International Journal of Commerce and Finance, Vol. 2, Issue 1, 2016, 25-35

COST OF POOR QUALITY IN ENERGY SECTOR

Özlem Aras, (MSc)

Kocaeli University Industrial Engineering Programme

Burcu Özcan, (Ph.D.)

Kocaeli University Industrial Engineering Programme

Abstract:

Companies need to produce their product and services with lower cost in order to survive in the competitive global market. That is why; firstly they need to define the visible and invisible cost of poor quality factors and then need to eliminate these Poor Quality Costs by utilizing the various improvement methodologies. In order to define the poor quality, firstly the project team members need to be assigned between the cross functional departments. Then, the current status needs to be defined step by step by utilizing the various methodologies such as Pareto Analyze etc. As a second step, Root Cause Analyze is performed, and lastly the actions and action plan are defined. All these steps are systematized with some methodologies such as PDAC, Practical Problem Solving (PPS), Six sigma DMAIC & 8D. In this study, it is aimed to decrease the Warranty Cost which is a factor of the Cost of Poor Quality in a factory in the Energy Sector. At the same time, it is aimed to decrease the customer complaints as well as to increase the customer satisfaction. The factors that cause the Warranty Cost have been defined in the Current Status Analyze. Pareto Analyze, Brainstorming, Fish Bone Analyze, Process Mapping, 5 Why Analyze etc. methodologies have been utilized in this study.

Key words: *Key Performance Index (KPI), Pareto analysis, Cost of poor quality (COPQ), Fish Bone, 5 Why*

1. Introduction

At the present century, companies strive to continuously develop and expand their actuality. Consequently, they try to define what their customers expect and how they can meet the customer expectations with a minimum cost. (Anderson,1993) To achieve this; they need to understand their customers properly; need to produce or service in a high quality on time with a low cost (Karaulova et al., 2008). A company that succeeds these requirements have loyal customer who make repeat orders (Jones and Sasser, 1995). Thus, the company guarantees to have great Return On Investment (ROI) (Karaulova and Shevtshenko, 2009).

Today companies need to be reliable and stable at their processes so that they can produce the quality with lower costs. The reliability and stability affect the performance of the company in its sector. For that reason each company needs to describe some metrics; Key Performance Index (KPI) to measure their performance. Thus, these KPI metrics measure the real status of the company at the certain time (Kaganski, 2013). For example Cost of Poor Quality / Revenue which is a KPI metric of a company. This KPI metric includes; scrap cost, rework cost, warranty cost which consumes recourses, time and money (Karaulova et al.,2012).

Therefore, in order to survive in the market, companies should increase the product and service quality as well as decrease the cost by utilizing various quality improvement methodologies. Particularly, in the today's competitive market, Cost of Poor Quality cannot be disregarded within the cost management. However, in the classical system, it was assumed that high quality was met with high cost. However, at the present day, it was understood that this approach was not true. It was accepted that the highest cost of a company is not to produce high quality product or service, it is to produce lower quality product and service (Karabınar and Geyik, 2001).

Efil stated in his book that "the cheapest way of doing a work is to do it true for the first time" (Efil, 1990).

The influence of the poor quality production can be handled in two ways; losses for the companies and also for the customers. Companies are faced with decreasing of the sales, loss of image, decreasing of the competitiveness and loss of the productivity. In point of customers ; the health and safety run a risk, the customers do not satisfy with the product, the customer dissatisfaction is increased, the trust of the customer is decreased, customer complaint and returns are increased (Sale, 2001). As a result, both companies and customers suffer with the poor quality of design, production and sales.

There are two kind of aims of the Quality Systems and Improvement Processes; to increase the customer satisfaction and to decrease the costs which are occurred because of non-conformities. Companies want to increase the customer satisfaction in order to sell more products. This means that they make more profit. The best way of decreasing the costs which are occurred because of non-conformities is to prevent before the cost occurs. If it is not possible, the companies need to define and solve the non-conformities in the sub-process of the production as soon as possible. The cost of the non-conformities increases when the defining of the non-conformities is late. This point of view should not be forgotten; the additional cost of the non-conformed product is because of the poor quality not because of the quality (Özkan, 2001).

In the recent years, while the customer expectations and production systems are continuously changed, the description of the quality costs are same in the last 50 years (Moen,1998).

In the past, companies were thinking differently regarding how their product specifications should be. Product specifications were being designed based on designer's desire or based on how company wants to provide the product to their customers. Henry Ford's quotation is an example for this way of thinking 'Customers can choose a car which color they want with black being conditions'. As can be seen, at the beginning of the 1900, the products were produced just in defined specific conditions, the customer expectation was not being considered. In the other word, companies focused on just conformity of the standards (Hitcher,1993). At the present, this way of thinking was changed as 'conformity to the requirements'. Companies started to produce product or service based on the customer requirements with this new approach. At the recent years, big companies started to respond the latent requirements of their customers. These latent requirements are the requirements that the customers have not thought over it or haven't realized it so far.

According to Bland; the cost of poor quality is equal to the variation between the actual operational cost and operational cost standard (Bland, 1998). Besides, customer dissatisfaction which is occurred due to this poor quality and also the cost which the customer has to bear should be added into the company COPQ.

According to the Sörqvist; the non value added cost should be called as COPQ and COPQ is the best way to increase the profitability and competitive capacity of a company.

In summary; poor quality firstly causes customer dissatisfaction then, loss of sale and loss of image. In actual fact, this is the main difference between the Quality Cost and Cost of Poor Quality. Even though the customer dissatisfaction cost and loss of company image cost called as latent cost are disregarded in the classical Quality Cost System, they are very important in the COPQ System. Because recent studies showed that these latent costs are very important that they can't be ignored. The aim of the COPQ is to provide required data to the management and the employees in order to define the improvement opportunities and to measure the continuous improvements in a company. COPQ system also helps a company to control itself in its own process.

2. Cost of Poor Quality

There are numerous ways to define and measure the Cost of Quality, in this study we use ASQ Cost of quality definition. There are two different variables in the cost of quality equation: Cost of Good Quality (COGQ) and Cost of Poor Quality (COPQ). Essentially, the COGQ relates to costs incurred to assure the quality in products and prevent poor quality. The COPQ is a measurement of the non–conformities (failure) costs incurred in producing the product. This can be understood in the following formula:

$$CoQ = CoGQ + CoPQ \quad (1)$$

Each of these variables has more specific dimensions. The CoPQ accounts for internal and external failure costs, while the CoGQ encompasses appraisal and prevention costs.

The CoPQ quantifies the traditional quality costs companies measure. These include scrap, rework, and returned materials. As these costs emerge from production line issues as well as external services employed by companies, such as the use of the supply-chain, it is important to identify their origin in the calculation. The CoPQ formula can be extended to show Internal Failure Costs (IFC) and External Failure Costs (EFC), giving us the following equation:

$$CoPQ = IFC + EXC, \text{ where:} \quad (2)$$

IFC = Scrap Costs + Rework Costs (3)

EFC = Returned Product Costs + Warranty Costs + Product Recall Costs (4)

Costs incurred internally and externally are caused not only by defects in products, but also by inefficiencies in production and processes. A more in-depth list of factors affecting IFC and EFC is below:

Factors Affecting IFC Factors Affecting EFC

· Weaknesses in quality resolution (CAPA/FMEA)

· Delayed work schedules

· Poor Materials Planning

· Materials shortages

· Equipment downtime

· Materials review

· Reengineering/redesigning products

· Poor service management

· Unresolved customer complaints

· Weak enterprise communication

· Environmental/sustainability nonconformance

· Adverse reputation events

3. Application

This study is carried out in a factory which trades in Energy sector and has 662k$ Cost of Poor Quality. This amount of COPQ was occurred in 2015 which is shown on the below Table 1. In this analyze, COPQ/Revenue which is the Non-Financial Key Performance Index of the company has been analyzed and targeted to decrease COPQ/Revenue from 1, 25% to 0, 68% until the end of the 2016 and to decrease the COPQ in the ratio of 45%, and additionally to decrease the Customer Complaint quantity in the ratio of 83%.

Table 1. Total COPQ, Warranty Cost, COPQ/Revenue, Targets

Total COPQ	662k$
Warranty Cost	300k$
Target Decreasing Ratio from COPQ	45%
Revenue	52.920k$
COPQ/Revenue	1,25%
Target COPQ/Revenue	0,68%

In this study, team members are gathered from Design Department, Planning & Purchasing Department, and Dispatching Department based on the Cross Functional Team requirement. A Cross Functional team should have members from all the functions needed to diagnose the root cause, develop and implement solutions. The methodologies used in this study are Process Mapping, Pareto Analyze, Brainstorming, Fish Bone, 5Why.

In order to analyze the COPQ / Revenue; the analyze steps were divided into four steps which are modeled from Deming's PDCA Cycle. Analyze steps are defined as below:

Define & Measure: Any process, sub process or financial performance metric that is measured and planned for improvement.

Analyze: This is a step where, the performance metric that needs to be improved is analyzed.

Improve : Actions that are necessary to create the change as per analysis completed in the earlier step.

Sustain: This is where process changes are effected and standardized to create a sustained performance after confirmation of achievement of the goal.

The analyze steps; Define & Measure, Analyze, Improve & Sustain are determined in Table 2 as Project Plan.

Table 2. Project Plan

Define & Measure:		
Project set up (team members), data collection: Define opportunity. Investigate to understand the current state in detail.		
	Action	Target Date
1	Analyze Current Warranty Cost	Q1/2016
	Classification of the Cost Type & Customer Complaints	
	Pareto Analyses; Define the highest costs & customer complaints	
2	Process Mapping: Review the Process flow to see the non-conformities occurred in the flow.	Q1/2016
Analyze :		
Analyzing the data: Identify and confirm root causes of the problem & Develop, pilot, and implement solutions that eliminate root causes.		
	Action	Target Date
1	Brainstorming Methodology	Q2/2016
	Fish Bone (Ishkawa) Methodology	
	5 Why Methodology for defining the Root Cause	
2	Solutions defined in order to eliminate the Root Causes.	Q2/2016
Improve:		
Developing & Implementing Long Term Solutions		
	Action	Target Date
1	Actions planned with smart targets: When & Who?	Q2/2016
Sustain:		
New work methods and processes standardized. Issue closed		
	Action	Target Date
1	Checking & standardization of the actions taken.	Q4/2016

3.1. Define & Measure:

First of all, Warranty Cost has been calculated within the Cost of Poor Quality. Afterwards, Warranty Cost has been classified based on the complaint type and thus, Customer Return Quantity and Customer Return Cost which come from the field have been obtained. Analyze has been resulted as below:

- There has been 662,47k$ Cost of Poor Quality which was occurred because of the non-conformity activities in the company during 2015. 45% of this cost is because of the Warranty complaints came from the customer return from the field as shown in the Table 1.
- The Warranty Cost classified based on complaint type has been analyzed by utilizing Pareto Analyze given In Figure 1. As can be seen from the below graphic, the most important problem is the missing delivery to the latest customers which is occurred 83% of the Customer complaints. Then technical failure comes from behind, Service support problems and damage.

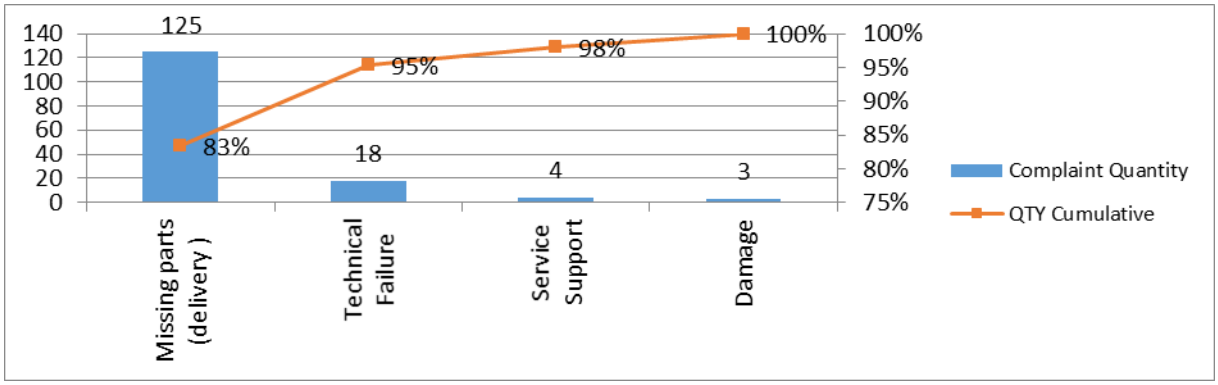

Figure 1. Pareto Analyze for the Customer Complaint Quantity

When the analysis is proceeded based on the cost, as can be seen from the Figure 2, missing part/delivery to customers has been occurred the 67% of the Warranty Cost.

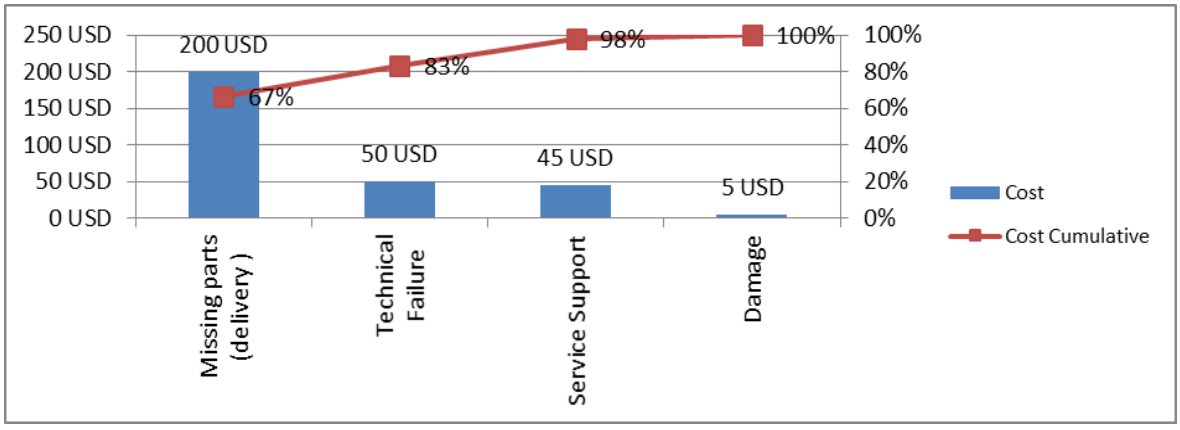

Figure 2. Pareto Analyze for the Warranty Cost Distribution

Secondly, in order to define the current status of the issue, an as-is Flowchart has been utilized to understand how the process currently flows. It will be helpful to compare this as-is Flowchart with a diagram.

In the as-is Flowchart diagram, the process steps of the Design and Dispatching Department were reviewed because these departments are directly responsible from the Missing Delivery Complaints. In Figure 3, Process flow has been analyzed step by step. All the traces which can cause the Missing Delivery were noted down on the

Process Flow in order not to overlook the details. This will help the team members to find the Root Cause. This method should not be omitted during Current Status Analyze.

Based on above explanation, all the steps summarized and charted as below:

Design Department prepares the Bill of Material (BOM). After preparing BOM, Material Resource Planning (MRP) is run. Then, Purchase Order is released to the Planning Department and Project Data Table is prepared by Design Engineer. After the preparation of the Project Data Table, Accessory Packing List is determined by the Design Engineer. Accessory Packing List cannot be transferred automatically from SAP BOM so it is prepared manually. Then, Packing List is sent to Dispatching Department just before the shipment and accordingly accessories are prepared by Dispatching Department. Finally packing and loading steps are completed.

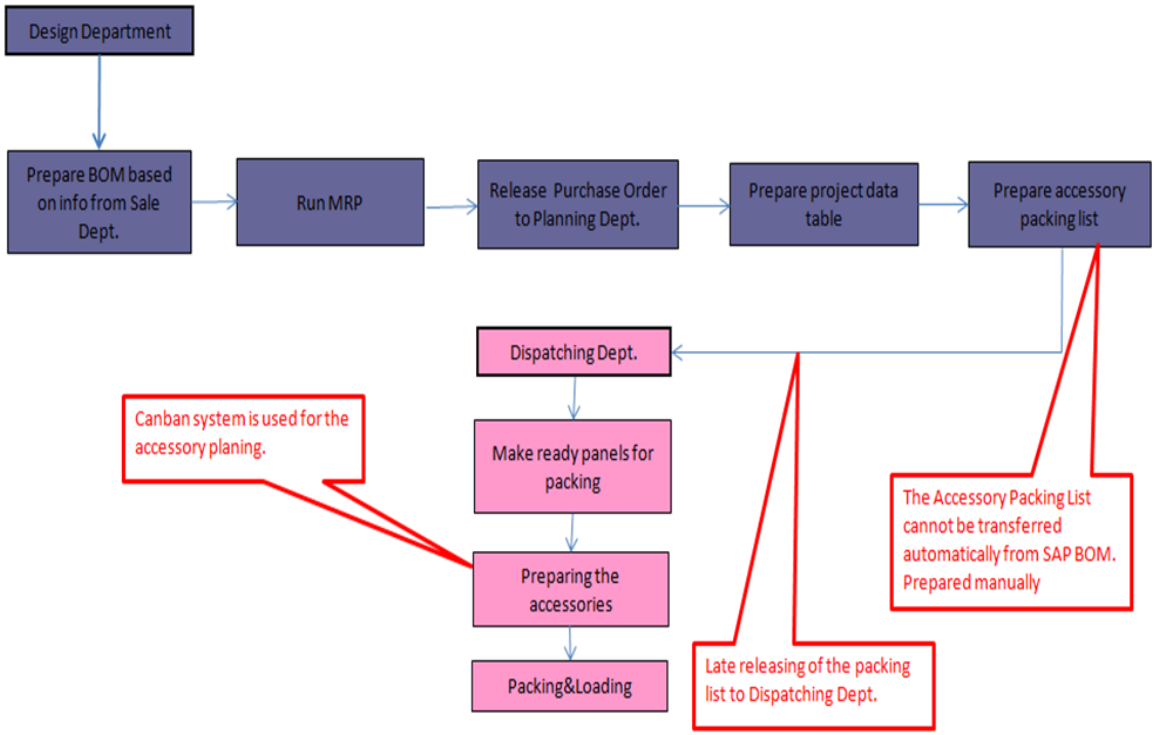

Figure 3. Process Flow Chart for Missing Delivery Issue

3.2. Analyze

At the Analyze stage of this study, Fish Bone Diagram has been utilized. Fish Bone Diagram is a tool that helps to identify, sort, and display possible causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. This type of diagram is sometimes called an "Ishikawa diagram" because it was invented by Kaoru Ishikawa, or a "fishbone diagram" because of the way it looks or Cause & Effect Diagram.

A Cause-and-Effect Diagram is a tool that is useful for identifying and organizing the known or possible causes of quality, or the lack of it. The structure provided by the diagram helps team members think in a very systematic way.

In this analyze, as defined above in Figure 4, all possible main causes of the issue have been determined by the Cross Functional Team by utilizing Brainstorming Methodology and possible causes were placed into Fish Bone Diagram. The main causes which affect the Missing Delivery Issue; Policies, Design, Procedures, People,

Production&Planning ve Plant have been determined and all the possible sub-causes have been defined and have been placed under the main causes.

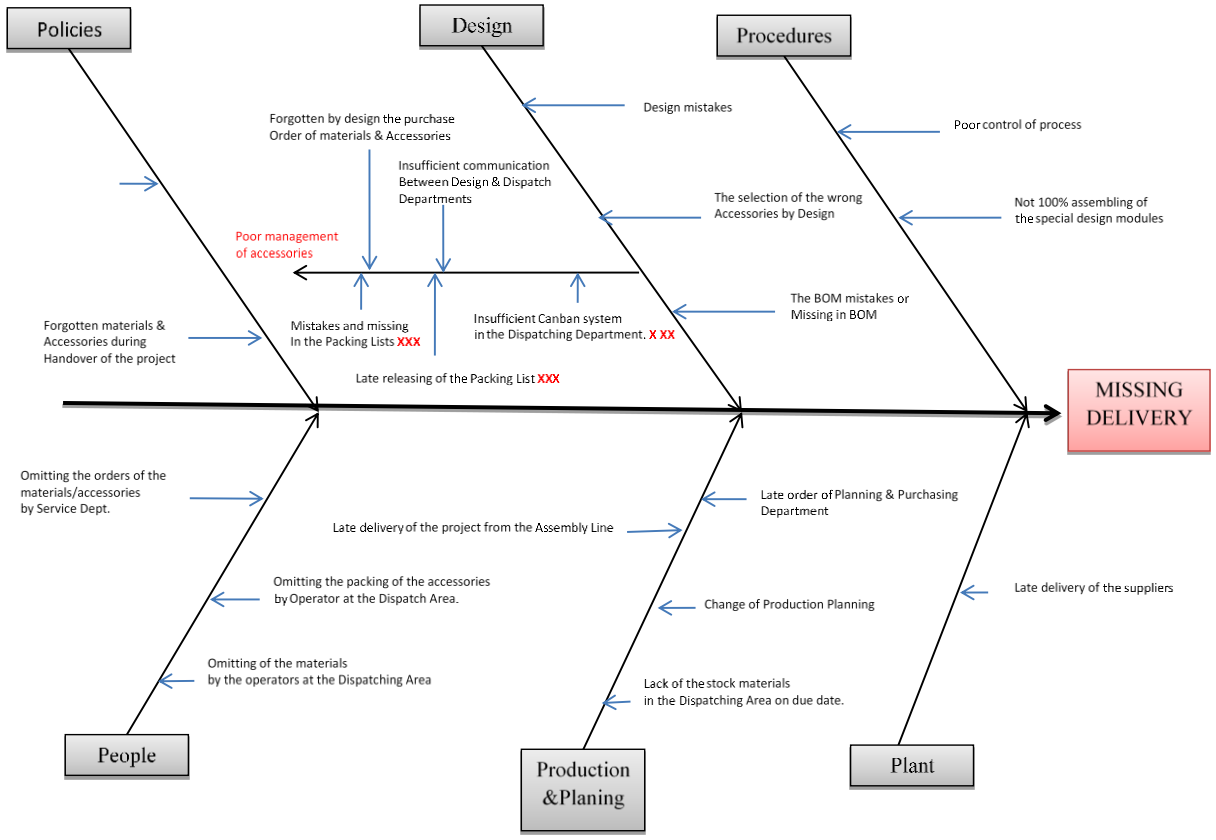

Figure 4. Cause-and-Effect Diagram

After placing the all possible sub-causes, most likely root causes of the issue should be found by the team members by utilizing the Process Flow Chart and their experiences. For the Root Causes of the issue, 5 Why Analyse has been used in this study. 5 Why Analyze is a method in order to reach the Root Cause of the issue. In this method, the team members always ask 'Why this happens? 'until they can't reply the question 'Why'. When they cannot proceed with the question why, that means they reach the Root Cause of the issue.

The team members of the study have reached Root Causes of the Missing Delivery to Customers as shown in the Table 3.

Table 3. Five Why Analyze

Investigation - 5 why analysis	1	Late releasing of the Packing List	2	Mistakes and missings in the Packing Lists	3	Insufficient Canban system at the Dispatching Dept.
	WHY?	It is not in the first priority of the work order for Design Engineer.	WHY?	The packing list is created manually by Design Engineer	WHY?	Planning Method is not suitable for Canban System.
	WHY?		WHY?	The Draft Packing List cannot be transferred automatically from SAP BOM	WHY?	
	WHY?		WHY?		WHY?	
	WHY?		WHY?		WHY?	
	WHY?		WHY?		WHY?	
Root cause		It is not in the first priority of the work order for Design Engineer.		The Draft Packing List cannot be transferred automatically from SAP BOM		Planning Method is not suitable for Canban System.

3.3. Improve

After defining of the Root Causes, the team members should define actions to eliminate the Root Causes. These actions need to be planned by smart targets such as 'What's the target, who is the responsible and when will it be completed '.

Based on the above explanation, the countermeasures have been defined for the each root causes and shown in the Table 4. The actions for first root cause are that the Packing List of the project will be determined in Design meetings and the preparation of the packing list will be reminded by mail to the related Design Engineer by the Dispatching Engineer when the project Work Order Released and project starts to be produced. The actions for second Root Cause are the accessories which can be assembled during production will be assembled at the assembly line and these accessories will be removed from accessory list and the accessories will be obtained automatically from SAP BOM, it will not be prepared manually. The actions for the third Root Cause are MRP system will be used for the accessories and Canban System will not be used.

Table 4. Root Causes and Actions

Root Cause and Actions	
Root Cause	1. It is not the first priority of the work order for Design Engineer.
Actions	1. The packing list of the project will be determined in Design Meeting. Who : Design Engineer / When : In the first coming project. 2. The preparation of the packing list will be reminded by mail to the related Design Engineer by the Dispatching Engineer when the project Work Order Released and project starts to be produced in the production. Who : Dispatching Engineer / When : In the first coming project
Root Cause	2. The draft packing list cannot be transferred automatically from SAP BOM.
Actions	1. The accessories which can be assembled during production will be assembled at the assembly line and these accessories will be removed from accessory list. For instance: bars, screws, washers, gas ducts will be assembled during the production. These parts will not be considered as accessories. Who : Production Department & Design Department / When : Q3 /2016 2. The accessories will be obtained automatically from SAP BOM, it will not be prepared manually. Who : Design Department with IT Department / When : Q3/2016
Root Cause	Production planning method (Canban System) is not suitable for the planning of the accessories.
Actions	MRP system will be used for the accessories and Canban system will not be used. Who : Design Department & Dispatching Department / When : Q3 /2016

3.4. Standardization

When all actions are taken, it should be concluded as dramatic improvement in the customer complaints and Warranty Cost. This can be observed by measuring the KPI. If the improvement is clearly related to the actions, we need to sustain the gains by standardization of these actions taken. It shall be done by changing work instructions, method provisions, check lists, sigma cards etc. This is very Critical Step and if not done immediately then the problems will keep repeating. This shall be supported by appropriate training as necessary.

As can be seen from below actions, some standardization has been applied in this study in order to keep the latest status.

- SAP system was revised & Accessories are planned in the system automatically.
- Accessory list was revised & some parts; bars, screws, washers, gas ducts are assembled in the Production Line, not in the Dispatching Area.
- MRP system is used for the planning of the accessories.

At the beginning of the following year (2017), the KPI metric ; COPQ / Revenue, Customer Complaint rate, Warranty Cost will be measured and the achievement of the study will be observed by the company management.

4. Conclusion:

In recent days, with regard to the companies, while the Quality is a strategical concept, it is one of the main factors which defines the choices with regard to the consumers. When the Quality is defined with the traditional approaches, it is handled as conformity of the standards or conformity of the purpose. However, today the Quality concept has gained a new dimension which does not fit into these definitions. Quality concept has been rescued from the narrow definition case and has been placed into the flexible and dynamic case. Based on this flexibility and multidimensionality of the Quality, numerous quality definitions have been defined related to the Quality concept and each definition has been used in different places. As a result, with the most common definition, Quality can be defined as a strategic management tool which is used for satisfaction of the customer expectation, improvement of the operational performances, decreasing the costs.

Productivity is an indispensable item for the companies. The companies which work efficiently, achieve minimization of the costs and accordingly get profitable results. The companies which apply the Six Sigma Approach, define the non-value added actions, remove the unnecessary actions from the company processes and thus, they provide profitable works with the minimization of the costs.

In this paper, Warranty cost which is the factor of the COPQ, has been analyzed by utilizing some methodologies such as; Pareto Analyze, Process Mapping, Brainstorming, Fishbone Analyze and 5 Why Analyze. Then it has been targeted decreasing of the Warranty Costs with the actions taken for the warranty root causes. In the Current Status Analyze stage, COPQ / Revenue which is the Non-Financial Key Performance Index (KPI) is determined as 1,25% . Then this KPI has been targeted to decrease until the 0,68%.

During the Current Status Analyze stage, Missing Delivery to Customer issue which is the 67% of the Warranty cost has been emphasized by utilizing the Pareto Analysis methodology. At the same time, it is aimed to decrease the customer complaint in ratio of 83% and accordingly to increase the customer satisfaction. After the Current Status Analyze, Root Cause Analyze has been performed. In the Root Cause Analyze stage, the main causes which affect the Missing Delivery Issue; Policies, Design, Procedures, People, Production & Planning and Plant have been determined and all the possible sub-causes have been defined by utilizing the Brainstorming methodology and these sub-causes have been placed under the main causes. The direct causes which were chosen by the team members within the possible causes are determined as Mistakes & Missings in the Packing List, Insufficient Canban System at the Dispatching Department, Late releasing of the Packing List. Then, the Root Causes of the Missing Delivery have been determined as Priority of the Design Engineer, Poor SAP system for the Bill of Material, Insufficient Planning by utilizing the 5 Why Analyze methodology. Based on the root causes defined some actions have been taken such as; Packing List needs to be defined in the Design meeting and when the work order of the project released and the project is started to be produced in Production Line, Design Engineers should be informed regarding the packing list of the project, Accessory Packing List has been revised and some accessory parts have been removed from the Accessory Packing List, Accessory parts needs to be taken from SAP BOM module automatically and utilizing from MRP System instead of Canban System for the planning.

References

Anderson, E. W. and Mary W. S. *The antecedents and consequences of customer satisfaction for firms.* Marketing science, 1993, 125-143.

Bland, F. Merle, John Maynard and David W. Herbert. "Quality Costing of an Administrative Process", The TQM Magazine. Vol.10, No.5, 1998, p.367.

Efil, İsmail. Toplam Kalite Yönetimi ve Toplam Kaliteye Ulasmada Önemli Bir Araç-ISO 9000 Kalite Güvencesi Sistemi. Bursa:Uludag Üniversitesi Basımevi, 1990.

Harrington, H. James. "Performance improvement: a total poor-quality cost system", The TQM Magazine. Vol.11, Iss. 4, 1999, p.221-230.

Hitchner, Earle, "Quality Works", National Productivity Review. Vol.12, Iss.2, 1993, p.285-290.

Jones, T. O. and Sasser, W. E. *Why satisfied customers defect*. Harvard business review, 1995, 88.

Kaganski, T., Snatkin, A., Paavel, M. and Karjust, K. *Selecting the right KPIs for SMEs production with the support of PMS and PLM*. International Journal of Research in Social Sciences, 2013, 69 - 76.

Kangilaski, T. *Challenges for SMEs partner network*. Proceedings of the 7th International Conference of DAAAM Baltic Industrial Engineering, 2010.

Karabınar, Selahattin ve Faruk Geyik, "Toplam Kalite Yönetiminde Parayla ifade Edilemeyen Maliyet Kalemleri Üzerine Öneriler", Üretim Sempozyumu,Gaziantep Üniversitesi, 2001, http://www.lnsresearch.com/ accessed 12.03.2016

Karaulova, T. and Shevtshenko, E. *Reorganisation of Production System on SME Enterprises*. Annals of DAAAM & Proceedings, 2009.

Karaulova, T., Kostina, M. and Sahno, J. *Framework of reliability estimation for manufacturing processes*. Mechanika 2012, 18.6.

Karaulova, T., Kramarenko, S. and Shevtshenko, E. *Risk Factors in Project Management Life Cycle*. 6th International Conference of DAAAM Baltic Industrial Engineering, Tallinn, Estonia, 24-26, 2008.

Moen, M. Rune. "New Quality Cost Model Used As A Top Management Tool", The TQM Magazine. Vol.10, No.5, 1998, p.334-341.

Özkan, Yılmaz. Toplam Kalite. Birinci Basım, Sakarya: Sakarya Kitapevi, 2001.

Sale, İsmail. Adım Adım Toplam Kalite Uygulamaları. Birinci Basım, Ankara: Seçkin Yayıncılık, 2001.

Torbica, Z. M. and Robert C. S. *Customer satisfaction in home building*. Journal of Construction Engineering and Management, 2001, 82-86.