Ishikawa diagram applied to identify causes which determines bearings defects from car wheels

L Luca¹, *, T O Luca²

¹Constantin Brancusi University of Targu Jiu, Str. Republicii nr.1, Targu Jiu, Gorj, România
²NURVIL SRL Targu-Jiu, Street Tismana, no.100, Targu-Jiu, Romania

Email: lylyanaluca@yahoo.com

Abstract. The use of quality management tools plays a great role in improving the quality of products or services offered and helping to ensure the internal efficiency and effectiveness of the organization as well as improving customer satisfaction. Considering the advantages of using quality management tools, the author of this paper presents a study on the application of the Ishikawa diagram for the problem of bearing defects from car wheels. A list of potential causes that generated the studied problem was made. Brainstorming method has also been used in this regard. The identified causes have been classified into four main categories: Man (M), Manufacturing of bearings (M), Service - Bearing replacement (S), Exploitation of the car (E). It resulted a new model of the Ishikawa diagram, that has the formula 2M + S + E. The Ishikawa diagram determined and presented in this paper identifies the causes that generate a non-quality type problem. The diagram provides the advantage of a correct orientation to correct nonconformities, as well as the basis for further studies with other appropriate methods, solutions or measures to eliminate the causes. This case study presented in the paper may be the basis for other studies related to the proposed problem.

1. Introduction
Increasing competitiveness and seizing sales markets has generated a new industry model, where quality is considered as a key factor for progress. At present, a new concept of quality is used, the concept of total quality, which also required the use of quality management tools.

Quality Management provides organizations with tools that help them find new solutions to ensure the continuation of the quality improvement process. Quality management tools are of two categories: some use definite data (numeric data), and others solve quality problems when there are no numeric data. In many cases solving some problems of quality management cannot be done in an analytical way and in these cases techniques for non-numeric data are used. For example, in the literature several tools are presented for analysing and identifying the causes that generate a problem: fishbone diagram (or Ishikawa diagram), tree diagram, relationship diagram, matrix diagram, affinity diagram, etc.

Several papers have been published in the literature that deal with the use of the fishbone diagram to find solutions to eliminate or reduce quality defects. A comprehensive study on the application of 5 management tools for quality improvement in universities was conducted by Al-Bashir Adnan and published in the paper [1]. The paper [2] presents a study of the application of quality management in quality planning. Also, papers [3] and [4] present case studies on the application of Ishikawa diagram for assessing and improving the quality of cars.
The defects of the welds were also analysed using a quality management tool and a study is given in the paper [5]. The Ishikawa diagram has been applied in various fields, including also public order services [6], in order to improve quality. Specialty literature shows that this diagram is very much used in the industrial field.

For example, paper [7] presents a new Ishikawa diagram designed to identify the causes that generate errors in evaluating the precision of execution of parts specific to machine building. Quality management tools have also been applied in the field of education. An interesting paper is [8], in this is presented the quality management applied in higher education.

An important application of quality management is given in the paper [9]. The papers [10], [11] present the use of modern tools of quality management in the study of the elimination of defects from some machine organs, in the field of industrial engineering.

The paper [12] shows a study on the causes of shrinkage defect in the castings for automobile. The authors of this paper present a procedure to identify the root cause and apply the Pareto diagram and the Ishikawa diagram. In the paper [13], Keqiang et al, present the analysis of the factors that influence the positioning performance in WLAN RSSI fingerprinting systems. In this paper the authors classify potential factors using the Ishikawa diagram.

The authors of the paper [14] propose an Ishikawa diagram that describes the factors that influence the success of IT investment. The diagram is based on six main factors.

In this paper it is used the fishbone diagram, which is based on non-numeric data, to show the causes that solve the problems proposed in the study, respectively the causes (factors) that determine the bearing defects from car wheels.

2. Factors influencing the bearing defects from car wheels

The Ishikawa diagram was invented in the 20th century by the Japanese professor Kaoru Ishikawa. Ishikawa is considered worldwide as one of the founders of quality management and modern management. Professor Ishikawa first used the term "tools" in quality management. The Ishikawa diagram is also called the fishbone diagram because it is built using a fish skeleton. The diagram provides visual support that stimulates the participants' creativity at the Brainstorming session. The diagram, through its form, highlights and hierarchies the actual or potential causes that generate a non-quality problem.

In this paper it is proposed to apply the fishbone diagram to highlight the relationships between a proposed general objective and the actions taken to achieve it.

For the diagram, the problem to be solved (also known as the general objective) is established: the bearing defects from car wheels. The steps of the diagram are proposed, according to the indications given in the paper [15]: define the effect; a list of all possible causes is drawn up, using the Brainstorming method; group the identified causes and define the main categories of possible causes; the diagram is started by writing the effect into a box on the right side; the main cause categories are positioned as power channels for the effect box; the diagram is developed by writing in the boxes all the secondary causes identified for each of the main causes.

In order to identify the causes (factors) and for achieving the proposed objective, a number of papers have been studied in which aspects of causes that determine the bearing defects, are presented. The research of factors related to the bearing defects from car wheels has been addressed for many years, so the literature is relatively extensive on this subject.

There is currently a major concern for the manufacture of new defect testing equipment, but also for the improvement of existing equipment. The paper [16] presents studies on defect testing equipment in bearings. The problem of small bearing defects is also addressed. Interesting studies of car wheels are also given in the paper [17], where the authors used the finite element method.

The literature shows that the problem of the bearing defects has been studied extensively. In [18] it is presented a new method of defect detection, that uses entropy. It is made a data processing using entropy (information entropy). In the paper are presented the experimental results showing that the entropy method is very effective in identifying defects and the frequency of defects.
The problem of bearings defects is detailed in the book [19]. The book is a manual edited by a Quebec society that deals with car insurance and covers several aspects related to: drivers while they are on the road, maintenance staff in the shop, mounting bearings, signs of bearing deterioration.

The book [20] shows, among others, the bearings theme and their reliability problems. The current investigations in wheel bearing diagnostic are very many and concern the causes of bearing failure, test methods and remedy and defect prevention measures.

Based on studies of specialized works, but also as a result of a Brainstorming meeting, they were drawn up a list with the potential factors that generate the problem: the bearing defects from car wheels. Brainstorming was attended by several specialists with more than 20 years of professional experience, including: professors of mechanic’s discipline, professors in quality management discipline, engineers specializing in automobile construction, engineers specializing in the repair and use of automobiles, engineers specializing in processing technologies and others.

The potential factors identified were grouped into the following categories:

**Man (operator):**
- The moral behaviour of every operator,
- The experience,
- Communication skills,
- Professional training,
- Indiscipline about technology compliance,
- The car drivers have different thresholds of perceptions.

**Manufacturing of bearings:**
- Inappropriate manufacturing documentation,
- Deviations from the prescribed manufacturing process,
- Machine tools inadequate,
- Inappropriate materials,
- Inappropriate heat treatment,
- Inappropriate machining devices,
- Inappropriate testing equipment,
- Wrong settings of quality testing equipment.

**Service- Bearing replacement:**
- Mounting that does not meet the technical prescriptions,
- Mounting of an inappropriate bearing,
- Inappropriate tools and devices,
- Inappropriate mounting procedure (with errors),
- The sensitivity of diagnostic tools for bearing defects
- Wrong settings of bearings test tools.

**Exploitation of the car:**
- Required bearing for heavy loads due to the masses loaded on the vehicle above the maximum allowable limit,
- Speed of movement above the maximum admissible limit,
- Driving at high speeds over road bumps,
- The car hits road curbs during the movement,
- Inflated tires at a pressure greater than the pressure provided by the car manufacturer,
- Frequency and intensity of braking,
- Long periods of vehicle immobilisation under improper conditions (high temperature, snow stored on the wheel).

3. A new model of the Ishikawa diagram for the bearing defects from car wheels
This article attempts to synthesize a new classification of factors that determine the bearing defects from car wheels, based on the theory of the fishbone diagram. In order to achieve the fishbone
diagram, the causes (factors) were identified and grouped in 4 main categories: Man (M), Manufacturing of bearings (M), Service- Bearing replacement (S), Exploitation of the car (E).

**Figure 1.** Ishikawa diagram, a new model
4. Conclusions

In all cases where the solving of quality problems cannot be done in an analytical way, use of techniques and tools for non-numeric data is used.

The Ishikawa diagram is one of the non-numeric tools that help us discover the important links between the various variables and the possible causes that influence a particular problem. The diagram provides a graphical illustration of the link between a result and the factors that determine this result, and also helps to address the causes and their elimination.

The diagram, through its design, stimulates creativity and challenges the imagination of the participants in search of suitable ideas for solving the problem.

The Ishikawa diagram developed in this paper highlights the real and potential factors that cause defects in bearings from car wheels. In this case the diagram enables dealing with particular problem comprehensively (the bearing defects from car wheels) and the diagram helps eliminate causes behind the problem. The determined Ishikawa diagram (model diagram: 2M+S+E) graphically illustrates the link between an effect - the defects of the car bearings and the actual and potential causes that cause these defects. The diagram is based on four main factors: Man (operator), Manufacturing of bearings, Service- Bearing replacement, Exploitation of the car.

The studied effect is a negative one and expresses non-quality bearing problems. Identifying causes is a useful step in solving the problem (the effect).

The study presented in the paper could be extended to measure the effects of each cause in order to prioritize the measures (actions) to be implemented.

The Ishikawa diagram presented in the paper may be useful in quality management within companies for manufacturing of bearings and in automotive repairs workshop.

Intelligent use of classical and modern quality management techniques and tools is an innovative way of measuring, analyzing and improving the quality of products or services offered to customers for industrial organizations and institutions with different activities.

References
[1] Al-Bashir A 2016 Int. J. Oper. Prod. Manag 4 87-98
[2] Cirtina L M, Cirtina D, Luca L 2014 Rev. App. Mech. and Mat. 657 891-895
[3] Luca L, Stancioiu A 2012 Proc. Int. Conf. The 3-rd Int. Conf. on Aut. and Transp. Syst. (Montreux, Switzerland) 192-195
[4] Luca L 2015 App. Mech. and Mat. 809-810 1257-1262
[5] Luca L, Cirtina L, Stancioiu A 2014 App. Mech. and Mat. 657 256-260
[6] Luca L, Filip C P 2011 Proc. Int. Conf. The Knowledge (Sibiu) 691-696
[7] Luca L 2016 Proc. Int. Conf. IMANEE 161-165
[8] Luca L, Cirtina L M 2011 Leadership- a principle of quality management in the context of an organization of faculty type, Proc. Int. Conf. 18th IECS (Sibiu) 195-198
[9] Radulescu C, Cirtina L M, Ghimiși S S 2015 Proc. Int. Conf. International Multidisciplinary SGEM GeoConferences (Bulgaria)
[10] Ghimisi S, Nicula D 2018 Actions to increase the reliability of chain transmissions, Proc. Int. Conf. The 22th edition of IManEE (Chisinau)
[11] Ghimisi S 2018 Sc. Bull. of Nav. Acad. 21 103-108
[12] Chokkalingam B, Raja V, Anburaj J, et al. 2017 *Arch. Foundry Eng.* 17 174-178
[13] Keqiang L, Yunjia W, Lixin L, et al. 2017 *Mob. Inf. Syst.* Article Number: 8294248
[14] Fauziah A, Ghani A, Aryati W, Noor Habibah A 2013 *Proceedings of the 4th Int. Conf. on Inf. Syst. Manag. and Eval. (ICIME 2013)* 27-34
[15] Kifor C V, Oprean C 2002 *Ingineria calității* (Sibiu: Editura Universitatii Lucian Blaga)
[16] Strackeljan J, Goreczka S 2010 *Proc. Int. Conf. The Seventh Int. Conf. on Cond. Mon. and Mach. Fail. Prev. Tech.*
[17] Moon H K, Lee M C, Joun M S 2007 *Finite Elem. Anal. Des.* 44 (1-2) 17-23
[18] Chen B, Zhaoli Y, Wei C 2014 *Entropy* 16 607-626
[19] *Wheel loss due to faulty bearings* 2017 (Quebec:Manual of Societe de l’assurance automobile du Quebec)
[20] Ghimisi S 2005 *Proiectarea Transmisilor Mecanice* (Bucuresti: Ed. Didactica si Pedagogica)