15

SELECTED METHODS AND TOOLS FOR ANALYSING PRODUCT NONCONFORMITY IN THE AUTOMOTIVE INDUSTRY

15.1 INTRODUCTION

When buying a car, the customer pays attention not only to the colour of the chassis, the equipment, dimensions or performance, but also to the make, which, in his opinion, proves the quality of the car. To ensure a high quality of products, car manufacturers worked out systems, methods and tools which, when implemented in a process, allowed achieving very good results in the manufacture of read-made products.

In the conditions of constantly changing technologies, specialization of particular companies and cost reduced by car concerns, car manufacturers have been forced to resort to outsourcing in the production of parts, focusing only on sub-assembling. Only strategic processes, like pressing car body sheets and paint job are still performed by car manufacturers, whereas the remaining process is a long production line with assembly and subassembly of such elements as engine, gear box, windows, body or suspension, which make up a car [5]. With so advanced outsourcing, concerns had to force suppliers to ensure high quality, among others by auditing the processes, monitoring of quality indicators or implementing methods and tools to solve quality problems [7]. When searching for cheap suppliers in so-called low-cost countries or countries offering cheap labour force, it is increasingly difficult to maintain a high quality of manufactured parts, which may result in a larger number of defects spotted in the process at the customer's place [3]. The aim of the study is to present tools applied to solve quality problems, with a focus on the phenomenon related to deterioration of the quality of parts delivered by suppliers.

15.2 OVERVIEW OF TOOLS

In the automotive industry a number of quality management methods and tools are used. They include methods widely used in other branches, such as: FMEA, SPC, Ishikawa diagram or Pareto chart [9]. However, automotive concerns have developed many quality management tools and methods which are not commonly applied. The study focuses on three of them:

- Seven Diamonds,
- 5WHY,

- Drill deep and wide.

All the methods and tools described below are used when a problem occurs at the supplier's or customer's place. Results obtained after their application are a starting point for taking preventive and corrective measures.

15.2.1 Seven Diamonds

Seven diamonds is a structured method used to identify the cause of a problem, whether it is related to the production process or product nonconformity. Each of the diamonds is a question requiring a positive or negative answer. A positive reply in any diamond results in a move to the next diamond. As a result of a negative answer, appropriate corrective measures are undertaken [10]. Below has been presented the algorithm of the procedure in the 7 Diamonds Method (Fig. 15.1).

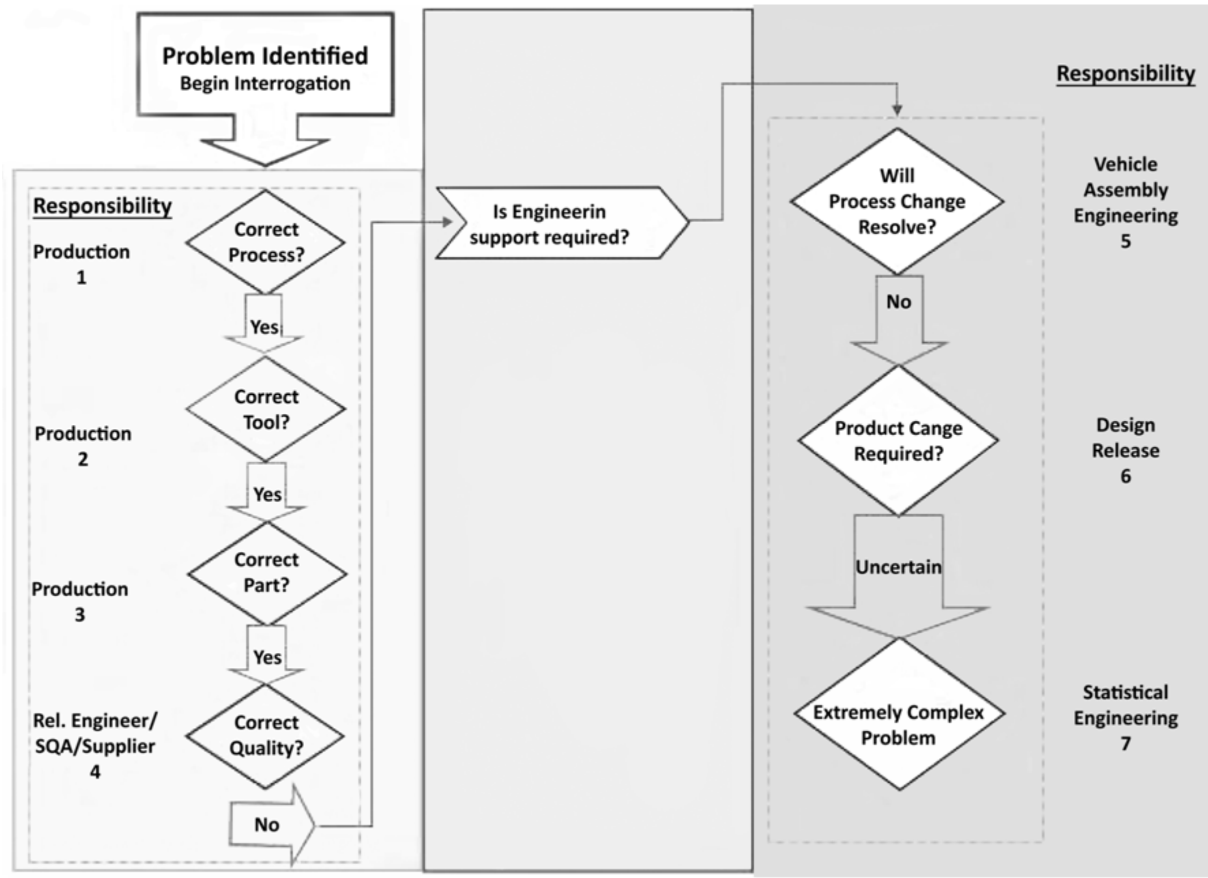


Fig. 15.1 Algorithm of the procedure in the Seven Diamonds Method

Source: [1]

Diamonds 1 to 4 concern the production process and are used to establish whether the organisation of production complies with the project assumptions. Initially, an analysis through 1-4 diamonds is conducted on the spot (e.g. at a workstation), in the place where a problem occurred. If the analysis reveals that the problem arose at the earlier stage of the production process, the analysis should also address the source of the problem. If, in the process of analysis, the answer to any of the below questions is negative, ambiguities should be resolved; if the process does not comply with the assumptions, it should be improved and revalidated so that it complies with the design. Positive answers to all the questions from diamonds 1-4 allow continuing the analysis and proceeding to the next diamond. When conducting an analysis, one should answer questions focusing on the areas marked in the diagram: Diamonds 1 to 5.

Diamond 1 – proper process? Questions contained in the first diamond concern the compliance of operator's work with requirements to be observed at a particular workstation and his general knowledge of procedures which have to be followed in non-standard situations, such as spotting a nonconformity at the workstation.

Diamond 2 – proper tool? The second area contains questions related to the correct use of workstation tools, the use of appropriate tools during an operation or control of machines at the workstation.

Diamond 3 – proper part? In the third diamond the correctness of a workstation's organisation, their layouts as well as the layout of parts at the operator's disposal are checked.

Diamond 4 – quality of parts? The person responsible for establishing whether a part has been changed or for checking the general quality of a product should collect the following information: data provided by the supplier (internal or external), results of tests and inspections of tangible values (dimensions, properties etc.), comparison of parts, comparison of batches.

Diamonds 1 to 5 are an evaluation of the production process stability. After the problem has been identified, answers should be provided automatically according to steps 1-4. This procedure algorithm should be a spontaneously performed activity in the problem solving process.

Diamond 5a – required support of engineers? Diamond 5a is used to filter and solve less complex problems before support of specialist in a given area is required. An analysis should be conducted using available quality management tools, such as: SPC, 5WHY, Ishikawa Diagram etc. If the problem is not solved after an analysis was carried out or its size has not been reduced, the matter should be referred to relevant departments (assembling, production etc.). Diamond 5b – change in the process solved? After filtrating the problems found as a result of analyses in Diamond 5a, a team of department engineers should think about making some changes in the process which will allow the problem to be solved. The fact that the problem has reached Diamond 5b means that the process was improperly designed or some important issues were neglected at the stage of new product implementation.

Diamond 6 – required changes in the design? Reaching Diamond 6 in the process of analysis is usually caused by permanent problems with a part, confirmed by many complaints from the customer, which have not been solved in a proper way. At this stage the problem should be referred to a team of engineers responsible for the part design. A change in the design of the part should not alter the established property or its key characteristics. Most frequently it is a minor modification of a tool making this part (e.g. tools for presses) or a foundry mould, a change of which will solve a problem related to e.g. collision with another part.

Diamond 7 – extremely complex problem? Problems solved in Diamond 7 are complex problems resulting from an unsuccessful process combined with an improperly designed part. This kind of problems are solved by outsourced teams of engineers or specialists, who will approach the problems in an objective way and, owing to their experience and knowledge, will be able to deal with them. However, it is extremely expensive as it usually involves a complete change of the process, purchase of a modern technology and paying the outsourced specialists.

15.2.2 5 WHY

5WHY is a very good tool, which allows getting to the root of the problem [2]. 5WHY analysis is two-level as it should answer two questions:

- why did the problem occur?
- why was the defect not spotted in the process or during an inspection of the part?

Before undertaking an analysis, one should collect as much information on the problem as possible so as to be able to engage appropriate people to find the root of the problem. Therefore, the following questions should be answered:

- establish what happened? on the basis of parts received,
- if there is information regarding the production batch on the part, we can define when it happened?
- what is the scale of the problem? how many nonconforming parts might we have?
- what the defect may cause in our place and at the customer's? Is there a big threat which obliges us to immediately inform the customer?

After answering the above problems, we should appoint a team of specialists that will help us construct the questions and find the real cause of nonconformity. Such a team could include engineers responsible for processes as well as operators, as they have the greatest knowledge about the place in which the defect might have arisen.

The last activity before starting an analysis is thorough and unambiguous formulation of the problem so that it will make us follow a certain thinking track and prevent us from going off course during the analysis. In general, 5WHY can be defined as a cause and effect analysis, because answering one question automatically leads us to another one until the real cause of the fault is found. Of course life shows that 5 WHY analysis is not limited to 5 questions, but can finish with a good result after 3 or 7 questions. We cannot restrict ourselves to 5 questions because we would either get stuck or we would come to wrong conclusions. Example of a 5 WHY method form has been presented in Fig. 15.2. In the above presented Fig. 15.2 potential causes of a problem have been identified. One can see that in the case of some questions there are a few alternative answers. As a result of analysis, one answer in the fifth question has been selected as the cause of nonconformity, for which target activities have been formulated.

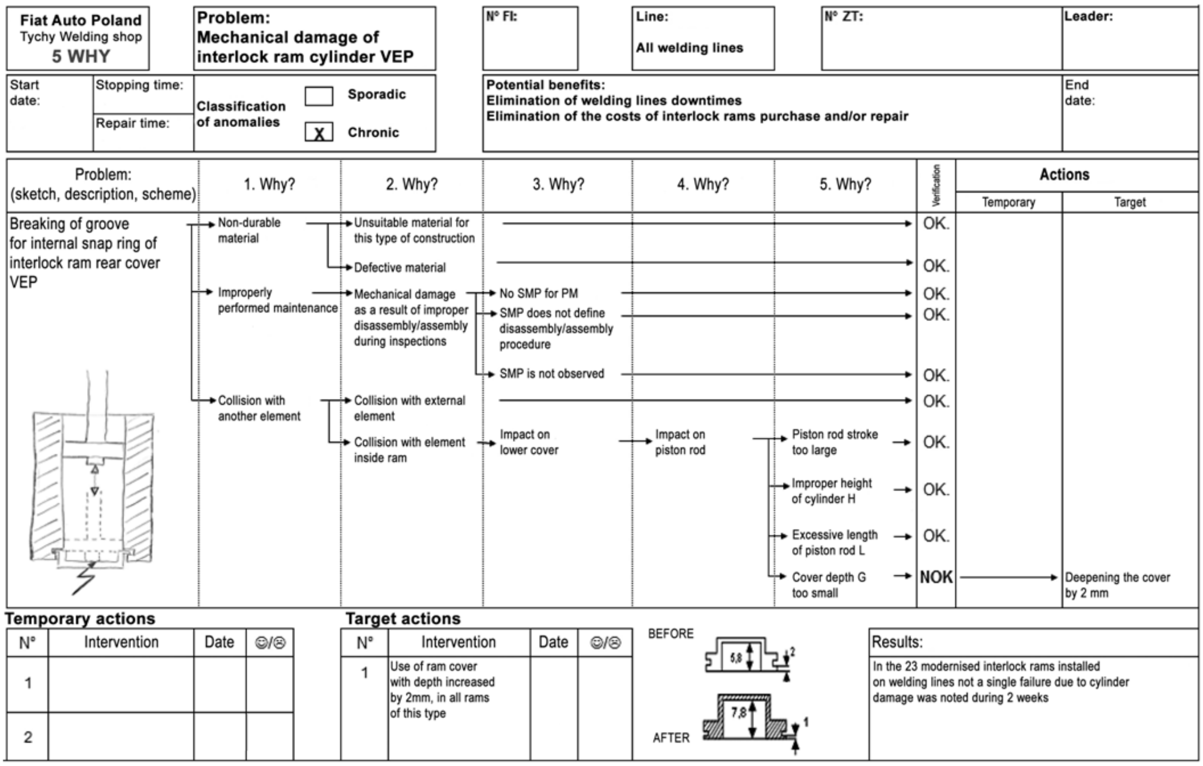


Fig. 15.2 5WHY form at Fiat Auto Poland

Source: [8]

15.2.3 Drill Deep and Wide (DDW)

DDW is one of the most developed tools applied for analysis in General Motors group (Fig. 15.3). It can be divided into two separate forms.

- the first one is Drill Deep form,
- the second one is a Drill Wide form.

Drill deep is a developed and modernised version of 5WHY. The informative part of the form contains basic information about responsible persons from the customers and supplier's side as well as data on the plate where the problem occurred. The analytical part of the drill deep form contains 4 aspects, which the supplier has to deal with and analyse the problem in these areas. Drill Deep is also called 3X5 WHY, because the general principle of operation in this case is the same as that applied in 5 WHY, except that an analysis is conducted in three major aspects:

The first aspect is „Prevent". This aspect concerns the production line, specifically the process of assembling, protection against the so-called Error Proofing defect and operation standards for operators. In this aspect the supplier must ask himself the question why the production system did not protect the customer against the defect described in "Failure Mode". In this aspect the quality assurance system in the plant is analysed. The second aspect is „Protect". This aspect concerns the area of quality control. When analysing this area, the supplier should consider issues related to the fact that quality control was not effective enough to protect the customer against its detection. The third aspect is „Predict". It is a new aspect compared to 5 WHY and equally important as the previous ones, as it concerns the area of quality planning in a plant. As it is known, one of quality planning methods is FMEA, therefore most considerations in this aspect are related to this method.

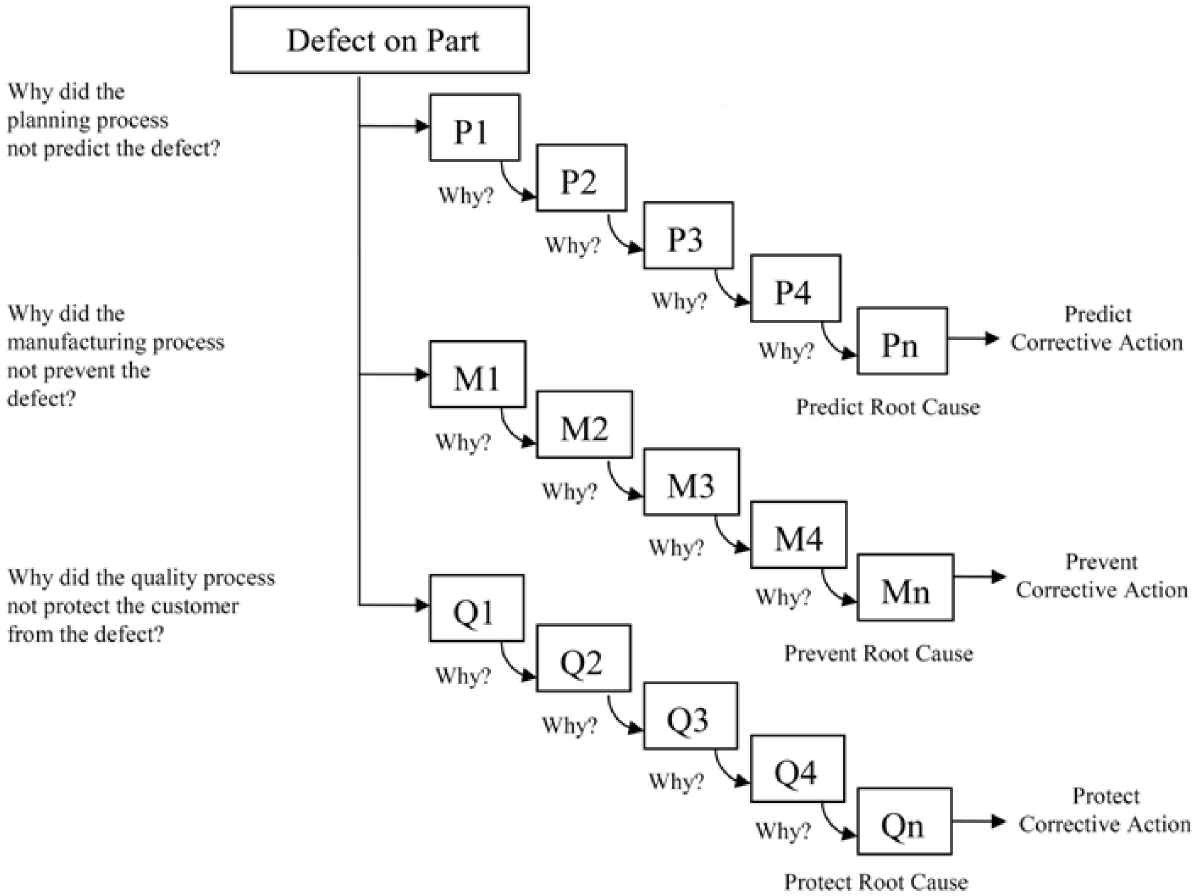


Fig. 15.3 Procedure algorithm in Drill Deep Method

Source: [4]

The fourth aspect is the field devoted to additional shortcomings or defects found in the process of analysis. Creating such a field does not cause limitations and provides possibilities for streamlining the process, the system of quality, planning and ensures implementation of corrective measures.

Similarly to 5 WHY, this analysis is not limited to asking 5 questions, but, if necessary, can be supplemented with additional questions. Since the analysis is conducted on a few planes, it can more effectively prevent the occurrence of a defect in the future, because every aspect consists of at least one corrective measure. To verify the rationale behind the conducted analysis, it is necessary to read it backwards, i.e., from the root (cause) of the problem upwards, by replacing the question “why” with the statement “because”. If we come to the same conclusions and do not lose the logic of the analysis, the analysis can be considered properly conducted. The universal character of this tool is reflected in the fact that apart from obligatory corrective measures which must be implemented after the cause of the problem has been found, a corrective measure can be proposed at each stage of analysis, as the structure of the form makes it possible.

Drill wide is an additional tool that complements Drill Deep, creating a very broad analysis under the name Drill Deep & Wide. This tool is used to standardize and thoroughly analyse significant problems and its aim is to supervise the implementation of corrective measures in all the areas listed in the forms. The extended name of this tool is Drill Wide – Read Across, which clarifies how it should be used. An analysis should be started with creating a template for the corporation because corporations such as Bosch, Delphi, Denso or Yazaki produce very similar products in many factories, frequently for one customer. Due to the fact that the form regards a few plants, its supervision is the responsibility of high-rank managers who are authorised to take decisions that can be simultaneously implemented in a few factories. Since Drill Wide is a tool applied only for serious problems, it should be used after a Drill Deep analysis has been conducted. Except differences related to the location for which the forms are applied, they contain the following data: information about the supplier, i.e. its name, DUNS, person responsible for the form, telephone number and e-mail address, legend regarding the manner of completing the template in "Symbol" rows. The meaning of the legend is as follows:

- O – means location of the problem occurrence, the accuracy including the machine where the problem was identified,
- X – means locations with similar processes in which corrective measures should be implemented,
- N/A – means that in a given plant or process corrective measures cannot be applied, as the process is considerably different from that in which the problem of occurred. In short – not applicable.

Each of the above mentioned symbols is also accompanied by colours denoting the status of undertaken activities:

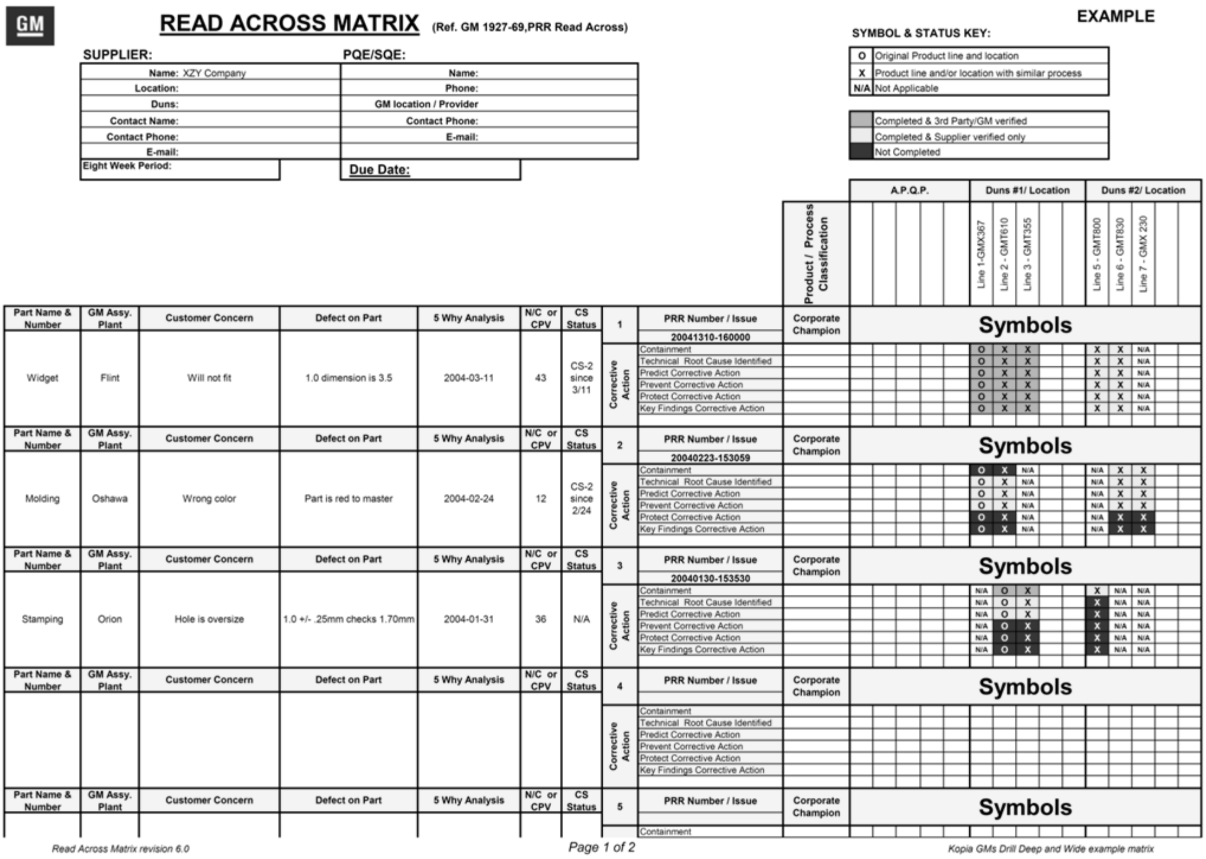
- red colour – means that measures have not been implemented or are currently being implemented,
- green colour – means that measures have been implemented and confirmed only by the supplier,
- blue colour – means that measures have been implemented and confirmed by GM or the authorised company (third party).

Next, according to the „Read Across" principle, the following can be found in the form:

- name and number of the part – which is connected with the number of complaint from Drill Deep,
- plant affected by the problem,
- description of nonconformities copied from Failure Mode cell contained in the linked Drill Deep analysis,
- description of the problem at the customer's place copied from Effect of Failure Mode cell contained in the linked Drill Deep analysis,
- number of nonconformities,
- type, status and date of implemented controlled delivery,

- date and person responsible for approving the Drill Deep analysis as well as the date and person responsible for approving the corrective measures in Drill Wide,
- number of complaint related to the problem,
- corrective or other measures implemented in the following areas:
  - confirmation of problem cause identification and implementation of corrective measures,
  - confirmation of implementing corrective measures for the production process – data from Drill Deep analysis for the Prevent aspect,
  - confirmation of implementing corrective measures for the quality system – data from Drill Deep analysis for the Protect aspect,
  - confirmation of implementing corrective measures for the area of quality planning – data from Drill Deep analysis for the Predict aspect,
  - confirmation of implementing corrective measures for the fourth aspect in Drill Deep, i.e. additional defects found in the process of analysis,
  - confirmation that the whole documentation is complete and updated, in particular applying to:

    - workstation instructions,
    - instructions for operation and tests,
    - notes from trainings devoted to the problem.


READ ACROSS MATRIX (Ref. GM 1927-69,PRR Read Across)

EXAMPLE

SUPPLIER:

Name:	XZY Company
Location:	
Duns:	
Contact Name:	
Contact Phone:	
E-mail:	
Eight Week Period:	

PQE/SQE:

Name:	
Phone:	
GM location / Provider	
Contact Phone:	
E-mail:	
Due Date:	

SYMBOL & STATUS KEY:

O	Original Product line and location
X	Product line and/or location with similar process
N/A	Not Applicable
	Completed & 3rd Party/GM verified
	Completed & Supplier verified only
	Not Completed

Part Name & Number	GM Assy. Plant	Customer Concern	Defect on Part	5 Why Analysis	N/C or CPV	CS Status		PRR Number / Issue
Widget	Flint	Will not fit	1.0 dimension is 3.5	2004-03-11	43	CS-2 since 3/11	1	20041310-160000
Molding	Oshawa	Wrong color	Part is red to master	2004-02-24	12	CS-2 since 2/24	2	20040223-153059
Stamping	Orion	Hole is oversize	1.0 +/- .25mm checks 1.70mm	2004-01-31	36	N/A	3	20040130-153530
							4	
							5	

Corrective Action: Containment; Technical Root Cause Identified; Predict Corrective Action; Prevent Corrective Action; Protect Corrective Action; Key Findings Corrective Action

Product / Process Classification; Corporate Champion; Symbols

A.P.Q.P.; Duns #1/ Location: Line 1-GMX367, Line 2 - GMT610, Line 3 - GMT355; Duns #2/ Location: Line 5 - GMT800, Line 6 - GMT830, Line 7 - GMX 230

PRR	Line 1-GMX367	Line 2 - GMT610	Line 3 - GMT355	Line 5 - GMT800	Line 6 - GMT830	Line 7 - GMX 230
1	O	X	X	X	X	N/A
2	O	X	N/A	N/A	X	X
3	N/A	O	X	X	N/A	N/A

Read Across Matrix revision 6.0
Page 1 of 2
Kopia GMs Drill Deep and Wide example matrix

Fig. 15.4 Drill Wide template

Source: [6]

Each of these measures requires appointing a person responsible for supervising its course and confirming that the activities were completed after successful validation [4]. The last element in the form is the template related to corrective measures and, depending on the level of the form, plants, production lines as well as operations and machines. In this template the symbols and colours denoting the status of implemented measures according to the legend are marked. An example of a Drill Wide form has been presented in Fig. 15.4.

CONCLUSION

The presented methods are used mainly for identifying the causes of noncomformities in a product or production process as well as documenting the implemented improvement activities. The simplest tool – 5 WHY is applied to solve uncomplicated problems related to product quality. It allows exploring the basic causes of the problem, which is necessary to develop effective corrective measures. The 7 Diamonds Method is more universal – it can be used for solving simple and complex problems. Its biggest advantage is the fact that it allows starting an analysis without knowing the scope of the problem. The method is adjusted to the level of problem complexity (the first four diamonds for uncomplicated problems or all the diamonds for complex problems).

The most elaborate method in the discussed set is the DDW method. It consists of two parts: Drill Deep and Drill Wide. The Drill Deep part enables identification of the causes of a problem and the reasons for failure to detect it in the process. The Drill Wide part allows identifying the scale of a negative phenomenon subjected to analysis in the whole concern. It helps in the process of documentation and management of improvement activities in many plants at different locations.

The presented methods and tools used in the automotive industry should have a more universal application. Applying them in other branches of industry can provide a lot of benefits by reducing product failure frequency, streamlining the production processes and improving co-operation with suppliers of half-products.

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SELECTED METHODS AND TOOLS FOR ANALYSING PRODUCT NONCONFORMITY IN THE AUTOMOTIVE INDUSTRY

Abstract: *The study contains a review of seldom encountered quality management methods and tools which are applied in the automotive industry to solve problems related to nonconforming products. Three tools have been discussed: 5WHY, 7 Diamonds and Drill Deep and Wide. The tools differ from each other in terms of their complexity and the scope of application: from the simplest problems related to product quality to complex problems occurring in the production process. The scope of their application may refer to one product, the whole production process as well as to all processes in the corporation.*

Key words: *quality, tools, 7 Diamonds, management, nonconformity, automotive industry, 5WHY, DDW*

WYBRANE METODY I NARZĘDZIA ANALIZY NIEZGODNOŚCI WYROBÓW STOSOWANE W PRZEMYŚLE MOTORYZACYJNYM

Streszczenie: *W opracowaniu przedstawiono przegląd rzadko spotykanych narzędzi i metod zarządzania jakością stosowanych w przemyśle motoryzacyjnym do rozwiązywania problemów z niezgodnymi wyrobami. Omówiono trzy narzędzia: 5WHY, 7 Diamentów oraz Wierć Głęboko i Szeroko. Narzędzia różnią się od siebie złożonością oraz zakresem stosowania: od najprostszych problemów z jakością wyrobów, do skomplikowanych problemów występujących w procesie produkcyjnym. Zakres ich stosowania może odnosić się do jednego wyrobu, całego procesu produkcyjnego, ale również do wszystkich procesów w całej korporacji.*

Słowa kluczowe: *jakość, narzędzia, 7 diamentów, zarządzanie, niezgodność, motoryzacja, 5WHY, DDW*

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