Analysis and Elimination of Nonconformity Causes – Increase of Organization Efficiency

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The article deals with the products poor quality diagnosing method – causes and effects diagram used for eliminating non-conformance causes as soon as possible. Problem importance is embedded in organization efficiency. Products quality control principles are formulated, the order of causes identification is shown, causes and effects diagram building principles and the ways of analysing this diagram results are presented. Conclusions emphasise the importance of the effects detailed definition prior the causes analysis process.

Keywords: non-conformance, effects, causes, quality assurance, quality control, causes and effects diagram.

Introduction

Problem and its relevancy. Organization efficiency is the relationship between the result achieved and the resources used (LST EN ISO 9000:2001). The costs for quality assurance enter into the sum of used resources and make up a significant part of them. Naturally, in order to increase organization efficiency we have to reduce also costs, related with quality, especially with that part, which is named “costs of failure” (Vanagas, 2004).

Quality is the degree to which a set of inherent characteristics fulfill requirements (LST EN ISO 9000:2001). Speaking about the products quality we say that a faulty product is the one which does not confirm the requirements set up to it. Generally, we call such product nonconforming product or product having a defect. Such products reduce production efficiency and in addition, due to faulty products we lose the market and deprive the reliability of our firm name. These are the key causes requiring searching for effective methods of defects elimination.

Why does a defective product appear? Specific defective product always appears due to some objective causes. Therefore, to avoid faulty products we have to clarify those causes and to eliminate them.

Generally the causes of defects appearance are various. However, the analysis shows that, despite products variety, a big part of the causes is universal. One of such causes – factors, influencing products quality is variability. If a producer could control the variability of those factors, he would produce significantly less defective (nonconforming) products. Those factors are infinitude. They are materials and raw materials, out of which the products are produced, they are also production methods, equipment and devices, as well as producers’ competence and qualification, and they are also work environment and other various factors.

The procedure of these factors variability causes’ search could be called process diagnosis. In order to reduce the possibility of appearance of defective products, first of all we must produce a right diagnosis, i.e., find proper causes of the defects appearance. Violent diagnosis cannot treat “patient”, therefore diagnostics is one of the most important elements of product quality control. Thus, the development of diagnostics methods and their practical application are one of the most topical modern problems in solving issues of produced products quality increase.

Subject of the research. In this article one of the diagnostics methods – causes and effects diagram theoretical and practical application in defining mass production defective (nonconforming) products causes is investigated.

Literature review. In 1953 Tokyo University professor Kaoru Ischikava (Ischikava Kaoru, 1968) for the first time formulated the conception of causes and effects diagram. It was applied in one Japan plant while analysing quality problems. This method spread very fast in Japan and other countries. Today in all quality textbooks it is widely described and recommendations for its application are given. Technical aspects of products nonconformities analysis are widely considered in the works of various specialists and scientists (Kruopis J. et al., 2004, 2005; Kalnius R. et al., 2004; Vaïšvila A. et al., 2002, 2004; Adomēnas V. et al. 1993; Montgomery D.C., 1991; Phadke M.S., 1998). In these works the main attention is paid to the drawn for establishment of nonconformities evaluation methodology and improvement of product quality control methods. In other works on this topic (Brassard, 1988; Department of the Navy, 1992, 1993, Gijo E.V. et al., 2003) many practical guidelines of managerial nature are given, however deeper explanations, especially considering effect conception and causes classification are missing.

Goals and tasks of the article. The main objective is to provide the users with the methodology of creating causes and effects diagram, as one of the most important diagnostics methods. Tasks:

- To analyse and define theoretical conception of effect and give practical recommendations for its application under real manufacturing conditions;
To provide the ways and means of the main cause definition, allowing successful elimination of negative effects or seeking for the established objectives implementation.

**Research methods.** For the problem analysis the study of scientific literature, internet information sources and generalization of long practical experience, working in quality management field have been applied.

**Principles of organization processes control**

Generally, for any organization process control we can apply the principles of Deming circle PDCA (Plan-Do-Check-Act) (P. Vanagas, 2004, LST EN ISO 9001:2001). Suppose that we wish to control the level of the defectiveness of products supplied to customers. Elements of this control, referring to long experience of quality management, are given in Figure 1.

![Figure 1. Scheme of products quality control](image)

Figure 1 shows substantial interaction connections between individual elements of product quality control. In the case of a negative situation (i.e., in the case of non-fulfilment of plan) it is necessary to carry out corrective and/or preventive actions. These actions will be effective, if we know well effects (problems) and properly define causes of these effects. Next chapters of this article are intended for the consideration of these issues.

**Effects identification**

To improve successfully quality or reduce quantities of defective (nonconforming) products, it is very important to properly name the attributes of this poor quality or so called effects. Nonconforming products in many cases are identified during the inspection or usage. Attributes of these nonconformities can be determined in various ways from rough assessment to a detailed definition. Specification depends on the carried out non-conformance assessment possibilities. The more detailed definition of nonconformity (effect), the easier is search of its occurrence causes.

Our task is to eliminate nonconformities or negative effects as soon as possible. The more precise and detailed definition of this effect, the easier and faster is the finding of the cause. Thus, a detailed definition of the effect is one of the most important stages in the improvement of products quality.

![Figure 2. Scheme of nonconformities and causes analysis](image)
The detailed definition of the effect is stipulated by the special operations of the production process, intended for non-conformances assessment and their detailed identification. Example of such production process is given in Figure 2.

Nonconformities identified during checking are, as a rule, only the initial rough assessment of the effect, not allowing to start successfully the analysis of these failure causes. With the help of additional checking (using visual or measuring methods) we always can more precisely assess the effect. Such assessment can be of several levels and it is purposively to carry out it until by the way of logical thinking or physical measurements we can sufficiently define the effect. Only having such assessment of the effect, we can start causes analysis. This is shown in Figure 3. For these purposes it is recommended to use one of the quality control tools – causes and effects diagram (Kume, 1988; Kolarik, 1995; Vanagas, 2004 et al.).

### Purpose of causes and effects diagram

Causes and effects diagram is the tool helping to define and show possible causes of particular problem or product non-conforming quality characteristics. It graphically demonstrates the relation between some result and all factors influencing this result. Sometimes the diagram of this type is called "Ischikava diagram", because Kaoru Ishikava (Kume, 1988) has proposed it.

Application of causes and effects diagram can very effectively help when it is needed:
- to define current or possible main causes of particular effect or other negative situation and factors affecting these causes;
- to present interaction of some factors, influencing specific process or effect;
- to analyse current or possible problems, in order to take corrective or preventive actions.

When analysing products quality this diagram is one of the most important tools in defining and eliminating current or possible causes of quality absence. Some specialists’ team should carry out causes analysis. Structure, provided by the diagram, helps specialists to think systematically, using their experience and advantages of collective thinking. Advantages of such systematic thinking:
- Structural approach highlights key causes of the problem very clearly.
- It impels group specialists activity and uses their knowledge of analysed process.
- It defines possible process changing causes.
- It deepens knowledge about the process and helps everybody to know more about the factors influencing process and their interrelation.
- It defines fields, in which the data for further research should be collected.

### Designing the causes and effects diagram

When creating causes and effects diagram, the structural-visual illustration is drawn. It shows the relation of causes with specific effect. In Figure 4 the model of this diagram is presented.

![Figure 4. Model of causes and effects diagram](image)

Causes and effects diagram is constructed gradually by stages.

I stage – formation of experts’ group and task formulation.

II stage – definition of the effects, which should be analysed. It is a very important stage, because proper effect’s identification essentially determines the result of work. We analysed this issue in more detail in the chapter “Effects identification”.

III stage – preparation for the graphical representation. For this purpose we draw the “backbone” and create effect window, into which the effect identified and specified in II stage will be later inscribed.

IV stage – definition of the main causes groups. These groups have to meet the implication of the analysed situation. For example, when analysing some effects of technical objects usually it is limited by five causes groups:
- A group – machinery (equipment, devices);
- B group – methods (of work, management);
- C group – people (managers, workers);
- D group – materials (raw materials, components, purchases);
- E group – environment (physical, manual labour, ergonomics and other factors).

V stage – a detailed analysis of each causes group. This is carried out by asking a question “Why?” First, so called the first level causes, which, according to experts, have the highest impact on effect results in that causes group, are defined. Later, by asking a question “Why?” it goes deep into the second, third etc. level of the causes, able to influence effect in that group. So all causes groups
are analysed and the factors of all levels, impacting the effect, are defined. Repeatedly asking the question “Why?”, sometimes up to 5 times successively, the layers of the causes features are well separated. This leads us to the clarification of the main causes of the problem. Sometimes this method is called “5 Whys?”; however we can note that often we have to ask less or more than five questions, until the issue is related to the problem will be found. The main advantages of “5 Whys?”:
- They help to define problem causes in a simple way.
- They define relation between different causes of the problem.
- They do not require statistical data analysis, experts’ opinion is sufficient.

Example. Suppose that we have problems with the conformance of some product to the requirements.

For the causes analysis the experts’ group was formed, which carried out detailed evaluation of problem and formulated the effect as follows:

Product X characteristics do not meet defined requirements

According to the experts this effect is determined by: machinery, people, materials and methods. By formulating the question “Why?” we will go deep into effect’s causes for several times. Answering the questions within the limits of experts’ competence, we will define all possible causes of machinery impact on effect.

Analogously, the analysis of other causes groups (people, materials, methods) is carried out and causes of all levels are defined. Answers are presented by the causes and effects diagram. Figure 5 presents the example of the diagram in more details showing causes group “machinery” data.

![Figure 5. Example of causes and effects diagram](image)

Data of Table 1 show that more than 80% of all effect causes make the first 3 causes. Therefore, when solving the problem (eliminating bad effect), it is necessary to look for effective means for the elimination of the mentioned 3 causes.

It is more difficult to define the main (the most important) causes when we have no appropriate statistical data on this question. Then the experience of the experts must play the main role. Suppose that 5 experts analyse causes of one effect. Experts assess causes defined in the causes and effects diagram in points: 10 points – the most important cause, 1 point – fully irrelevant cause. The results of

### Table 1

<table>
<thead>
<tr>
<th>Number of causes</th>
<th>Kinds of causes</th>
<th>Quantity of causes, units</th>
<th>Accumulated quantity of causes, units</th>
<th>Causes’ quantity, %</th>
<th>Accumulated caus.’s quantity, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 cause</td>
<td>104</td>
<td>104</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>2</td>
<td>2 cause</td>
<td>42</td>
<td>146</td>
<td>21</td>
<td>73</td>
</tr>
<tr>
<td>3</td>
<td>3 cause</td>
<td>20</td>
<td>166</td>
<td>10</td>
<td>83</td>
</tr>
<tr>
<td>4</td>
<td>4 cause</td>
<td>10</td>
<td>176</td>
<td>5</td>
<td>88</td>
</tr>
<tr>
<td>5</td>
<td>5 cause</td>
<td>4</td>
<td>180</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>6 cause</td>
<td>3</td>
<td>183</td>
<td>1.5</td>
<td>91.5</td>
</tr>
<tr>
<td>7</td>
<td>7 cause</td>
<td>3</td>
<td>186</td>
<td>1.5</td>
<td>93.0</td>
</tr>
<tr>
<td>8</td>
<td>Other causes</td>
<td>14</td>
<td>200</td>
<td>7</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Analysis of causes and effects diagram**

Causes and effects diagram shows the most possible causes according to the experts opinion. Having looked at diagram “balance”, we can make the following primary conclusions:

- Solid pool of causes in one “group” can show the need for further research (may be it is necessary to divide this group into subgroups and analyse them individually).
- If one “group” has only several specific causes, this can show the need for the further causes identification.
- If several main “groups” have only one subgroup, this shows the need for the combining of these groups.
- Causes repeated in “groups” show their importance (they can be the main causes).

Elimination of bad effect or solving of the problem depends on the possibilities of elimination of defined causes.

When eliminating a bad effect, it is impossible to eliminate all defined causes. Therefore it is necessary to choose the most important (main). For this purpose we can use Pareto principle.

To draw Pareto diagram is easy, when experts can use collected statistical data about the interaction of effect and causes. Suppose we have such data (Table 1).
their work are given in Table 2.

### Table 2

<table>
<thead>
<tr>
<th>Kinds of causes</th>
<th>Experts and assessment by points</th>
<th>Sum of points</th>
<th>Running number according to the importance</th>
<th>Accumulated percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cause</td>
<td>1 3 2 4 1</td>
<td>11</td>
<td>4.0</td>
<td>9</td>
</tr>
<tr>
<td>2 cause</td>
<td>3 5 4 3 3</td>
<td>18</td>
<td>6.6</td>
<td>7</td>
</tr>
<tr>
<td>3 cause</td>
<td>5 4 3 2 2</td>
<td>16</td>
<td>5.8</td>
<td>8</td>
</tr>
<tr>
<td>4 cause</td>
<td>9 8 8 10 9</td>
<td>44</td>
<td>16.0</td>
<td>2</td>
</tr>
<tr>
<td>5 cause</td>
<td>10 7 9 9 10</td>
<td>45</td>
<td>16.4</td>
<td>1</td>
</tr>
<tr>
<td>6 cause</td>
<td>7 10 7 8 8</td>
<td>40</td>
<td>14.5</td>
<td>3</td>
</tr>
<tr>
<td>7 cause</td>
<td>6 6 5 5 7</td>
<td>29</td>
<td>10.6</td>
<td>5</td>
</tr>
<tr>
<td>8 cause</td>
<td>4 1 1 1 4</td>
<td>11</td>
<td>4.0</td>
<td>10</td>
</tr>
<tr>
<td>9 cause</td>
<td>2 2 6 6 5</td>
<td>21</td>
<td>7.6</td>
<td>6</td>
</tr>
<tr>
<td>10 cause</td>
<td>8 9 10 7 6</td>
<td>40</td>
<td>14.5</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>275</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

Data in Table 2 show that more than 60% of all causes of effect made 4, 5, 6 and 10 causes, therefore when solving the problem (eliminating bad effect) first of all it is necessary to look for the means eliminating the mentioned 4 causes.

### Conclusions

1. One of the organization efficiency improvement means is an effective implementation of quality control principles according to the Deming circle. This allows on-the-fly define the main problems and their causes, to take actions for the elimination of these causes.

2. To successfully, eliminate problems it is necessary first of all to define effects properly and in detail. For this purpose we need to invite experts, having experience in the considered issue.

3. Problem can be eliminated only when we precisely know its occurrence cause. For the definition of causes it is purposively to use the methodology of causes and effects diagram given in the article.

### References


Vidmantas Adomėnas, Anicetas Vaišvilė, Eduardas Vaičiukonis

Neatiktikų priežačių analizė ir šalinimas – organizacijos efektyvumo didinimas

Santrauka


Priežasčių ir pasekmių diagramos

I etapas – pirmiausia pateikti priežasčių ir pasekmių diagramas. Tai labai svarbus etapas, nes teisingas pasekmės identifikavimas iš esmės nulemia darbo rezultatą.


III etapas – pagrindinių priežasčių ir grupių nustatymas. Šios grupės turi atitikti nagrinėjamas situacijas prasmę. Pavyzdžiui, analizuojant techninių objektų tam tikras pasekmės, paprastai apsiribojama penkiomis priežasčių grupėmis: mašinos (treningai, įrankiai); metodai (darbo, vadybos); žmonės (vadovai, darbininkai); medžiagos (žaliavos, detalės, pikriniai); aplinka (fiziniai, fizininkai, ergonominiai ir kt. faktoriai).

IV etapas – kiekvieno priežasčių grupės detalizavimas. Tai atliekama užduodant klausimą „Kodel?“, kartais šis metodas vadinamas „5 kodėl?“

V etapas – pagrindinis priežasčių ir pasekmių diagramos sudarymo pavyzdys. Priežasčių ir pasekmių diagrama parodo expertų nuomonę, labiausiai tikintas priežastis. Pagrindinės „balansų“ galia padaryti šias pirmines išvadas:

1. tankus priežasčių telkinius vienoje „grupėje“ galėti rodyti tolimės tyrimo poreikį (gal reikia šią grupę dalinti į pugi

Pagrindiniai „5 kodėl?“ privalumai:

- pataikymas naudoti priežasčių ir pasekmių diagramos, kaip vieno svarbiausių diagnostos metodų sąlygoms;
- pateikti pagrindinių priežasčių nustatymo būdus ir priemones.

Sprendimai galima padaryti šios pirmines išvadas:

- tankus priežasčių telkinius vienoje „grupėje“ galėti rodyti tolimės tyrimo poreikį (gal reikia šią grupę dalinti į pugrius ir nagrinėti atskirai);
- jei viena „grupė“ turi tik kelių specifines priežastis, tai galėtų rodyti tolimesnio priežasčių identifikavimo poreikį; 
- jei keletas pagrindinių „grupių“ turi tik po vieną grupę arba rodo šių „grupių“ susijungimo poreikį;
- pagrindinės „grupės“ priežastys rūšių įkelia klausimą, arba galėtų būti pagrindinės priežastys.

Būtina išsirinkti svarbiausias (pagrindines). Čia galima panaudoti Pareto principą.

Sunkiai išskirti pagrindines (svarbiausias) priežastis, kai nėra tuo klausimui atitinkamų statistinių duomenų. Tada pagrindinių vaidmenį turi vaidinti expertų patirtis.

Išvados

1. Vieną iš organizacijos efektyvumo didinimo priemonių – rezultatyvaus kokybės valdymo principų pagal „Demenio ciklą“ įgyvendinimas. Tai leidžia organizacijoms susikaupti priežasčių ir pasekmių diagramų sudarymo procedūros atlikimui

2. Norint sėkmės galima aiškinti problema, būtina visų pirmų teisingai ir detaliai apibūdinti pasekmės. Tai reikia pasiekėtis, turinčius patirtį nagrinėjus klausimui.


Raktožodžiai: neaiškūs, pasekmė, priežastis, kokybės užtikrinimas, kokybės valdymas, priežasčių ir pasekmių diagrama.

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