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DURABILITY AS A CRITERION OF COMPLEX PRODUCT QUALITY ON THE EXAMPLE OF A COMPONENT IN THE FORM OF THE MANURE SPREADER GEARBOX SHAFT

Summary

The basic aim of this paper is an attempt to examine the phenomenon of qualitative differentiation, including the answer whether the improvement of product quality through an increase in its durability, is an appropriate, at the present times, way how to build a market advantage by the manufacturer of agricultural machinery, including manure spreaders. As part of the study, attempts to answer the question of whether, and if so, the differentiation of a complex product by increasing durability (quality) of its components, is the right strategy, taking into account the higher cost of production, have been made. For this purpose, a comparison of the cost of manufacturing the product comprised of higher quality components with the cost of the effects caused by a defect resulting in a product of lower quality. Taking up the discussion on the specific issues, the conceptual model of the thesis, corresponding to the listed paper's objectives, has been adopted, namely: the cost of the effects caused by a defect in a complex product is growing very rapidly with the distance between the moment of occurrence of defect and the time it was discovered, which confirms the expediency of manufacturing higher quality products, even at the expense of the originally assumed profit.

Key words: product quality, durability, manure spreader, gearbox shaft

WYTRZYMAŁOŚĆ JAKO KRYTERIUM JAKOŚCI PRODUKTU ZŁOŻONEGO NA PRZYKŁADZIE PODZESPOŁU W POSTACI WAŁKA PRZEKŁADNI ROZRZUTNIKA OBORNIKA

Streszczenie

Podstawowym celem niniejszej pracy jest próba zbadania zjawiska dyferencjacji jakościowej, w tym odpowiedź na pytanie czy doskonalenie jakości wyrobu, poprzez wzrost jego wytrzymałości, to właściwy w obecnych czasach, sposób budowania przewagi rynkowej przez producenta maszyn rolniczych, w tym rozrzutników obornika. W ramach badań podjęto próbę odpowiedzi na pytanie czy i jeżeli tak, to kiedy różnicowanie produktu złożonego, poprzez podnoszenie wytrzymałości (jakości) jego podzespołów, jest właściwą strategią, biorąc pod uwagę wyższe koszty wytwarzania? W tym celu dokonano porównania kosztów wytwarzania wyrobu składającego się z podzespołów wyższej jakości z kosztami skutków wywołanych przez wadę powstałą w produkcie niższej jakości. Podejmując dyskusję na temat poszczególnych zagadnień, przyjęto koncepcyjny wzorzec tezy, odpowiadający wymienionym celom opracowania, a mianowicie: koszt skutków wywołanych przez wadę w produkcie złożonym rośnie bardzo szybko wraz z odległością pomiędzy momentem powstania wady a momentem jej wykrycia, co potwierdza celowość wytwarzania produktów wyższej jakości, nawet kosztem pierwotnie zakładanego zysku.

Słowa kluczowe: jakość produktu, wytrzymałość, rozrzutnik obornika, wałek przekładni

1. Towards the perfect quality product – a few facts from the market of agricultural mechanisation

"Either we find a way to our customers, or they will go its own way" as D. Lee notes [5, p. 557]. There is no doubt about it. Therefore, the development of concepts and methods of management follows the variability of the conditions in which companies operate [7, p. 5]. In the context of the above, the management science has been enriched with new elements taken from the technical science, in order to efficiently and effectively respond to changes in the environment and business management system. The authors refer to the knowledge oriented towards learning the materials, technology of their production and processing, as well as the relationship between building and properties of the materials, which allows to use them better and to adapt to the needs of the developing technology.

Manufacturing plants of the agricultural machinery sector operating in Poland, wishing to effectively compete with the foreign companies with a strong and established posi-

tion, which are intensively and expansively entering our market, should consciously and flexibly shape their attitude towards changing conditions and needs of the market [3].

Therefore, according to the authors of this paper, it should be assumed that the quality will increasingly constitute a symbol of freedom of the customer choice and pressure, which an individual buyer can put on the manufacturer operating in the agricultural mechanisation sector. According to List [1, p. 1], this quality is the fulfilment of the customers' requirements in relation to the characteristics of the quality of products, the access to them at the right time, and the associated costs. The quality is a cause for satisfaction, and satisfaction is a good and reliable measure of quality. The quality must be present in thinking, behaviour and actions of customers.

The discussion on the quality assurance, the total quality management (TQM) is mostly ended in the demand for directing the company to manufacture the market-adapted products, i.e. reflecting the demands of potential customers leading to increase their satisfaction.

However, the authors are aware of the fact that in order to make working on the quality of the final product, which reaches the customer, more effective, it cannot be only restricted to work on the quality of this product. It must cover everything that we do and how we do, and thus the raw materials, semi-finished products, tools, processes, organisation of work, working conditions as well as knowledge resources and skills that employees of the company have. This so-called quality chain should also extend to suppliers and cooperators.

According to the study conducted by the authors among all the factors affecting the decision on the purchase of the agricultural machinery, the quality of the product (average assessment 4.65; 70% of responses for the assessment of 5 points) and the technological performance (average assessment 4.65; 72% of responses for the assessment of 5 points) have the greatest importance. The third place in the importance hierarchy is the brand (average assessment 4.56; 63% of responses for the assessment of 5 points), and right behind it is the price (average assessment 4.56; 65% of responses for the assessment of 5 points). Looking at the gradation of the core determinants made by the respondents, it can be concluded that the purchasing tendency is determined by the factors of a multilateral character. The study conducted during the International Fair of Agricultural Mechanisation POLAGRA - PREMIERY, held in Poznań on 16-19 February 2012. As part of the study, the respondents assessed the influence of selected factors on making their decision on purchasing the agricultural machinery.

The studies quoted above confirm that the product quality is of primary importance for the customer and affects the decision on purchasing in the agricultural mechanisation sector.

Therefore, the growing importance is assigned to the ability to see opportunities, which gives manufacturers the ability to implement a qualitative differentiation strategy, especially that [3, p. 96] in order to examine the phenomenon of differentiation from a strategic point of view, the question about the way of building a competitive advantage by the manufacturer of the product distinguishing itself among others.

As part of the conducted studies, the attempt to answer the question of whether the differentiation of a complex product by increasing its durability (quality) is the right strategy, taking into account the higher cost of production, has been made. According to the authors, the answer is affirmative. However, the adoption of such a strategy and manufacturing model requires a diagnosis and taking into account some assumptions by the manufacturer, namely: 1) the product quality is appreciated only by a predetermined segment of the market, and the offer should be addressed

for these customers, b) the existence of a sufficiently large number of customers, for whom distinct features of the product will be interesting due to the appropriate relationship between the value of the product and its price, is assumed, c) the uniqueness of the offer allows to leave the direct both price and cost competition because the product of a given company is difficult to compare with seemingly the same products from other manufacturers; they differ in the aspect of quality (read: durability), d) the most important features that have to be fulfilled by the products implemented for the first installation or as a replacement, they should focus on the design and establishment of the manufacturing process enabling the elimination of defects during their use. It is assumed that the customer will be able to see and appreciate the specifics of the offer.

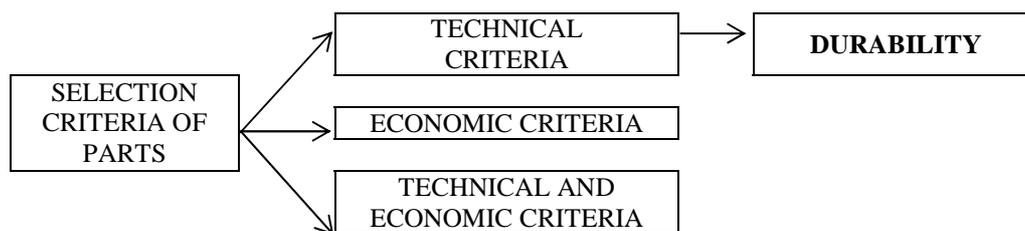
2. Durability as a determinant of the component quality of the complex product

On the agricultural mechanisation market, the identification of the customers' needs, enriched with the market research, should be a starting point to begin the process of manufacturing parts and components of the agricultural machinery. On the basis of the knowledge about the buyers' needs, a company develops the action plans. These plans are used by the sphere of production, designing and manufacturing planned products, and by the sale assisted by the marketing, which owing to its actions, provides customers of the implemented products. The need to purchase a selected part or component of the agricultural machine results from the desire to satisfy or use certain functions, which can be simply divided into three selection criteria (Fig. 1).

The technical criteria (value in use) refer to the factors related to the product use. In this study, it was assumed that in case of the gearbox shaft (Fig. 2), its durability, among others, constitutes a technical criterion.

In general terms, the durability deals with observing the behaviour of the body subject to external forces in terms of the corresponding (caused by them) internal forces as well as the corresponding stresses and deformations caused by them.

The basic assumption of the durability of materials is that the material body is deformed due to load. The field of engineering knowledge (technical sciences), a part of the mechanical engineering dealing with a description of the phenomena occurring in the construction materials and structures subject to external loads. A condition of a strain during the torsion does not consist in exceeding the permissible angle of relative rotation of cross sections per unit of length. More information: [4, p. 332 and other].



Source: own work / Źródło: opracowanie własne

Fig. 1. The selection criteria of parts on the market of agricultural engineering
Rys. 1. Kryteria wyboru części na rynku mechanizacji rolnictwa

There are two types of deformation: the elastic deformation, which disappears after the removal of load, and the permanent deformation, the so-called plastic deformations, which remain after the removal of their cause. It should be noted that the permanent deformations are accompanied by the process of loading from the beginning but their value begins to have practical importance (in case of linear elastic materials) after exceeding the scale, known as the elastic limit. In addition, it is assumed that in most cases, any deformation in relation to the dimensions of the body are slightly small, which anyway corresponds to the practical conditions of exploitation of the structural elements. In this paper, it was assumed that the durability category will involve the resistance to torsion. In the view of the above, it was assumed that torsion occurs when a pair of forces forming torque lies in a perpendicular plane to the axis of the structural element, which in the analysed case is the shaft.

3. How much does "quality" cost? – a comparison of the production costs in the context of the increased durability of the gearbox shaft

The studies, referred to in this part of the paper, were conducted in the manufacturing plant specialising in the production of agricultural trailers, and their components dedicated to the first assembly also to other factories of agricultural machinery.

The agricultural machinery industry is a quite extensive network of the suppliers providing components directly for their own production, to other factories, service stations as well as the secondary market of spare parts. Accordingly, in each of these cases, the individual requirements related to the product quality occur. In the view of the above, there is a need to comply with specific requirements of the buyer. In order to achieve the assumed objectives, presentation and verification of the assumptions, the authors found it appropriate to conduct a two-option analysis of the production costs related to the gearbox shaft of the spreading unit of the manure spreader (Fig. 2). The shafts are the parts of devices or machines supporting other elements rotating in the axis. In contrast to the axis, the shafts transfer the loads resulting in their torsion. Hence, their durability is so important.

In the further part of the paper, the studies concerning the durability of two components of the bevel gearbox of the spreading unit of the manure spreader have been presented. The gearbox shaft of the catalogue number

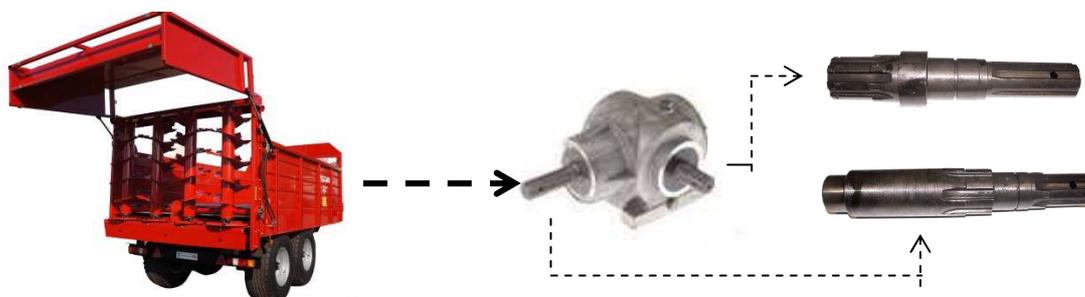
0200214480 and the gearbox shaft of the number 0200213100. The mentioned components, in a form of the shaft, constitute an element subject to a large load which is largely exposed to torsion. In the context of the above, the classification of gearboxes, where the first group of gearboxes included those, in which the drive shafts made of steel grade S235, was performed. According to the standard, this material is designed intended for the production of parts subject to low load, it is not very resistant to torsion. The factor grouping products according to their quality was a number of complaints after the conversion of applications into 50 pieces of the sold product. The thorough diagnosis allowed to identify the causes of damage. The components in the form of the said shaft proved to be "a bottleneck". It is called a normal-durability or general purpose constant value. R_e – the yield strength of this type of steel stands at 235 [MPa], while R_m – brake limit strength is 410 [MPa].

As part of the gearboxes belonging to the second group (higher quality), the steel of the 50HS grade, whose resistance to torsion, and at the same time, the "new" quality is much higher, was used. The spring steel – the steel used for the production of shock absorbers, springs and torsion bars. The yield strength of this type of steel stands at 1180 [MPa], while the brake limit strength is 1320 [MPa].

In the further part of the paper, the comparison of two options [O] of a given shaft production, reflecting its costs of production in relation to the total costs of the gearbox production was made.

Detailed data are presented in tables 1 and 2. The information necessary for the implementation of this part of the study was obtained by the authors on the basis of the analysis of the process sheet of the product as well as a result of the participant observation.

The total costs of manufacturing the gearbox shaft 0200214480 in the first option (a product of lower quality) oscillate at PLN 18.38. Taking into consideration the second option, within the framework of which the product of much higher durability parameters is obtained, and the manufacturer shall pay the cost of the gearbox shaft production at PLN 25.59 per piece. In the context of the above, the difference between the higher quality product and the product of reduced functional properties is PLN 7.21. Accordingly, the authors of this paper assume that in case of the shaft 0200214480, for higher quality, the manufacturer has to increase the additional cost of the mentioned amount.



Source: own work / Źródło: opracowanie własne

Fig. 2. The gearbox shaft of the spreading unit of the manure spreader
Rys. 2. Wałek przekładni aparatu rozrzucającego rozrzutnika obornika

Table 1. The analysis of the production costs of the gearbox shaft 0200214480 – the comparison of options
 Tab. 1. Analiza kosztów produkcji wałka przekładni 0200214480 - porównanie wariantów

| | | | | | |
|--------------------------------------|---|--------------------------------|--|--|--------------------|
| Gearbox shaft Product name | | 0200214480 Catalogue number |  | | |
| Raw material | | Dimension [mm] | Weight [kg] | Price of the raw material [PLN] | Total [PLN] |
| W I | Rolled bar grade S235 Cross section: 52 mm | L-280 | 4.68 | 2.56 | 11.98 |
| O II | Rolled bar grade 50HS Cross section: 52 mm | L-280 | 4.68 | 4.10 * | 19.19 |
| Labour costs ** [PLN] | | | | | 6.40 |
| TPC (total production cost) [PLN] | | Option I | | Option II | |
| | | 18.38 | | 25.59 | |

* The price was determined on 13.10.2014 by negotiation with the Multistal&Lohmann company

** As a part of the manufacturing operations, the following actions here distinguished: turning – PLN 2.40, milling – PLN 2.00, cutting – PLN 1.00, drilling – PLN 0.50, hardening – PLN 0.50

Source: own work work based on the study / Źródło: opracowanie własne na podstawie badań

Table 2. The analysis of the production costs of the gearbox shaft 0200213100 – the comparison of options
 Tab. 2. Analiza kosztów produkcji wałka przekładni 0200213100 – porównanie wariantów

| | | | | | |
|-------------------------------|---|--------------------------------|--|--|--------------------|
| Gearbox shaft Product name | | 0200213100 Catalogue number |  | | |
| Raw material | | Dimension [mm] | Weight [kg] | Price of the raw material [PLN] | Total [PLN] |
| O I | Rolled bar grade S235 Cross section: 52 mm | L-235 | 3.92 | 2.56 | 10.03 |
| O II | Rolled bar grade 50HS Cross section: 52 mm | L-235 | 3.92 | 4.10 | 16.07 |
| Labour costs * [PLN] | | | | | 6.60 |
| CKP [PLN] | | Option I | | Option II | |
| | | 16.63 | | 22.67 | |

* As a part of the manufacturing operations, the following actions here distinguished: turning – PLN 2.60, milling – PLN 2.00, cutting – PLN 1.00, drilling – PLN 0.50, hardening – PLN 0.50

Source: own work work based on the study / Źródło: opracowanie własne na podstawie badań

The same situation occurs in case of the shaft No. 0200213100. In the first option (a product of lower quality), the total costs of its production oscillate at PLN 16.63. Taking into consideration the second option, within the framework of which the product of much higher durability parameters is obtained, and the manufacturer shall pay the cost of the gearbox shaft production at PLN 22.67 per piece.

In this case, the manufacturer has to bear additional cost of PLN 6.04 for higher quality.

According to the conducted analyses, it is clear that the additional cost, incurred in connection with raising the quality of the gearbox (measured by the durability of the component in the form of the shaft), oscillates at PLN 13.25.

In the context of the above, the total costs of the gearbox production in the first option (a product of lower quality) oscillate at PLN.

At this point it is worth asking the question: is it worth economising on the quality of the component? The answer is clear. It is not worth it. The authors emphasise that the costs, which at first glance seem to be unjustified, in the long term, their raising is the most rational, and even advisable. In the following part of the paper, the case of complaints, the service of which significantly exceeded the costs of the so-called higher quality, was presented.

4. How much the low quality costs – the comparison of the costs of "higher" quality and the warranty service

In the context of the analysed case, the authors assume that the increase of costs of PLN 13.25 causes that in the production process, the manufacturer implements a greater product, in terms of the criterion of its durability. Generally, it can be said that "perfection" costs so much in this particular case. In terms of the conducted studies, the authors analysed the costs of effects caused by the defect occurred in the lower quality product, taking into account the sale of 73 gearboxes. The obtained results confirmed the authors' presumption, which can be paraphrased with the words "cheap does not mean good". In case of the gearbox performed on the components under the first option, the mentioned manufacturer paid high costs associated with the repair or replacement of a product free of faults. Since it is impossible to present all the incurred costs in such a short paper, the authors limited it to one example, where under the removal of a defect, the costs, significantly exceeding the amount of the so-called "higher quality", were incurred. It is worth mentioning that in case of option I, the manufacturer noted even 39 complaints per 73 sold gearboxes. It means that in 23%, the product did not meet the minimum quality criteria. As part of the second option, numerous defects occurred only in case of 2 pieces, which proves that 71 per 73 sold gearboxes met the durability standards.

Taking into account higher costs associated with the higher quality standards of the shaft, in case of the sale of 73 gearboxes, the manufacturer pays the additional cost, which is PLN 967.25. Considering only the costs of production and exchange of shafts in case of 39 complaints, the manufacturer suffers a loss of PLN 1882.14 and PLN 1365.39 related to the production of the shafts, which were damaged due to the low durability parameters. Due to the publishing requirements related to the volume of the article, the authors abandoned the analysis of other costs concerning the warranty service, such as e.g. transportation costs, installation costs (additional work), or the costs related to other shafts, and the gearbox components, damaged as a result of failure.

5. Conclusions

The studies conducted by the authors of this paper predispose them to present important conclusions, namely:

1. Every organisation, regardless of the potential and the occupied market position, should behave in a flexible and creative way, in other words, it must have the skills characteristic of small, aggressive, and innovative companies [2].
2. The quality, especially in case of the complex product, designed for the first assembly, is of the paramount importance.
3. It has to be born in mind, especially in view of the global market, in which the costs of service of a given complaint will amplify with the increasing distance of the buyer of a given product, in other words, the cost of the effects caused by a defect in the product increases very rapidly with the distance between the moment of its occurrence and the moment of its detection, which confirms the desirability of manufacturing higher quality products, even at the expense of the originally assumed profit.

4. The more complex is the product (a number of the components used in the process of their production), the greater the number of the components sensitive to the quality is, i.e. these, the insufficient quality of which may contribute to a defect of the entire finished product.

5. As for the implemented complex product, there may occur the components, "the low quality" of which is not economically justified, i.e. the costs, which at first glance, seem to be unjustified, in the long term, their raising is the most rational, and even advisable. Otherwise, the manufacturer is exposed to incur significantly higher costs associated with the warranty service.

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