Problem-solving and developing quality management methods and techniques on the example of automotive industry

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Abstract: *The knowledge about methods and techniques of quality management together with their effective use can be definitely regarded as an indication of high organisational culture. Using such methods and techniques in an effective way can be attributed to certain level of maturity, as far as the quality management system in an organisation is concerned. There is in the paper an analysis of problem-solving methods and techniques of quality management in the automotive sector in Poland. The survey was given to the general population, which in case of the study consisted of companies operating in Poland that had certified quality management systems against ISO/TS 16949. The results of the conducted survey and the conclusions of the author can show actual and potential OEM suppliers (both 1st and 2nd tier) in which direction their strategies for development and improvement of quality management systems should go in order to be effective. When the universal character of methods and techniques used in the surveyed population of companies is taken into consideration, it can be assumed that the results of the survey are also universal for all organisations realising the TQM strategy. The results of the research confirmed that methods which are also the basis for creating key system documents are the most relevant ones, i.e. flowcharts and FMEA, and moreover process monitoring tools (SPC) and problem solving methods -above all 8D.*

Key words*: quality management, quality techniques, automotive industry, FMEA, SPC, 8D, problem solving, quality methods*

1.Introduction

The knowledge about methods and techniques of quality management together with their effective use can be definitely regarded as an indication of high organisational culture. Using such methods and techniques in an effective way can be attributed to certain level of maturity, as far as the quality management system in an organisation is concerned. Such maturity, in turn, can be achieve when the top management is aware that the use of such methods and techniques is reasonable and that it is necessary to incorporate such methods and techniques in corrective actions and actions taken as part of the continuous improvement process. It has to be pointed out here, though, that only a limited number of organisations use the tools. Even fewer organisations do it with deliberation as a permanent element of their quality management systems. The customers most frequently require this type of actions to be taken (e.g. Fortel Q (the requirements of VW), Alliance Supplier Guide (ASG) (the requirements of Nissan and Renault)) or standard requirements (e.g. ISO/ TS 16949:2009, TL 9000). There is in the paper an analysis of problem-solving methods and techniques of quality management in the automotive sector in Poland. The survey was given to the general population, which in case of the study consisted of companies operating in Poland that had certified quality management systems against ISO/TS 16949.

2.Literature review

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One of the main assumptions underlying a quality management system is improving the ability to define nonconformities, as well as to plan and realise corrective and preventive actions. ISO/TS 16949 is a standard for QMS. This standard outlines the specific requirements for the application of ISO 9001:2008 to automotive production and relevant service part organizations (Lin et all 2004). This standard recognizes the uniqueness of every automotive supplier's process, while providing critical tools to help your company better meet customer specific requirements (Bakhtiar et all 2010).

What it means in practice is that the organisation must implement effective mechanisms thanks to which it can react fast to any problems, analyse the causes of the problems and chose and realise the most appropriate actions that are directed at the causes of such problems. What is more, one should not forget about the requirements set in standardised management systems, and especially in Chapter 8 Measurement, analysis and improvement (ISO/ TS 16949). This chapter determines the need to take actions related to defining nonconformities, identifying the causes of nonconformities, correcting

nonconformities, as well as planning and realising corrective and preventive actions. However, the standard defines only what should be done. It does not state which methods and tools should be used to meet the requirements and realise the targets. A significant number of those methods are even called systems, because they constitute an integral and necessary element of cooperation between organisations in the customer-supplier relations, (Liker and Hoseus 2009; Bandyopadhyay 2007; Delbridge 2007; Liker and Meier 2008; Sila 2006; Żuchowski and Łagowski 2004; Imai 2007; Nazrul et all 2012).

The methods of problem solving can be used in supply chain management in automotive sector (Scalera 2011). Supply Chain is defined as a system where suppliers, contractors, clients and their agents work together in coordination to install and utilise information in order to produce, deliver materials, plant, temporary works, equipment and labour and other resources for construction project (Hatmoko Scott 2010). Supply Chain Management as a whole takes a system view of the production activities of autonomous production units and seek global optimisation of these activities (van Tran et Tookey 2012).

Literature of the trade, describes a great variety of methods and techniques of quality management that are used in practice (Łuczak and Matuszak-Flejszman 2007; Wolniak and Skotnicka 2011; Munir et all 2012; McGeoch et all 2013; Schlitz and Ladenburg 2013; Duru et all 2013; Franceschini and Turyna 2013; Damasio et all 2012; Kuo et all 2012; Vila et all 2013; Cheng et all 2012) and especially in automotive sector (Łuczak 2008, 2010; Wolniak 2012, 2013; Wolniak and Burtan 2010).

Quite often the two terms, i.e. "method" and "technique" are used interchangeably. Encyclopaedic sources (PWN 1999, p. 74) usually define a "method" as a conscious and consistently used way of conduct to achieve specific aims, i.e. a set of deliberate actions and means. On the other hand, "a technique" is a deliberate and rational way of conduct in a specific area that is based on theory. At each step of the Deming Cycle some tools for quality management can be used, as shown in Table 1.

Table 1. Tools for quality management used at each step of the Deming Cycle

Step 1 – plan:	– Flowchart, – Nominal Group Technique (NGT), – Pareto Analysis, – Brainstorming, – Cause-and-effect Diagrams, – Process mapping, – Hoshin Planning.
Step 2 – do:	– Design of experiment, – Process monitoring, – SPC, – Control plan.

| Step 3 – check: | – Control sheets,
– Control charts,
– Key process characteristics indicators,
– Control sheets. |
| Step 4 – act: | – Process modelling,
– Force Field Analysis,
– Impact analysis. |

Source: own study based on (Tague 1995; Smith 1998).

It is also very important to pay attention to the methodologies of problems solving, which in essence refer to particular tools and methods. Above all, the 8D method (developed at Ford Motor Company) is worth remembering (table 2). This method is based on a multi-stage approach to a problem, starting from a full diagnosis of its causes and ending with ensuring the efficiency of undertaken actions that are also consolidated in a system. Many authors (Elsmar, 2012; Jung, et all, 2011; Kokol and Gladež, 2011; Ubani,2011) describe the eight disciplines of systematic problem solving. Their theoretical description and practical experience on the use of the 8D method (eight steps) are collected in the following sub-sections. The 8D method is a procedure for systematic introduction of improvements and elimination of problems and errors. It can be used on a product, but also on a system and process level.

Table 2. Stages of the 8D method

No.	Phase of the 8D process	Description
1	Appointing the 8D team	Establishing a small team of employees with knowledge about the problem/ product/ process that has the authority, time and skills to solve the problem and implement corrective and preventive actions, choosing the team leader.
2	Defining the problem	Defining the internal or external problem – determining what is improper and describing it in a way allowing answering such questions as: What? Where? How? How many? etc.
3	Implementing and verifying interim actions	Defining and implementing interim actions to protect the internal/external customers from the problem until permanent corrective actions can be implemented. Verifying the effectiveness of these actions.
4	Defining and verifying root causes	Identifying all causes that could explain why the problem occurred. Identifying and verifying causes by testing each potential cause against the problem description and available data. Defining possible corrective actions to eliminate the root causes.

5	Choosing Permanent Corrective Actions	Confirming through pre-production programs that the selected corrective actions will resolve the problem for the customer and will not cause undesirable effects. If appropriate, based on risk assessment.
6	Implementing Permanent Corrective Actions	Establishing an implementation plan for permanent corrective actions and defining a system of on-going control over their effectiveness. Ensuring that all root causes or undesired effects are eliminated, monitoring the long-term effectiveness and implementing alternative actions, if it is necessary.
7	Preventing recurrence	Modifying the management system in the scope required to prevent recurrence of this and all similar problems in the future. Identifying possibilities for improvement and establishing a process of initiatives for improvement.
8	Congratulating your team	Recognising the work of the team.

On the system and process level, the 8D method is used as a tool for continuous improvement / as corrective measures to remedy minor or major non-conformities. The use of the method on a product is focused on solving the problem identified on the product (customer complaints as well as internal/inter-plant complaints).The table 2 characterises the phases of the 8D method (Krajnc 2012).

Quality teams established to solve particularly significant problems in case of which neither the root causes nor the mitigating measures are known use the 8D method. During each of the abovementioned phases, different quality management methods can be used. For example, at the fifth phase (Choosing Permanent Corrective Actions) the following methods are used: FMEA, cause-and-effect (Ishikawa) diagram, verification plans, DVPSOR reports.

3.Brief description of research method and data collection techniques.

In order to explain the research problem the aim of the paper had to be defined at first and then realised. In case of the following paper the aim was narrowed down to identifying the methods and techniques that were used by OE/OES suppliers in the automotive industry, on the one hand, and evaluating how relevant each one of them was for the QMS to be effective, on the other hand.

In consequence, the following tasks had to be performed in order to realise the general aim of the paper:
• Verifying reference literature on quality management in automotive industry, and specifically literature that was directly related to the formulated research problem.
• Collecting documents, standards, procedures that constituted sets of essential methods and techniques and were exclusively determined in customer specific requirements (CSR).

• Identifying requirements which were not formalised and had the nature of know-how used by OEM suppliers.

• Describing key methods and techniques of quality management that were used in the automotive industry.

• Studying the relevance of requirements on a sample of companies which underwent a comprehensive assessment both from the perspective of certifying bodies and customers, as well as which realised their own priorities which were aimed at improving the effectiveness and efficiency of management systems and business efficiency.

• Drawing conclusions in the form of recommendations specifically for supplier companies and potential suppliers for the automotive industry and more generally for all organisations wishing to improve their QMS.

In order to realise the aim of the project the following research hypothesis had to be verified: the most relevant methods and techniques used by suppliers in the automotive industry for quality management are the Flowchart, the FMEA analysis and the 8D process.

Two surveys, namely a preparatory survey (S1) and proper survey (S2) were conducted in course of the research. In the proper survey (S2) a questionnaire was used as the research tool. It was given to the general population, which in this case consisted of companies operating in Poland that had certified quality management systems against ISO/TS 16949. Moreover, the direct interest of the author were the methods and techniques used for quality management.

The surveys and analyses that were carried out applied to the automotive industry and above all to the manufacturers of engine-powered vehicles. In practice, these companies were the 1st and 2nd tier OE/OES suppliers.

Experts representing six well-known companies, suppliers for the automotive industry, participated in the preparatory survey. These experts had to meet a number of specific recruitment criteria. First of all, the main aim of the preparatory survey, which was performer by means of the Delphi method, was to determine which methods and techniques of quality management, out of the wide spectrum of methods and techniques, were really of relevance. Then, based on the results of the preparatory survey a research tool (in the form of a questionnaire form) was compiled in order to conduct the proper survey.

So, in other words, the preparatory survey was a prerequisite of the proper survey. The organisations that were examined held ISO/TS 16949 requirements compliance certificates. The fact that they held such certificates also meant that they cooperated within the framework of OE/OES supply contracts.

4.Identification of methods and techniques of quality management – preparatory research

The preparatory survey was carried out in accordance with the rules of the Delphi method and 7 formal sessions had been realised via e-mail, video and teleconferences (McGeoch et all 2013). The experts analysed the consecutive versions. Initially the versions were related to the specific aims of the survey, defining the category of methods and techniques of quality management, the list of methods and techniques and eventually the questionnaire form.

We should prepare specific survey because each culture has it's own value and

methods used by employers and employees within an organizations (Jaafreh and Abegalfatth 2012; Pudjihardo and Nama 2012; Sabarirajan A. and Geethamjali 2011).

As a result of the preparatory survey, the list of methods and techniques of quality management was narrowed down to the Flowchart, the cause-and-effect (Ishikawa) diagram, the Pareto diagram, the ABCD (Suzuki), brainstorming, the QFD method, the FMEA analysis, the Histogram, data collection sheets, SPC control sheets, the 8D process, the 5PPJ, the Layout and the Turtle Diagram. However, the respondents could also add some other methods and techniques of quality management that were used in their companies.

In order to verify the hypothesis and research aims, the following questions were put in the questionnaire form:

- Does your organisation use methods and techniques (M&T) of quality management?
- Would you place the following terms and definitions in the category "methods and techniques of quality management"?
- What are the determinant factors of using M&T for quality management?
- Which of the following M&T are used in your company?
- What is the purpose of M&T used in the company?
- What is the relevance (frequency of use and effectiveness) of using M&T in the company (1 – irrelevant, 5 – very relevant)?
- What are the reasons for limited use of M&T in the Company?
- Are reports on the use of M&T created (without using the methods and techniques)?
- How would you assess your knowledge about M&T? ('1' signified very poor knowledge and '5' very good knowledge)?

The questionnaire also included a column to collect basic personal information about the respondents.

5.Evaluation of relevance of methods and techniques of quality management – proper research

The S2 survey was performed on a group of companies with principal place of business in Poland that held ISO/TS 16949 compliance certificates. The performed survey was complete and exhaustive in nature. Due to the percentage of returned questionnaires (i.e. 23%) and other statistical parameters it was possible to infer about the whole surveyed population. The questionnaire form provided the author with data that were analysed afterwards. Subsequently on the basis the obtained data, statistical inference was conducted so as to verify the hypothesis that was defined in the paper. Conducting the survey with the use of questionnaire form and according to a scenario can be regarded as a statistical observation, a statistical study and a statistical analysis (Ignatczyk 2004).

To conduct the survey a questionnaire form was used which by assumption had been distributed exclusively by electronic means (e-mail) and had been appropriately prepared to make use of the Internet questionnaire (Kaniewska-Sęba et all 2006; Mazurek-Łopacińska 2005; Pociecha 1996; Macik 2005; Gorodzeisky 2011).

Realising the aims defined in the paper and verifying the formulated hypothesis was in the first place related to evaluating the relevance of previously specified methods and techniques of quality management.

Nearly all respondents declared that they used methods and techniques of quality

management. It was an answer that could be anticipated as the use of methods and techniques of quality management is specified by ISO/TS 16949 and very often in customer specific requirements.

So the aim, i.e. identifying and selecting methods and techniques used by suppliers in quality management systems, was realised with good results. The respondents indicated which of all of the methods and techniques were used. The following methods and techniques were used by the highest percentage

of respondents (more than 60%): the FMEA, the Flowchart, the Pareto diagram, the Layout, brainstorming, histograms, control sheets, the 8D process, the cause-and-effect (Ishikawa) diagram and data collection sheets.

Concurrently, the Turtle Diagram (fig 1) was far less popular, even despite the fact that in literature it was often presented as a tool frequently used in the automotive industry.

Figure 1. The use of specific methods and techniques of quality management as a percentage
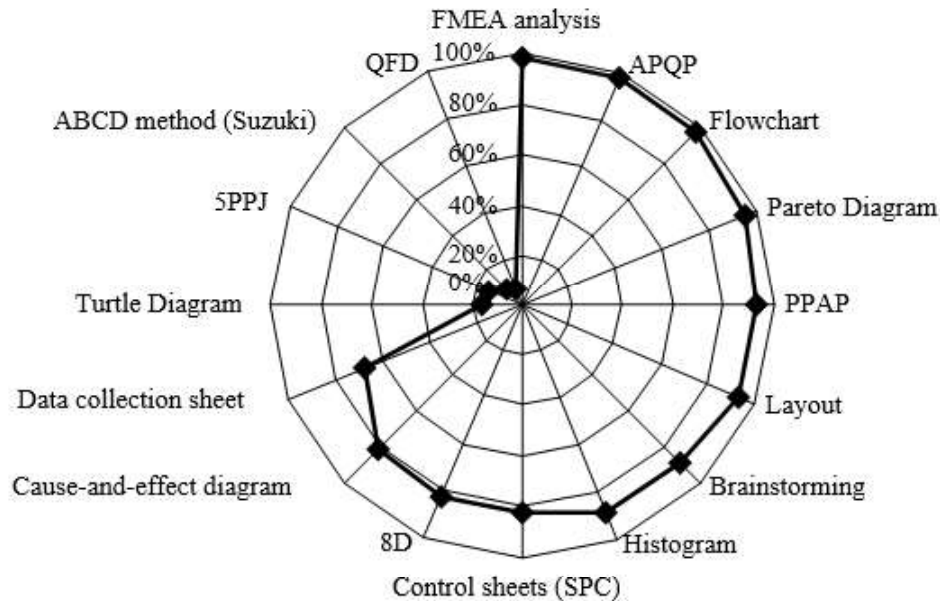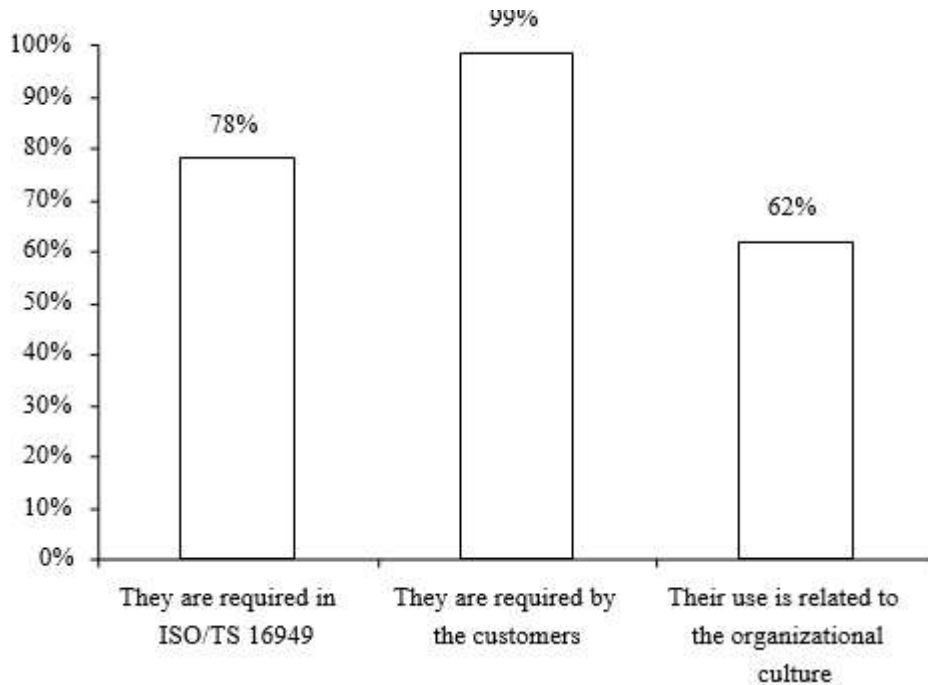

Source: Own study based on the results of the questionnaire survey.

Both the 5PPJ and the QFD shall be recognised as highly specific tools. The first one is required only by a limited number of car manufacturers (8D is far more frequent in use). The second one is highly specific due to the fact that only a small share of companies (respondents) realised activities connected to R&D.

Suppliers in the automotive industry use methods and techniques of quality management primarily because of customer requirements (99%) and ISO/TS 16949 (78%). A significant group of the respondents (62%) consider the organisational culture to be of great importance. For them the use of methods and techniques of quality management is obvious and common (fig. 2).

Figure 2. Main reasons for using methods and techniques of quality management

Source: Own study based on the results of the questionnaire survey.

The classic approach to the classification of methods and techniques of quality management is related to using them for activities taken as part of the PDCA circle. The respondents were asked to match the methods and techniques they used with the following actions:

- defining the problem,
- defining the solutions,
- defining the causes,
- control the effectiveness of implemented actions,
- improving the QMS.

Almost all suppliers use methods and techniques of quality management as far as improving the quality management system is concerned. They are most useful when it comes to the defining problems (80.88%)

and defining their causes (82.35%). The tools which 8 support defining solutions and which are used to control the effectiveness of taken actions are more theoretical in nature (table 3).

As it was assessed how frequently the selected methods and techniques of quality management were used it was also possible to evaluate their relevance (defined as the resultant of the frequency and effectiveness of their use). The most relevant methods as indicated by the respondents were: the Flowchart, the FMEA method, SPC control sheets as well as multi-stage problem solving methods e.g. 8D, 5PPJ. However, not only the 8D method was considered to be relevant by the respondents, but also the cause-and-effect (Ishikawa) diagram (figure 3).

Table 3.The purpose of using M&T in the company

	Yes		No	
Defining the problem	55	80.88%	13	19.12%
Defining the solutions	42	61.76%	26	38.24%
Defining the causes	56	82.35%	12	17.65%
Controlling the effectiveness of implemented actions	28	41.18%	40	58.82%
Improving the QMS	67	98.53%	1	1.47%

Source: Own study based on the questionnaire survey.

Figure 3. Evaluation of relevance of M&T in companies
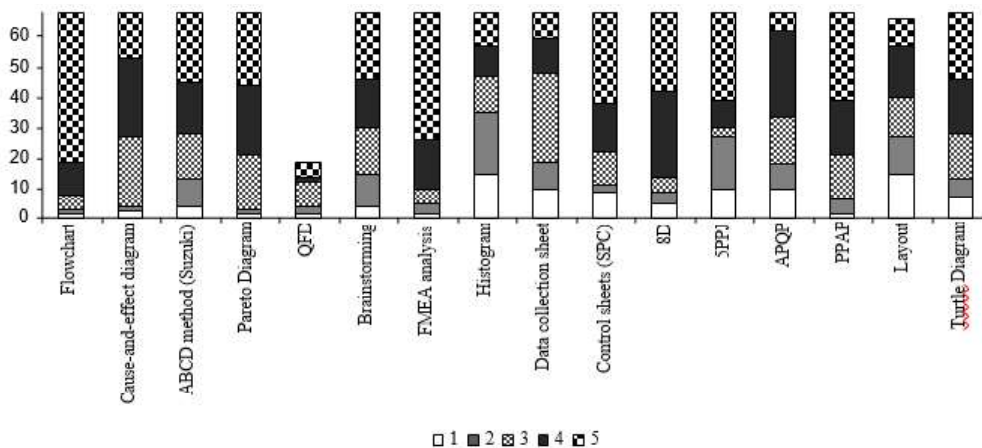
Source: Own study based on the questionnaire survey.

The selected statistical population (suppliers certified for ISO/TS 16949 compliance) guaranteed that the methods and techniques of quality management would be frequently used. As it turned out, the motivating factors to use M&T were in each individual case different. In most cases they resulted from necessity, i.e. requirements set by the QMS or customers. It can be certainly assumed that conscious and effective use of methods and techniques of quality management (irrespective of the reasons) is a sign of maturity as far as quality management is concerned.

The respondents (60%) admitted, though, that not seldom the requirement of usingm appropriate methods and techniques is fictitious, i.e. 8D reports, FMEA reports etc. Were compiled not as the effect of teamwork, one of the stages of problem solving activities, but as a formal task which simply had to be completed.

This is caused by a number of unequivocal factors, such as (figure 4):
• the fact that such actions require much time (77.94%),
• insufficient staff (72.06%),
• and the fact that the employees are not sufficiently prepared to use them (72.06%).

Figure 4. The causes of limited use of M&T in a company as a percentage
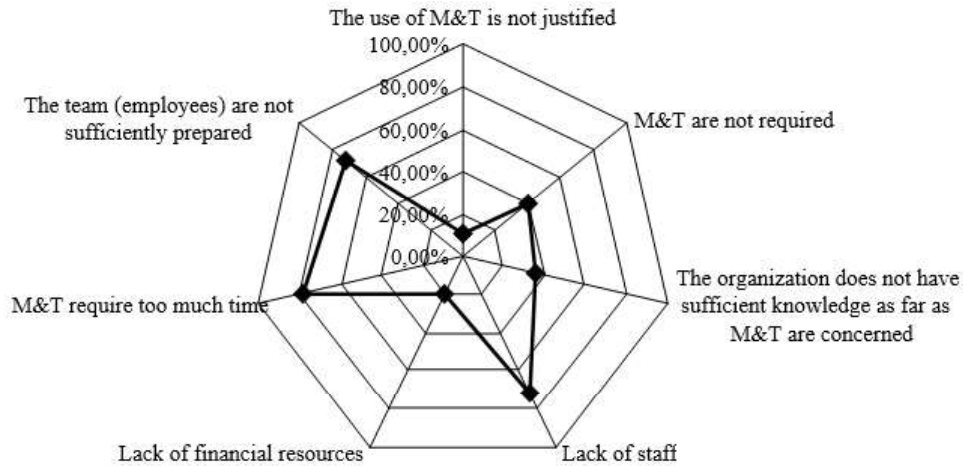
Source: Own study based on the questionnaire survey.

It must be pointed out that the respondents did not consider using M&T as unjustified or connected with significant financial expenses. It may be assumed that suppliers in the automotive industry are aware that such methods and techniques can be used effectively. What is more they feel the need to use them and even the lack of requirements related to their use does not contribute to the fact that such M&T are applied less frequently.

The results of self-evaluation concerning the knowledge of respondents (quality managers, quality department managers, proxies for quality) confirmed that limitations in the use of M&T exist (figure 5). Generally, respondents evaluated their own knowledge as quite good (46%). However, there were no randomly selected people in this group. All of them felt the need to educate and develop in that specific area of expertise.

6.Summary

There is a verification of the common theoretical approach regarding the methods and techniques of quality management in the paper. The research also showed that companies in the automotive industry used in practice only a limited number of the huge number of tools described in literature. In addition to that, the results of the research helped to determine which methods and techniques were the most effective when it came to their use. This was of key relevance as effective methods can considerably support non-compliance monitoring, or taking corrective and preventive actions.

The results of the conducted survey and the conclusions of the author can show actual and potential OEM suppliers (both 1st and 2nd tier) in which direction their strategies for development and improvement of quality management systems should go in order to be effective. When the universal character of methods and techniques used in the surveyed population of companies is taken into consideration, it can be assumed that the results of the survey are also universal for all organisations realising the TQM strategy.

The results of the research confirmed that methods which are also the basis for creating key system documents are the most relevant ones, i.e. flowcharts and FMEA, and moreover process monitoring tools (SPC) and problem solving methods – above all 8D.

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