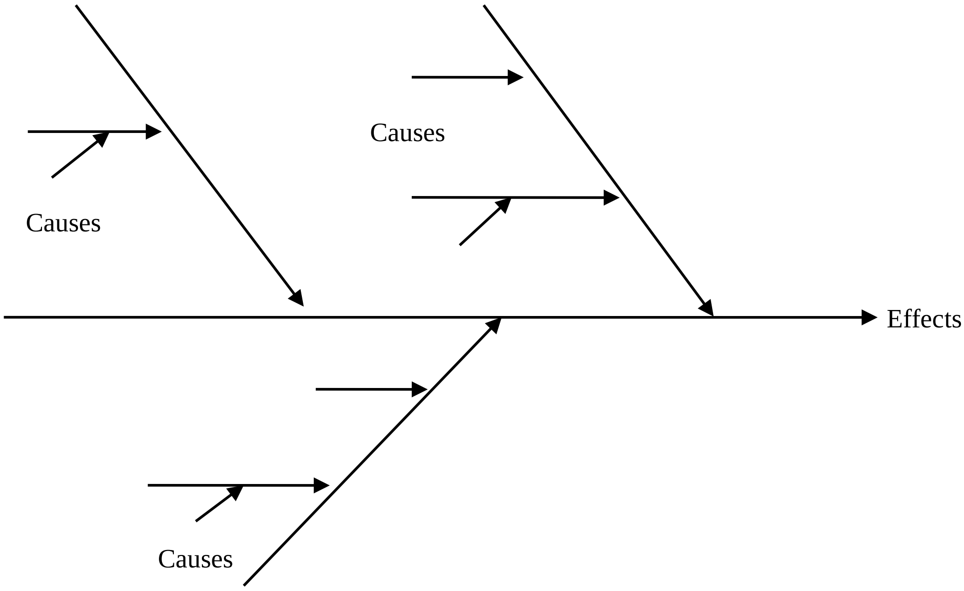

Figure 1. The principle of Ishikawa diagram construction [Borkowski S., 2004].

The other quality management tool that is used in the production quality problems identifying and solving is Pareto-Lorenz diagram based on the Pareto analysis. Pareto analysis is a tool to determine the validity of the factors causing the problem. It was invented by Italian economist who founded that uneven distribution of occurs exists in many areas of life (e.g. 20% of customers report 80% of all complaints). Generally, it can be stated, that 80% of all defects is a result of 20% of the causes. This means that the quality management efforts should be focused on eliminating the few phenomena, causes of errors that have a major impact on the final quality of the product. Pareto analysis is applied to organize and analyze previously collected data. It is used when production goal is to prevent [5, 2, 7]:

- negative phenomena with the greatest frequency,
- phenomena creating biggest costs.

Pareto-Lorenz diagram is a tool for prioritizing factors influencing the studied phenomenon. It is a graphical view showing both relative and absolute distribution of errors types, problems or its causes. It allows to present the data in a column diagram emphasizing the elements which give the largest contribution to the problem. There are basic assumptions for Pareto diagram creating process [3, 9]:

- identifying the problem to be analyzed,
- formulating a list of causes and definition of the categories,
- arranging a sets of reasons according to frequency or by costs that create an analyzed problem,
- drawing up a column diagram (Pareto diagram) based on an ordered list,
- analysis of the diagram in the context of the Lorenz curve (that presents accumulated values of the problem causes).

Research object characteristic

The research related to qualitative analysis of the combine harvesters production have been realized at one of the biggest producer of equipment for agriculture industry located in Western Germany, that is the largest manufacturer of agricultural machinery in the world, operating for over 150 years. It currently employs close to 55,000 employees in 140 countries. The analyzed company spends daily around $2 million for research and development. Combine that have been tested are produced in Zweibrücken factory, where the daily production is around 50 combines. The factory has a number of certifications, among others, ISO 9001:2008.

In the analyzed plant in Zweibrücken there are produced combine harvesters and forage harvesters. In total, the factory produced approximately 7,000 pieces combine WTS 9000 per year. The analyzed factory employs about 1,000 workers, where about 400 works in such sectors as construction, research and development, and the other directly in production. The main control system used in the production is a vacuum system (pull), but there are also noted MRP and MRP II systems which include embossing systems (push). Analyzed combines and tractors are produced only on the clients demand [7, 11, 17].

The analyzed object related to the study assumption is the brand combine harvester John Deere 9000 WTS (specifically the three parts of the harvester – heeder auger finger, blades for cutting strip and straw chopper knives). The auger's finger and knife blades are located in the front of the combine, and the chopper knives is located at the combine back. The eight machines of the 9000 WTS series were tested. Each of the analyzed machine performed a similar problem during the operation on the parts tests [14, 18, 19].

The aim of the study was to identify factors affecting the faults associated with the fingers of the screw, razor knife and chopper blades during operation of the combine. It also includes a preventive action which lead to minimize the number of defects during the using equipment. Identification of the causes of production nonconformities has been done with Ishikawa diagram and Pareto – Lorenz diagram applying.

Research findings analysis and discussion

The analyzed combine harvesters 9000 WTS production was started in the analyzed production plant in 2001. The production of the tested harvester amounted 7000 items in period 2001 – 2005.

Table 1. The general 9000 WTS combine model specification

Engine:	Brand:	The analysed model:
	Type:	9540i - 6068HZ060 9560i - 6068HZ470
	Engine power (in accordance to ECE-24) with at 2300 r / min	9540 -158kW (215hp) 9560 -181kW (248hp)
	Capacity:	6.8 L (414 cu. in.)
	Air filter:	Dry with safety element
	Thermostat (two)	82 C (180 F)
Electrical system:12 volt (120-amp alternator)		
Transmission: 3 speed		
Brakes: Hydraulic		
Cylinder:	Number of rasp bars	10
Concave:	Type:	13 open bar
Beater	Number of leaves	8
Beater grate	Type:	Open bars. Adjustable in two places
	Number	10
Finger rake	Type:	Regulated
Separator	Type:	Straw walkers
Straw walkers:	Type:	Universal
	Number of walkers	5
Separator power:	Type:	withdraw able
	The fingers number	15
The grain tank	Capacity:	7500 L (213 bu.)
	Average time to empty the tank	4200 L/min. (120 bu./min)
Weight	Without heeder	9540-12720 kg 9560-12580 kg
The fuel tank	Capacity	700 L

Source: own study based on the data from the company X.

The analyzed combine harvesters allow for the quick set, while reducing to a minimum the number of lost grain, high yield at harvest f the each plant kind in all conditions. The specification of the 9000 WTS combine was presented in table 1.

RESULTS

The first stage of the qualitative problems identification was related to Ishikawa diagram applying to identify main problems related to the product elements quality level. The main problem identified in the production of elements for the tested combine harvester concerns the fracture of auger fingers that cause the lower quality level of the produced combine harvesters.

Ishikawa diagram graphically presents the relationship between the causes and the problems associated with a particular concept to solve these problems. This tool helped in illustrating the main causes of faults identified in the production of combine harvester 9000 series associated especially with the combine part - heeder of auger fingers. Figure 2 shows the application of Ishikawa diagram in the presentation of nonconformities identified in the production of the heeder.

As it results from the analysis of the Ishikawa diagram (Fig. 2), where the main identified quality problem concerns fractures of the auger fingers, factors from the group “man” and “nature” have the greatest impact on the quality problems identified for heeders production. Therefore, the human labor should be taken into consideration as the quality problems source in the production. The action, which significantly improve the fault associated with the fingers of the screw is workers training within the problematic issue. Wrong setting of the heeder for high speed during harvest belong to the mistakes group that were committed, and much affecting the machine operation.

The Pareto – Lorenz analysis is used to determine the priority of corrective and preventive measures. It is a technique that allows carrying out activities aimed at improving the quality level. The primary source of information about the reasons for breaking up of the heeder fingers come from the owners of the analyzed combine harvesters 9000 series 600R with the heeder (Table 2).

Table 2. Basic data about the Combine harvesters 9000 series 600R with the heeder

Model of the combine	The production year	The working hours number
9640 WTS	2002	2086
9580 WTS	2002	2133
9680 WTS	2003	1986
9640 WTS	2004	1960
9640 WTS	2002	1854
9680 WTS	2003	2033
9580 WTS	2004	1366
9560 WTS	2002	1798

Source: own study based on the data from the company X.

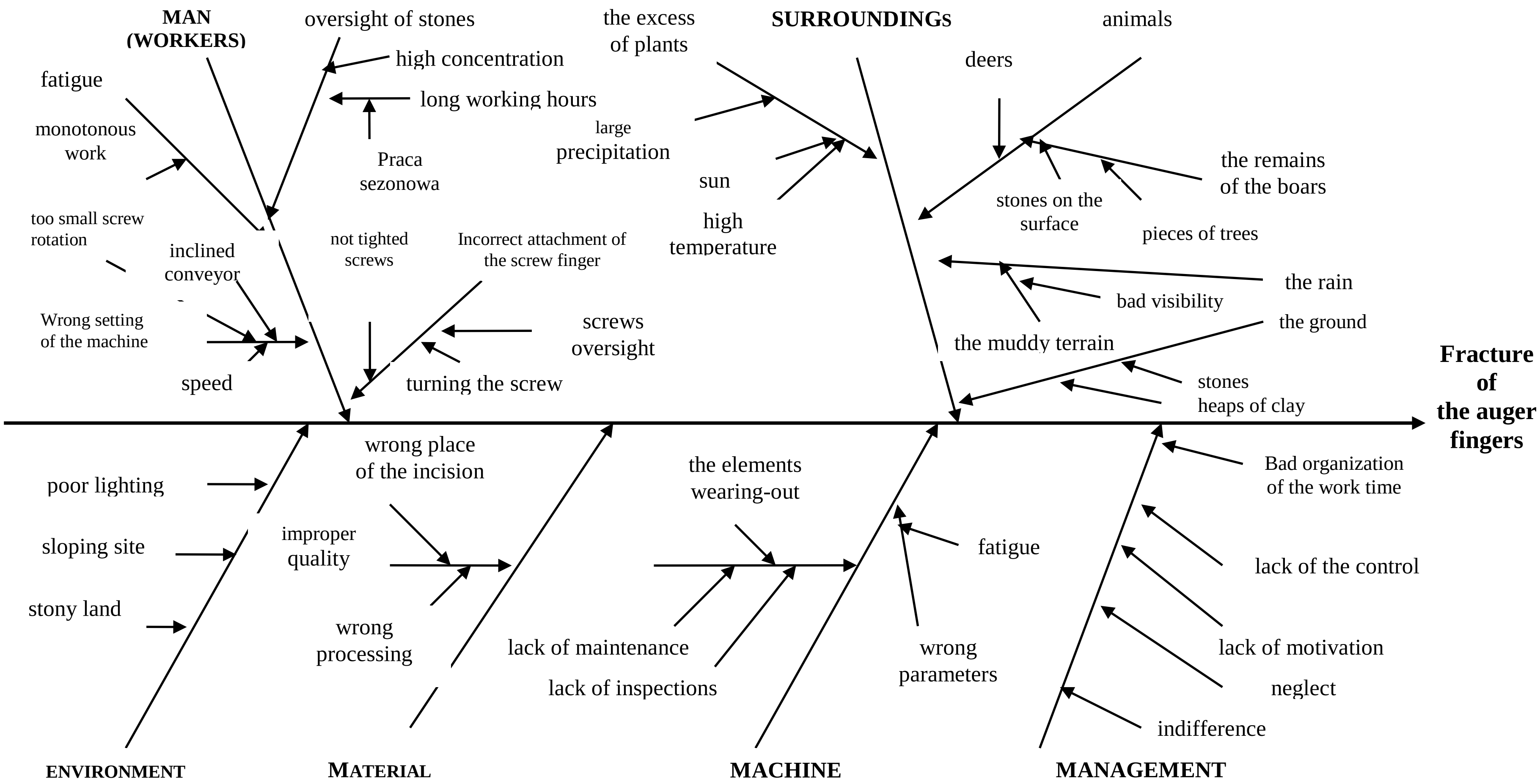

Figure 2. The Ishikawa diagram for the identified quality production problem: fracture of the auger fingers.
Source: own study based on the data from the company X.

The study was conducted in 4 years of analysed machine operation. The data obtained from the survey are shown in Table 3. The obtained data are the basis for the preparation of Pareto – Lorenz diagram (Fig. 3), which identified frequently mentioned reasons for breaking of the auger fingers during operation of studied 8 machines:

- W_1 - enters the stones to the heeder auger,
- W_2 - driving too fast while mowing,
- W_3 - poor heeder setting,
- W_4 - too low mowing height,
- W_5 - too much grain mass,
- W_6 - bad quality of the auger finger.

As it results from the analysis of the Ishikawa diagram (Fig. 2), where the main identified quality problem concerns fractures of the auger fingers, factors from the group “man” and “nature” have the greatest impact on the quality problems identified for heeders production. Therefore, the human labor should be taken into consideration as the quality problems source in the production. The action, which significantly improve the fault associated with the fingers of the screw is workers training within the problematic issue. Wrong setting of the heeder for high speed during harvest belong to the mistakes group that were committed, and much affecting the machine operation.

The Pareto – Lorenz analysis is used to determine the priority of corrective and preventive measures. It is a technique that allows carrying out activities aimed at improving the quality level. The primary source of information about the reasons for breaking up of the heeder fingers come from the owners of the analyzed combine harvesters 9000 series 600R with the heeder (Table 2).

Table 2. Basic data about the Combine harvesters 9000 series 600R with the heeder

Model of the combine	The production year	The working hours number
9640 WTS	2002	2086
9580 WTS	2002	2133
9680 WTS	2003	1986
9640 WTS	2004	1960
9640 WTS	2002	1854
9680 WTS	2003	2033
9580 WTS	2004	1366
9560 WTS	2002	1798

Source: own study based on the data from the company X.

The study was conducted in 4 years of analysed machine operation. The data obtained from the survey are shown in Table 3. The obtained data are the basis for the preparation of Pareto – Lorenz diagram (Fig. 3), which identified frequently mentioned reasons for breaking of the auger fingers during operation of studied 8 machines:

- W_1 - enters the stones to the heeder auger,
- W_2 - driving too fast while mowing,
- W_3 - poor heeder setting,
- W_4 - too low mowing height,
- W_5 - too much grain mass,
- W_6 - bad quality of the auger finger.

Table 3. Numeric list of the events, which testified to the broken auger finger in the study period.

No	The defect identification	The percentage of defects in the analyzed period [%]	The cumulative percentage in the analyzed period [%]
1	W_1	50	50
2	W_2	18,75	68,75
3	W_4	12,5	81,25
4	W_5	6,25	87,5
5	W_3	6,25	63,75
6	W_6	6,25	100
The sum		100	-

Source: own study based on the data from the company X.

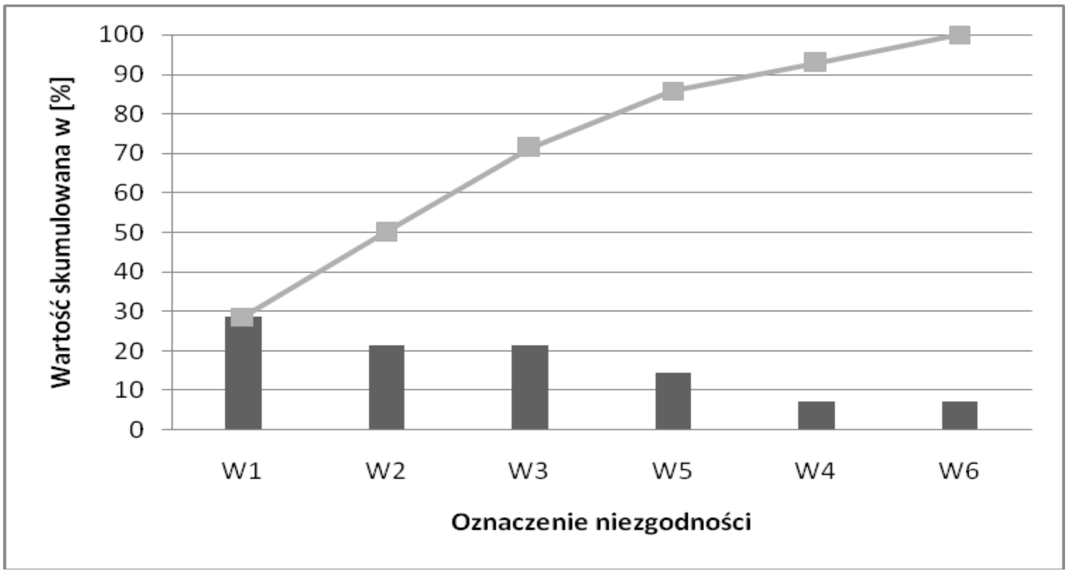

Figure 3. The Pareto-Lorenz diagram for the identified quality production problem: fracture of the auger fingers.

Source: own study based on the data from the company X.

Analysis of the data presented in Pareto – Lorenz diagram (Fig. 3) confirms that in the research period about 90% (precisely 81.25%) of identified nonconformities identified in the chosen harvester elements manufacturing process meet the following defects:

- W_1 - enters the stones to the heeder auger,
- W_2 - driving too fast while mowing,
- W_4 - too low mowing height,

Pozostałe wady stanowią łącznie tylko 18,75%

In order to reduce the number of identified defects on the fingers auger production and improve the manufacturing process there must be taken following corrective actions such as:

- focusing the attention to the stones lying in the field,
- reduction of the speed during threshing,
- appropriate setting the heeder height.

CONCLUSION

According to the research results achieved by the analysis of data presented with applying of Ishikawa diagram, we know the main causes of failure during the operation of the combine harvester, namely: the man and the environment. These two groups of reasons are responsible for most defects that cause the lower product quality and lower quality of the agriculture equipment operation. As an example of natural factors that negatively affect the combine work there can be given the occurrence of stones in the field. Heavy rains washed out the earth and the rocks are on top of which leads to fractures finger auger blade or knife. Factors causing the fault, and coming from the "man" is primarily a very fast speed while the combine and the wrong setting of the machine. High speed will provide more mass harvesting in a short period of time, the machine can deal with this not help it, and therefore takes break the fingers of the cochlea. In contrast, the low setting the heeder causes some moments of contact with the ground equipment, which leads to fracture blade knife.

The structure of defects in operation of 9000 WTS combine determined on the basis of Pareto – Lorenz diagram for research period (8 years) which identified six main quality nonconformities. Analyzing the results of Pareto - Lorenzo diagram, it can be seen that the greatest influence on the occurrence of auger fingers faults has defect W1 (stones penetrates to the heeder auger) and W2 (too fast, running the combine while mowing).

REFERENCES

[1] ADAMICKÝ, D. - KAPLÍK, P. - KORENKO, M. 2013 Analýza systému merania prostredníctvom metódy opakovateľnosti a reprodukovateľnosti. In Najnovšie trendy v poľnohospodárstve, v strojárstve a v odpadovom hospodárstve. 1. vyd. 1 CD-ROM (362 s.). ISBN 978-80-552-1014-8. Najnovšie trendy v poľnohospodárstve, v strojárstve a v odpadovom hospodárstve. Nitra : Slovenská poľnohospodárska univerzita, 2013, s. 1-8, 1 CD-ROM.

[2] BAKO, P. - KAPLÍK, P. - KORENKO, M. 2013 Využitie metódy 8D pri nezhodných produktoch. In Najnovšie trendy v poľnohospodárstve, v strojárstve a v odpadovom hospodárstve. 1. vyd. 1 CD-ROM (362 s.). ISBN 978-80-552-1014-8. Najnovšie trendy v poľnohospodárstve, v strojárstve a v odpadovom hospodárstve. Nitra : Slovenská poľnohospodárska univerzita, 2013, s. 27-36, 1 CD-ROM.

[3] BORKOWSKI S., 2004. Mierzenie Poziomu Jakości, Humanitas, Sosnowiec, 2004, pp. 36.

[4] BORKOWSKI S., Ulewicz R., 2008. Zarządzanie produkcją. Systemy produkcyjne, Wyższa szkoła Humanitas, Sosnowiec 2008.

[5] JAZON, A., 2002. Doskonalenie zarządzania jakością, Bydgoszcz 2002.

[6] KAPLÍK, P. - BURDA, M. - KORENKO, M. 2010 Zlepšovanie kvality vo výrobnej organizácii prostredníctvom metódy Poka Yoke. In XII. medzinárodná vedecká konferencia mladých 2010 : zborník vedeckých prác, 22. - 23. september 2010. Nitra : Technická fakulta SPU, 2010. ISBN 978-80-552-0441-3. , s. 66-71.

[7] KORENKO, M. - BELOEV, H. - KAPLÍK, P., 2013. Quality control, using PPAP method. *scientific monograph*. 1. vyd. Ruse : Angel Kanchev University of Ruse, 2013. 139 s. ISBN 978-619-7071-12-2 (brož.).

[8] KORENKO, M. - KAPLÍK, P. - JABLONICKÝ, J. - BULGAKOV, V. 2010 Detection of reserve production organizations by raising the performance of their production processes. In Mechanizacija ta elektrifikacija siľskogo gospodarstva. ISSN 0202-1927, 2010, vol.. 94, no. 1, s. 518-524.

[9] KORENKO, M. - KAPLÍK, P. - KARAS, A. 2010 Využitie benchmarkingu pri zvyšovaní kvality produkcie. In Kvalita a spoľahlivosť technických systémov : 15.

medzinárodná vedecká konferencia, 25.5. - 26.5. 2010, Nitra : sprievodná akcia Medzinárodného strojárskeho veľtrhu 2010 v Nitre = Quality and reliability of technical systems : 15th International scientific conference : accompanying event of International Machinery Faire 2010 Nitra. Nitra : Slovenská poľnohospodárska univerzita, 2010. ISBN 978-80-552-0390-4. , s. 96-100.

[10] KORENKO, M. - KAPLÍK, P. 2010 The process efficiency increase and quality improvement in manufacturing organizations by six sigma method. In Engineering and quality production. Dnipropetrovsk : Yurii V. Makovetsky, 2010. ISBN 978-966-1507-34-9. , s. 98-107.

[11] KORENKO, M. - KAPLÍK, P. 2011 Implementácia metódy 5S vo výrobnej organizácii. In Kvalita a spoľahlivosť technických systémov : zborník vedeckých prác. Nitra : Slovenská poľnohospodárska univerzita, 2011. ISBN 978-80-552-0595-3. , s. 41-46.

[12] KORENKO, M. - KAPLÍK, P. 2011 Improvement of process performance and efficiency in a production organisation using a Six Sigma method. In Acta technologica agriculturae. ISSN 1335-2555, 2011, ročl. 14, č. 4, s. 105-109.

[13] KORENKO, M. 2014 Manažérstvo kvality procesov. 1. preprac. vyd. Nitra : Slovenská poľnohospodárska univerzita, 2014. 111 s. ISBN 978-80-552-1157-2.

[14] LANČARIČ, D. - TÓTH, M. - SAVOV, R. , 2013. Which legal form of agricultural firm based on return on equity should be preferred? A panel data analysis of Slovak agricultural firms. In *Studies in Agricultural Economics.* Vol. 115, no. 3 (2013), s. 172--173. ISSN 1418-2106.

[15] SAVOV, R. - LANČARIČ, D., 2014. Strategický manažment. 1. vyd. Nitra : Slovenská poľnohospodárska univerzita, 2014. 142 s. ISBN 978-80-552-1137-4 (brož.).

[16] SMITH G.F.,1998. Quality Problem Solving, ASQ Quality Press, Milwaukee 1998.

[17] KADNÁR, M. - RUSNÁK, J. 2008 Ekologické oleje aplikované do oblasti klzných uložení : metódy, prístroje a interpretácia : monografia. 1. vyd. Nitra : Slovenská poľnohospodárska univerzita, 2008. 87 s. ISBN 978-80-8069-998-7.

[18] RUSNÁK, J. - KADNÁR, M. 2007 Optimalizácia kĺbového spojenia nosného rámu stavebného stroja Dumper Trag 30. In Výrobné inžinierstvo. - Košice : Technická univerzita, 2007. ISSN 1335-7972, 2008, roč. VII., č. 1, s. 49-50,60.

[19] RUSNÁK, J. - KADNÁR, M. - KUČERA, M. 2012 Výskum kľúčových parametrov klzných uložení mazaných ekologickými olejmi : metódy, prístroje a interpretácia. 1. vyd. Nitra : Slovenská poľnohospodárska univerzita, 2012. 87 s. ISBN 978-80-552-0764-3.

CONTACTS

Renata Stasiak-Betlejewska, Institute of Production Engineering, Faculty of Management, Częstochowa University of Technology, Poland, e-mail: renatastasiak@wp.pl

Miroslav Prístavka, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Slovakia, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia Tel.: +421376414105, e-mail: miroslav.pristavka@uniag.sk

Hristo Beloev, University of Ruse, Agrarian and Industrial Faculty, Department of Agricultural Machinery, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: hbeloev@uni-ruse.bg