THE MODEL OF QUALITY AWARENESS FORMATION AMONG EMPLOYEES OF SUPPLIER IN THE AUTOMOTIVE INDUSTRY

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Abstract
In the paper a six-step model of quality awareness formation inspired by the concept of E. Deming’s PDCA cycle is proposed. The authors have constructed their model with the following steps: 1) acquisition and analysis of a general data about the supplier, 2) setting the key objectives the quality awareness model should be focused on, 3) acquisition and analysis of data related to the current level of quality awareness, 4) detailed planning of the quality awareness development program among employees, 5) implementation of the program, 6) effectiveness evaluation and program verification. Finally, if the defined objective is not achieved the procedure will return to step 2 and the cycle of steps is repeated as long as the defined objectives are satisfied. In the paper special attention is paid to two steps of the method in which the structure and mechanism of quality awareness development is constructed (step 4) on the basis of diagnosed symptoms (step 3). It means the nature of quality awareness development is an appropriate composition of a single and/or periodic trainings and workshops, which agenda and intensity depend on the diagnosis done before.

Keywords: Quality awareness, suppliers, automotive industry.

1 INTRODUCTION
1.1 Quality awareness in automotive industry
While fundamental terms of quality improvement and quality awareness have been extensively explored for many decades authors and practitioners have claimed that most of efforts on quality are still producing defeative results (e.g. Hussain et al [1], Eben-Chaine [2]). Nowadays, production is based on a complex sociotechnical system that combines technology advances with human involvement. Due to the increasing complexity of the products, its shorter life cycles and increasing quality expectations, production management is increasingly challenging task (e.g. Brauner et al. [3], Schmitt and Schmitt [4]). While technological development is ongoing, the impact of human factor on quality is still a matter of high interest. Thus, since the product quality is not only the result of its end-control but is achieved at every stage of its production and in the processes around, the quality awareness among all employees is one of the key elements.

Human factor is critical not only by the step of machine operator (it will be more and more automatized) but in the whole organisation and planning process. Starting with the layouts and process models, through the human resources, up to the cleanliness etc. It all has an influence on the final product. The quality shall be intentionally produced, and not only controlled.

The role of human factor in quality awareness is also emphasised by many authors. Hussain et al. [1] have defined four key component of quality awareness, including communication, training and education, planning (scheduling), and basic quality knowledge. In fact, this concept and personal observation in automotive industry have become a key motivation to construct a holistic model of quality awareness forming model, which is discussed in the following section of this paper.

1.2 State-of-the-art in quality awareness development
Quality awareness among employees is a matter of indisputable influence on the quality of the final outcome of a process, including product or service. In the literature, one can find both analysis of measurement and evaluation of the level of quality awareness among employees as well as the techniques of shaping it.

As far as quality awareness measurement issue is concerned Gajdzik [5] has built a 6-level reference scale (0, 1, ..., 5) for quantitative evaluation of the quality awareness among the employees. Each level on the scale is referred to seven simultaneously considered aspects, including: knowledge on quality, tasks performance, innovation, relationship with customers, commitment to the process improvement, professional development and organizational culture. Some other research on quality awareness evaluation is also presented by Talib et al. [6], Berhe and Gidey [7]. Previously, the authors of this paper have also carried out their research on quality evaluation with human factor involvement, incl. Sawicki et al. [8] and Sawicki [9].

Taking into account a formation of quality awareness, Brauner et al. [3] have examined how game-based training can improve the decision-making ability of human operators in a ramp-up processes and how training intervention increases the operator’s quality awareness. In the game, the player is faced with predefined quality problems (e.g. damaged parts delivered by the supplier or unreliable production processes and resulting customer complaints). The objective of the game is to choose an optimal quality policy that minimizes customer complaints and maximises company profits. Some other approach to game-based learning approach is presented in work of Pfeifer and Schmitt [10], Philipson et al. [11] and Prensky [12].

1.3 The objective of the paper
The paper deals with the problem of quality awareness development among employees at various organisational levels of supplier in the automotive industry. A supplier is responsible for manufacturing components for the vehicle assembly performed by producer, called original equipment manufacturer (OEM). Nowadays, due to intense competitive rivalry all OEMs are strongly oriented on reducing cost of production while keeping or even raising quality standard. As a consequence all these requirements are directly translated to the results expected from suppliers. The most of responsibility for the product development and requirements definition has the OEM, but only with the relevant cooperation with the suppliers’ chain it can be really effective. If the supplier is aware of the requirements and his own abilities and disabilities, he communicates and solves the problems together with the customer. That is
one of the reasons, why the paper focuses on the suppliers’ quality awareness and not OEM. The authors have presented the results of preliminary research carried out with the group of automotive suppliers that are working with OEMs on the German market. As a result, a classification of the most common quality problems has been discovered, and one of the key conclusions from the research is that a level of suppliers’ quality awareness is still too low. All the analysed quality instances were the basis for a construction of the quality awareness model among a supplier’s employees.

2 QUALITY AWARENESS IN PRACTICE

2.1 The key analytical assumptions

Several real life cases within quality management area, occurring between a supplier and an OEM, as well as in the further supply chain perspectives have been analysed. They have been considered from the point of view of the external specialist, who has received experience from both: supplier - as a quality customer service, and customer - as a supplier quality assurance. As an input for the quality problems, the quality claims evidence from the customer has been taken into consideration. Based on the type, quantity and costs of the claims, it is possible to define daily supplier-customer quality problems. For each of the claims, according to the customer requirement, an action plan together with a root cause analysis (so called 8D report) have been made. Although, the authors went one step further and they analysed the problems deeper. They looked for the not obvious, indirect, further root causes of the problems. For each case, the quality awareness of the employees that influence the process directly or indirectly has been analysed.

2.2 A review on practical applications

The practice in the automotive industry shows, that the actions, which are supposed to improve quality factors, very often boil down just to corrective and eliminating actions caused directly by the external pressure: from customer or from certifying unit. Adding the pressure and time factors, all actions are implemented without thorough problem analysis. They are acceptable in the documentation, but not necessarily really eliminate the root cause of the problem. Additionally, while the certification, audit or claim procedures at the customer site are finished, the stress and direct pressure have also decreased. Actions start to decline and the risk of the issues increase again.

The authors have analysed selected and specific examples of quality issues in few European automotive plants that happened during last 10 years. For each issue defined root cause and implemented corrective actions have been mutually considered. As a next step the authors have formulated a question, if it is possible to prevent such and problems in the future. As a result, problem analysis (based on ‘5 x why’ method) has showed, that one of the base root causes of quality problems is missed or not sufficient quality awareness in different areas of the company.

Some results of the analysis are presented in the Table 1.

<table>
<thead>
<tr>
<th>Problem and its effects</th>
<th>Causes of errors</th>
<th>Quality awareness aspects</th>
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<tbody>
<tr>
<td>Repeating customer claims - problems’ escalation, more claims and costs of each single defective part, lost of customer’s trust to the supplier, lost of potential following projects.</td>
<td>8D report prepared by the Quality Customer Service Dept. without participation of another depts. representatives; as a result the actions written in the report was not implemented.</td>
<td>Insufficient knowledge about customer requirements in the depts. responsible for implementing the activities.</td>
</tr>
<tr>
<td>Repeating customer claims - the same defects are repeatedly occurring, despite some actions implemented before.</td>
<td>Inadequate corrective and preventive actions after complaints (8D report).</td>
<td>The lack of understanding among the employees responsible for defining the activities. It is not obvious for whom and why 8D report and the customer’s expectations are defined (it concerns several depts.: Quality Assurance, Production, Industrial Engineering, Inbound Logistics).</td>
</tr>
<tr>
<td>Delayed response to the customer – in sending 8D report and action plan; lowering customer quotes as well as risk of loosing potential new projects.</td>
<td>Ignoring quality optimization activities by the manufacturing and support departments due to the tight production schedule.</td>
<td>Lack of qualitative awareness among staff responsible for planning production, insufficient knowledge of customer requirements and the processes of the recruitment.</td>
</tr>
<tr>
<td>The acceptance of all complaints including those that are even not valid: higher quality costs.</td>
<td>No assertiveness among quality engineers.</td>
<td>Lack of awareness of customer quality requirements and standards among quality engineers.</td>
</tr>
<tr>
<td>Repetition of problem from the previous projects in new one.</td>
<td>Lesson learned is not implemented (or implemented inadequately) while a new project is planned (incl., layout design, machine and tools design, etc.).</td>
<td>Lack of knowledge of the company’s quality issues among project planning employees (incl., Project Management, Production Planning, Industrial Engineering).</td>
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Table 1. The analysis of root causes of exemplary quality problems at suppliers in automotive industry.
2.3 Recommendations
When analysing the causes of the problem, the focus is on discovery a direct causes of the problem. Often, these causes are imperceptible to those who are involved in the execution of processes on a daily basis, especially if they have no experience with other companies or processes. In fact the problems can be diagnosed first by taking the right perspective.

The analysis carried out by the authors showed that the cause of inappropriate actions, or even a lack of them, has been mainly resulted from inadequate personal involvement into the process. Thus, insufficient level or lack of awareness among employees causes misunderstanding of the underlying action. It is, however, problematic to diversify the level of awareness at each level of the organizational structure of the company.

A conscious leadership knows how important is educated employee, and award employees on the other hand are not afraid to communicate problems while avoiding the consequences of errors. Any error resulted from human factor is an indispensable element of human nature, resulting from the pressure of time and working in shifts, etc. But it is important to have mechanisms to diagnose the level of quality awareness among employees at various levels of organisational structure and increase it as a result. This will minimize the effects of the resulting errors.

3 THE CONCEPT OF QUALITY AWARENESS FORMING MODEL

3.1 Key assumptions
A model of quality awareness formation inspired by the concept of E. Deming’s plan-do-check-act (PDCA) cycle is proposed (see Fig. 1) in the paper. The model is constructed with the following six steps: 1) acquisition and analysis of a general data about the supplier, 2) setting the key objectives the quality awareness model should be focused on, 3) acquisition and analysis of data related to the current level of quality awareness, 4) detailed planning of the quality awareness development program among employees, 5) implementation of the program, 6) effectiveness evaluation and program verification. If the defined objective is not satisfied, the last step should be linked with step 4 again and the cycle is repeated as long as the defined objectives are satisfied.

3.2 Major steps of the model
Key steps of the model, which the paper is focused on, are the step 3 (acquisition and analysis of a data related to the current level of quality awareness), and step 4 (detailed planning of the quality awareness development program among employees). Depending on the objectives defined by the top management of the plant (see step 2), a detailed analysis should be done to describe present quality awareness level among employees. Thus, if the defined objective is to reduce the number of quality complaints coming from customers, the detailed evidence of complaints has to be taken into consideration. On the other hand, if the objective is to reduce number of ppm (defective parts per million delivered) to the customer, or the scrap costs, the evidence of quality reports from customer / scrap or ppm have to be taken into consideration, respectively.

Based on the quantity and the root cause analysis of the claims, an action plan has to be constructed. First actions should be planned within the most critical area (incl., production, engineering, logistics, quality etc.) and most critical level (incl., manual worker, team leader, top management, etc.).

Secondly, the most dominant problem has to be classified to one of the three principle categories, including:
- human error (for manual processes),
- process error (incl. machines, tools, materials, etc.),
- inbound logistics error (incl., stock level, inbound transport).

Depending on which root cause is responsible for most of the problems, an appropriate ‘actions path’ across the quality awareness forming model (step 4) should be traced.

A detailed process map of creating an action plan in this area is presented in Fig. 2. The list of corresponding abbreviations (e.g. C15P, C2S, …, C15P) of special action in this model is attached in the following Tab. 2. In the rest of this section an exemplary application to one of the considered quality awareness problem is presented to explain concept proposed by the authors.

Coming back to Tab. 1 see first row – problem of “repeating customer claims, (...)”, the direct root cause was that 8D report has been prepared by the Quality Customer Service Department, without participation of another department’s representatives. As a result, the actions written in the report was not implemented in the real process, or in spite of implementation, the problem has not been eliminated effectively.

The analysis showed, that further root cause was lack of or insufficient awareness about customer’s requirements among production and other responsible departments. The management was also not aware, that each employee, from production and also from logistics and technical department, has an influence over the product quality. The clear requirement for the participation among the departments was also missed.

While analysing suggested problem with application of the proposed model, during step 3(see Fig.1) an available data is analysed. All the data from customer claims’ list are then categorised by the general root cause. Let’s assume, that most of the claims were “human errors” (the percentage...
Figure 2. Process map within step 4 of quality awareness forming model.
Table 2. The list of detailed actions in quality awareness model, step 4.

<table>
<thead>
<tr>
<th>Code</th>
<th>S</th>
<th>P</th>
<th>Action</th>
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<tbody>
<tr>
<td>C1SP</td>
<td>+</td>
<td>+</td>
<td>Training on complaints and customer requirements, incl. programme for: directors (1.1), departmental managers (1.2), engineers and experts (1.3) and machine operators (1.4).</td>
</tr>
<tr>
<td>C2S</td>
<td>-</td>
<td>-</td>
<td>Training on 8D report, incl. programme for directors (2.1), departmental managers (2.2), engineers and experts (2.3) and machine operators (2.4).</td>
</tr>
<tr>
<td>C3S</td>
<td>+</td>
<td>-</td>
<td>Training on problem solving, incl. programme for directors (3.1), departmental managers (3.2), engineers and experts (3.3) and machine operators (3.4).</td>
</tr>
<tr>
<td>C4S</td>
<td>+</td>
<td>-</td>
<td>Training on problem analysis (discovering).</td>
</tr>
<tr>
<td>C5S</td>
<td>+</td>
<td>-</td>
<td>Training on normative requirements, incl. ISO/TS 16949, VDA, FormelQ etc., including programme for directors (5.1), departmental managers (5.2), engineers and experts (5.3) and machine operators (5.4).</td>
</tr>
<tr>
<td>C6S</td>
<td>+</td>
<td>-</td>
<td>Training on the impact of the human factor on complaints; motivations, incl. programme for human resource depts., (6.1) and masters or team leaders (6.2).</td>
</tr>
<tr>
<td>C7P</td>
<td>-</td>
<td>+</td>
<td>Workshop on two-way communication between superiors and subordinates.</td>
</tr>
<tr>
<td>C8P</td>
<td>-</td>
<td>+</td>
<td>Workshop on increasing employee’s motivation, incl. program for human resource departments (8.1), masters and team leaders (8.2) and team leader with his team (8.3).</td>
</tr>
<tr>
<td>C9P</td>
<td>-</td>
<td>+</td>
<td>Workshop on production line, incl. programme for departmental managers (9.1), team leaders (9.2), machine operators (9.3), production engineer (9.4) and maintenance service (9.5).</td>
</tr>
<tr>
<td>C10SP</td>
<td>+</td>
<td>+</td>
<td>Training on lessons learned from the previous projects.</td>
</tr>
<tr>
<td>C11S**</td>
<td>+</td>
<td>-</td>
<td>Training on customer’s requirements at the pre-serial and project management, incl. project planning, milestones and changes implementation.</td>
</tr>
<tr>
<td>C12P**</td>
<td>-</td>
<td>+</td>
<td>Training on the problems issues discovered during pre-serial production, incl. interactions between Project Management and Production, Industrial Engineering, Maintenance Service and Pre-serial Quality Planning.</td>
</tr>
<tr>
<td>C13S</td>
<td>+</td>
<td>-</td>
<td>Training on Statistical Process Control, incl. an impact of preventive actions on quality and cost reduction.</td>
</tr>
<tr>
<td>C14S</td>
<td>+</td>
<td>-</td>
<td>Training on process capability (Cpk) and machine capability (Cmk) measures.</td>
</tr>
<tr>
<td>C15P</td>
<td>-</td>
<td>+</td>
<td>Workshop on the implementation of the problem solving process with all responsible units, including: Quality Assurance, Inbound Logistics, Production, Industrial Engineering, Maintenance Service. Preparation a common 8D reports.</td>
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</table>

* frequency: S – single, P – periodic; ** applies only to companies with own R&D department

of the root causes L is higher than a suggested threshold L1, i.e. L > L1). That is why a first focus should be on building the quality awareness among production and supporting departments’ employees (quality assurance, inbound logistics, maintenance, industrial engineering) but also among team leaders and management. By such advanced escalation and repeating problems it is required to educate first the people, who lead the processes, decide about work steps and instructions and then to go down in the company’s organizational structure, until the single machine / tool operator is involved in action plan.

First training within phase II (i.e. Generalisation and classification based on the causes of errors) would be about customers’ requirements and summary of claims from customers. Single kick-off training (S in C1SP, see code in Fig. 2 and Tab. 2) about past and present situation and later on periodically repeated training (P in C1SP) on actual claims’ status should be performed. The detailed programme (subject of the training) has to be adapted to the organisational level (i.e. top management receives more strategic information, about claims, and employees at departmental level receive more operational information). Next, employees have to participate in a customised to the organisational level single training about 8D report (C2S) and problem solving process (C3S). As a result it would increase the quality awareness of employees about what really need the customer, after receiving defected product, as a response from the supplier.

Further step should be devoted to training managers and engineers on problem analysis methods (C4S), i.e. how to discover the real root cause of the defect. Based on the knowledge and awareness the teams for creating 8D report and problem solving have to be constructed. From each department at least one representative should be selected and trained within this action.

Parallel, a training programme on automotive normative requirements (C5S), incl. ISO/TS 16949, VDA, FormelQ etc., for a production and supporting departments and with respect to a structural level should be constructed and applied once (see S in C5S). The aim is to show employees the potential consequences of not respecting the procedures. The last action of the step 4.1 is the training on employees’ motivation and its influence on the claims (C6S). This kind of action is dedicated to human resources forces, managers and shift / team leaders, who have direct influence on employee’s supervision.

Within phase II (Detailed actions depending on causes of errors), a corresponding step on “action path” is step 4.5 (see Figure 2). It is mainly devoted to the workshops and periodic actions with the employees, which aim to improve internal communication in the plant (between management, human resources and staff) and to increase the motivation among employees. Within step 4.5 a periodic workshops on how to increase employees’ motivation (C8P) should be organised, first for human resource forces and management (8.1 and 8.2), second for supervisors with their teams (8.3). Parallel, for the specific quality claims, a sequence of workshops at the production line where defected parts were produced should take place. A target group of these workshops on possible improvement actions (C9P) should consist of operators, team leaders and supporting team.

Supplementary, within step 4.5, it is suggested to implement a programme of optimisation proposals (C7P), across a whole plant. Each employee should have a chance to submit an optimisation proposal to reduce cost of production or to improve quality. As a motivation engine some rewarding system for the most effective ideas can also be proposed.
4 CONCLUSIONS

4.1 The result of the research

The paper deals with the concept of a quality awareness formation model among employees in a supplier of the parts and components for automotive industry. A concept of the model assumes 6 interrelated steps, starting with general diagnostics, and ending with evaluating the effectiveness of the developed and implemented action plan. Within the paper the authors have concentrated exclusively on the construction of a detailed action plan (step 4) in reference to the results of the preceded analysis (step 3). A detailed decision model consists of 11 sub-steps within 3 main phases (I - III).

The practical application of the proposed model has been explained on a basis of exemplary problem diagnosed with one of the suppliers of automotive parts and components.

4.2 Further research

Due to the preliminary nature of the research so far, it is necessary to develop further actions, including:

- Construction of a quantitative procedure for evaluation the current level of quality awareness among employees. The result of this procedure is expected for at least two purposes, first while formulation a quality objectives, second while evaluating the effectiveness of the action plan implementation.
- Pilot implementation of the model into the several automotive suppliers as an alternative way to solving diagnosed quality problems. As a result a real advantages of model implementation should be defined.
- Final development of the model, including its corrections and modifications resulting from pilot implementation should also be performed.