A new model of Ishikawa diagram for quality assessment

Luca Liliana

University ”Constantin Brâncuşi” of Targu-Jiu, Str. Eroilor, No.30, Romania

E-mail: lylyanaluca@yahoo.com

Abstract. The paper presents the results of a study concerning the use of the Ishikawa diagram in analyzing the causes that determine errors in the evaluation of theparts precision in the machine construction field. The studied problem was"errors in the evaluation of partsprecision” and this constitutes the head of the Ishikawa diagram skeleton.All the possible, main and secondary causes that could generate the studied problem were identified. The most known Ishikawa models are 4M, 5M, 6M, the initials being in order: materials, methods, man, machines, mother nature, measurement. The paper shows the potential causes of the studied problem, which were firstly grouped in three categories, as follows: causes that lead to errors in assessing the dimensional accuracy, causes that determine errors in the evaluation of shape and position abnormalities and causes for errors in roughness evaluation. We took into account the main components of parts precision in the machine construction field. For each of the three categories of causes there were distributed potential secondary causes on groups of M (man, methods, machines, materials, environment/ medio ambiente-sp.). We opted for a new model of Ishikawa diagram, resulting from the composition of three fish skeletons corresponding to the main categories of parts accuracy.

1. Introduction

Most organizations use quality tools for various purposes related to controlling and assuring quality. Although a good number of quality tools specific are available for certain domains, fields and practices, some of the quality tools can be used across such domains. These quality tools are quite generic and can be applied to any condition. There are seven basic quality tools used in organizations. These tools can provide much information about problems in the organization assisting to derive solutions for the same.

The seven tools are: histogram, cause-effect diagram, Pareto diagram, correlation diagram, control chart, data stratification, Brainstorming.

Ishikawa diagrams were popularized in the 1960s by Kaoru Ishikawa, who pioneered quality management processes in the Kawasaki shipyards, and in the process became one of the founding fathers of modern management. It is known as a fishbone diagram because of its shape, similar to the side view of a fish skeleton.

Dr. Kaoru Ishikawa (1915 – 1989) was a Japanese professor, advisor and motivator with respect to the innovative developments within the field of quality management. Kaoru Ishikawa is best known for the development of the concept of the fishbone diagram, which is also known as the ‘Ishikawa diagram’. This diagram is still used in many organizations for making diagnoses or taking concrete actions in which the root cause of the problem is identified.

With his cause and effect diagram (also called the "Ishikawa" or "fishbone" diagram), management leader made significant and specific advancements in quality improvement.

The design of the diagram looks much like a skeleton of a fish. Fishbone diagrams are typically worked right to left, with each large "bone" of the fish branching out to include smaller bones containing more detail.

The technique uses a diagram-based approach for thinking through all of the possible causes of a problem. This helps you to carry out a thorough analysis of the situation. There are four steps to using the tool:

1. Identify the problem.
2. Work out the major factors involved.
3. Identify possible causes.
4. Analyze your diagram.

Causes are usually grouped into major categories to identify these sources of variation. The categories typically include:

- People: Anyone involved with the process;
- Methods: How the process is performed and the specific requirements for doing it, such as policies, procedures, rules, regulations and laws;
- Machines: Any equipment, computers, tools, etc. required to accomplish the job;
- Materials: Raw materials, parts, pens, paper, etc. used to produce the final product;
- Measurements: Data generated from the process that are used to evaluate its quality;
- Environment: The conditions, such as location, time, temperature, and culture in which the process operates.

Ishikawa diagram is being defined as a graphic representation that schematically illustrates the relations between a specific result and its causes, [1,2]. The studied effect or negative problem is “the fish head” and the potential causes and sub-causes define the “fish bone structure".

Therefore, the diagram clearly reveals the relations between a problem identified in a product and its potential causes.

Ishikawa Diagram is a simple graphical instrument to understand the causes that produce quality defects and is used to analyze the relation between a problem and all possible causes. All categories of causes start with the letter M (machines, methods, man, materials, maintenance, mother nature - environment, management) for the productive domains. 4M, 5M, 6M, 7M Ishikawa diagram were performed like this.

In [3] it is shown that obtaining a correct diagram is possible only through working in a team with experience. An interesting model of Ishikawa diagram was developed in the case of some automotive defects [4,5].

In [6] it is presented a method for assessing the quality of welding by applying one of the classic instruments of quality management.

Ishikawa diagram application areas are continuously expanding. For example, nowadays the method is also being applied in the medical field [7].

In [8] it is presented a study regarding tracing the cause-effect diagram concerning the tolerance dimensions by using software instruments.

Many specialized work in the fields of Quality Management and Quality Engineering show different patterns of Ishikawa diagrams. We can illustrate with a few categories of main cases which were the basis of some existing Ishikawa diagrams, [3,9,10,11,12,13,14]:

Man, Method, Measurement, Machine, Material;

-Material, Personnel, Process, External factors, Management;

- Software, Users, Hardware, Environment;
- Equipment, Process, People, Materials, Environment, Management;
- People, Material, Method, Environment, Machine;
- Working conditions, Raw materials, Management, Technology, Machine, Workers;
- Measurements, Materials, Personnel, Environment, Methods, Machines;

- Transport, Premises, People, Clients, Finance, IT;
- Physical evidence, People, Place, Service, Process, Promotion, Price, Productivity & quality
-Equipment, Policies, Procedures, People, Environment, Measurement;
-Measurement, Material, Man, Mother nature, Machine, Method;
-Environment, Material, People, Equipment, Process;
-Technology, Procedures, Policies, People.

The paper presents the results of a study concerning the use of the Ishikawa diagram in analyzing the causes that determine a non-quality problem in the evaluation of the parts precision.

The studied problem was "errors in the evaluation of the parts precision in the machine construction field".

The development of the Ishikawa diagram in a detailed form for determining the possible causes of a problem has the advantage of giving the possibility of identifying and analyzing all the factors connected to the problem.

2. Study concerning the use of the Ishikawa diagram in analysing the causes that determine errors in the evaluation of the parts precision

The non-quality problemstudiedin this paperis"errors in the evaluation of the parts precision in the machine construction field". This paperproposesIshikawadiagramby covering the stepssetforthbyDalein[15], namely the following:
- It is defined very clearly the effect of the problem considered,
- It is written the effect in the right and it is drawn a line from right to left,
- It is checked if each team member has understood well the problem,
- They are determined the main categories of causes which are the main branches of the diagram,
- It is organized a brainstorming session to determine possible secondary causes,
- It is organized another brainstorming session in order to discuss in detail the causes and to determine those who have the major degree of probability for producing the studied effect,
- They are traced and recorded the appropriate sub-branches.

Following the brainstorming session conducted with specialists from the technical measurements domain, potential causes were identified coming from 3 directions.

The study identified three directions from which derive the causes:

A) Causes that lead to errors in evaluating the dimensional accuracy, fish skeleton -(5MA):

Man: tired and nervous operator; untrained operator, inexperienced operator; carelessness within measuring;

Methods: inadequate measuring method; inaccurate measuring scheme; error of the position of the measured object; error of the position of the device; errors of the regularization procedure; inaccurate regularization to the nominal size; number of the realized measurements; suppression of gross errors; blocks with inaccurately chosen amount of scales; not applying the corrections generated by systematical errors;

Machines: A. devices with an accuracy inadequate to the tolerance; devices with inadequate measuring limits; attrition of the devices; not observing the periodical metrical checks; errors of the device limiting the measurement force; theoretical errors of the devices; abnormalities of the measuring surfaces; inaccurate choice of the sensitive contacts; inaccurate choice of the changeable elements (tips, calibrated wires);

Materials: patterns realized with flaws; scales not clinging; opening of the position prisms; caliber attrition; spatial variations of the piece;

Medio ambiente (sp.) / Environment: temperature, pressure, humidity, vibrations, noise, light, air composition.

B) Causes that determine errors in the evaluation of shape and position abnormalities, fish skeleton -(5MB):

Man: tired and nervous operator; untrained operator, inexperienced operator; carelessness within measuring.

Methods: inaccurate choice of the measuring base; the position of the verified surfaces; errors of the regularization procedure; inadequate measuring method; inaccurate measuring scheme; error of the position of the measured object; error of the position of the device.

Machines: Errors within the movement system of the measured object; errors within the movement system of the device; errors of the design of the measuring device; errors within the fabrication of the measuring device; devices with inadequate measuring limits; not observing the periodical metrical checks;

Materials: Spatial variation of the surfaces; scales not clinging;

Medio ambiente (sp.) / Environment: temperature, pressure, humidity, vibrations, noise, light, air composition.

C) Causes for errors in roughness evaluation, fish skeleton - (5MC):

Man: visual acuity; eye sensitivity and adaptation, tired and nervous operator; untrained operator, inexperienced operator; carelessness within measuring.

Methods: A. inadequate measuring method; inaccurate measuring scheme; error of the position of the measured object; error of the position of the device; number of the realized measurements.

Machines: Flaws of the printing system of the roughness graph; altered tip of the sensitive contact; errors of the movement device of the sensitive contact; inaccurate settings of the working parameters of the devices; flaws of the optic systems; not observing the periodical metrical checks;

Materials: Bending of the piece surfaces; inadequate roughness samples;

Medio ambiente (sp.) / Environment: temperature, pressure, humidity, vibrations, noise, light, air composition.

3. A new model for Ishikawa diagram

We determined many possible causes and potential sub-causes and we grouped them into three main causes of the defect:

A. Causes that lead to errors in evaluating the dimensional accuracy,

B. Causes that determine errors in the evaluation of shape and position abnormalities,

C. Causes for errors in the evaluation of roughness.

For each of the three categories of causes there were distributed potential secondary causes on groups of M (man, methods, machines, materials, Medio ambiente (sp.)/ Environment). We opted for a new model of Ishikawa diagram, resulting from the composition of three fish skeletons corresponding to the main categories of parts accuracy. This new model with the formula (5MA + 5MB + 5MC) adds itself to the list of multiple choice Ishikawa diagrams that have been created so far. We opted for a new model of Ishikawa diagram, resulting from the composition of three fish skeletons corresponding to the main categories of parts accuracy. This diagram is presented in the paper, figure 1.

4. Conclusions

Above seven basic quality tools help you to address different concerns in an organization. Therefore, use of such tools should be a basic practice in the organization in order to enhance the efficiency.

Performing the Ishikawa diagram in a more detailed form in order to determine the potential causes of a found defect has the advantage that it offers the possibility to identify and analyze all factors, which relate to the problem studied.This tool is excellent for capturing team brainstorming output and for filling in from the 'wide picture'. Helps organize and relate factors, providing a sequential view. This diagram deals with time direction but not quantity. It can become very complex and can be difficult to identify or demonstrate interrelationships.

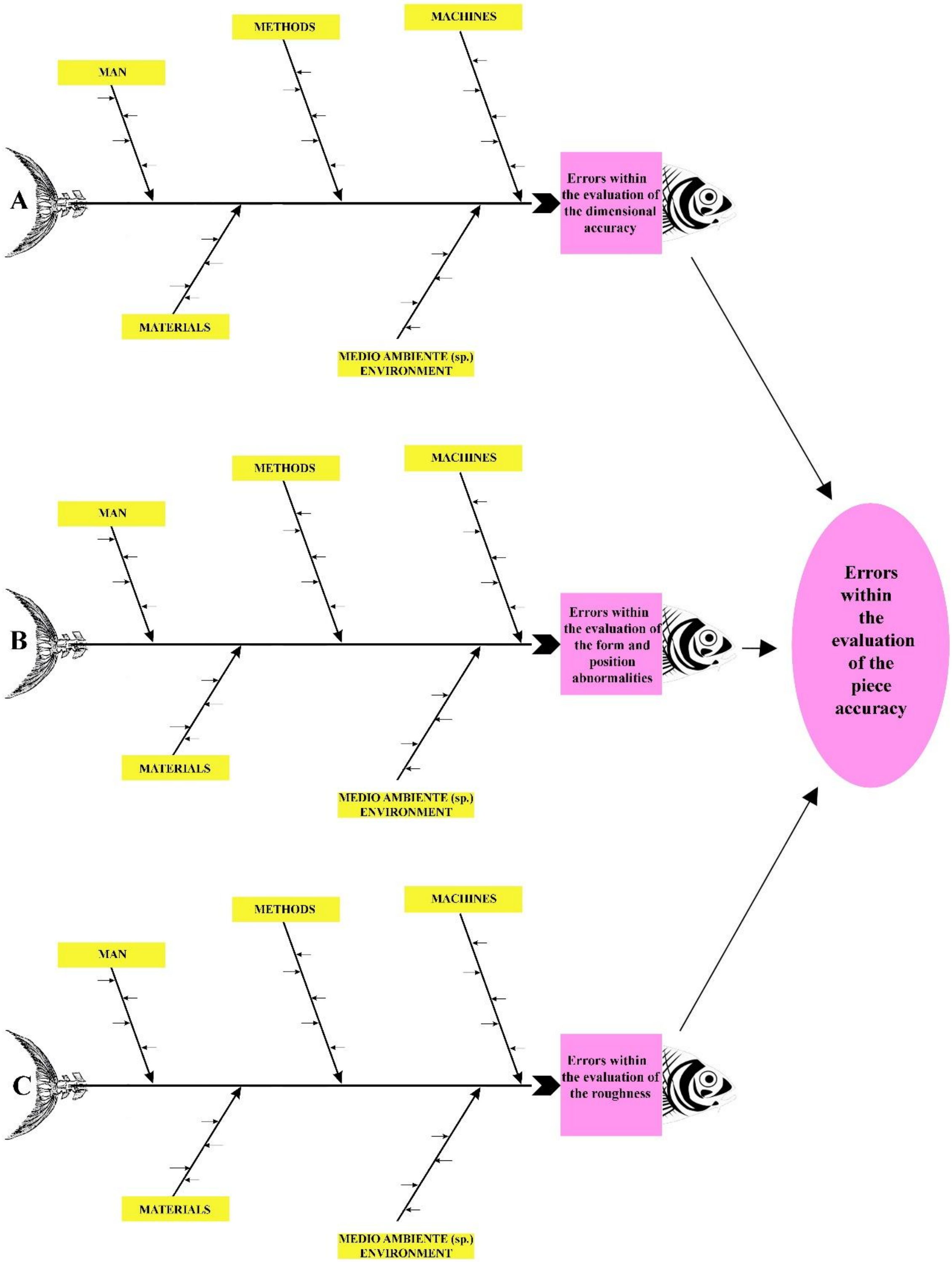

Figure 1. A new model of Ishikawa diagram, ($5M_A+5M_B+5M_C$)

IOP Conf. Series: Materials Science and Engineering **161** (2016) 012099 doi:10.1088/1757-899X/161/1/012099

Benefits of Using a Cause-and-Effect Diagram: helps determine root causes; encourages group participation; uses an orderly, easy-to-read format; indicates possible causes of variation; increases process knowledge; identifies areas for collecting data. The paper presented a new formula for the Ishikawa diagram was determined, (5MA + 5MB+5 MC). The determined Ishikawa diagram provides a complete picture of all potential causes that produce the studied failure.

The application of control and quality assessment techniques proves the important role that the customer with his requirements has. The traditional tools of quality management are the base in many organizations where improving quality is desired and they must be known and applied.

References

[1] American Society for Quality, Fishbone diagram. http://www.org/learn-about-quality/cause-analysis-tools/overview/fishbone.html

[2] Ishikawa K, Loftus J H (Eds)1990 *Introduction to quality control* , Tokyo Japan: 3A Corporation.

[3] Paraschivescu A O 2006 *Managementul calitatii,* Tehnopress Publishing (Iasi) pp.155-156.

[4] Luca L 2011 Study on the determination and classification of the causes that determine the faulty operation of a vehicle fuel pump. Recent Researches in Manufacturing Engineering. 3-rd WSEAS International Conference On Manufacturing Engineering, Quality and Production System (MEQAPS'11). Published by WSEAS Press ISBN 978-960-474-294-3 pp. 21-24.

[5] Luca L 2015 *The Study of Applying a Quality Management Tool for Solving Non-Conformities in an Automotive. Applied Mechanics and Materials* ISSN: 1662-7482 Vols. **809-810**Trans Tech Publications (Switzerland) pp 1257-1262.

[6] Luca L 2014 *Study on Identification and Classification of Causes which Generate Welds Defects. Applied Mechanics and Materials* ISSN: 1662-7482 Vol. **657** Trans Tech Publications (Switzerland) pp 256-260.

[7] Kam Cheong Wong 2011Using an Ishikawa diagram as a tool to assist memory and retrieval of relevant medical cases from the medical literature. *Journal of Medical Case Reports* 5:120. http://www.jmedicalcasereports.com/content/5/1/120.

[8] Cirtina L M 2012 *Improving the quality of processes by drawing cause-effect diagram using software instruments* 12h International Multidisciplinary Scientific Geoconference (SGEM), (Albena) Vol. **IV**, pp. 1017-1021.

[9] Cananau N 1998 *Sisteme de asigurarea a calitatii* Junimea Publishing (Iasi) pp121-126.

[10] Ionita I 2008 *Managementul calitatii si ingineria valorii* ASE Bucuresti Publishing pp186-187.

[11] Pruteanu O 1998 *Managementul calitatii totale,* Junimea Publishing (Iasi) pp.166-167.

[12] Ilie G, Ciocoiu C N 2010 *Application of Fishbone diagram to determine the risk of an event with multiple causes. Management Research and Practice, Vol.* ***2*** *Issue 1*pp: 1-20.

[13] http://www.cityprocessmanagement.com/Downloads/CPM_5Ys.pdf

[14] http://www.nursingtimes.net/Journals/2013/04/12/k/x/z/Using-fishbone-analysis--to-investigate-problems-160413.pdf

[15] Dale, B G 1994 *Managing quality* (2-nd Ed.), Prentice Hall, (Horls).