QUALITY AND MANAGEMENT TOOLS, AN INTEGRATED APPROACH FOR QUALITY COST REDUCTION

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Abstract. Successful quality management is dependent on first class problem solving and continuous improvement. Cost control and product quality can sustain the organizational competitive advantage, while the innovation creates it. Both, problem solving and continuous improvement need the same managerial techniques, quality and managerial tools. However, it is difficult to decide which technique should or could be used in different situations and to see how different approaches are related to each other. The article briefly describes the "Seven basic quality tools", "Advanced quality tools", "Seven new management tools" and makes the link between different situation and the tool that must be used. Based on ten years of experience in this field of activity in Romanian companies, in the last part of the article are presented the key points for a good implementation and proper use of all this tools.

Keywords: quality tools, problem solving, quality cost

1. Introduction

Quality tools help staff to identify, analyze and assess qualitative and quantitative data that is relevant to each activity, in order to take decisions. These tools can identify procedures, ideas, statistics, cause and effect concerns and other issues relevant to the organizations. Each of this can be examined and used to eliminate non-quality, or, in other words, to enhance the effectiveness, efficiency, standardization and overall quality of procedures, products or work environment, in accordance with ISO 9000 standards.

According to Juran and Parker [1, 2] in USA, France and Great Britain the cost of non quality represents between 5 % to 40 % of the company's turnover. In order to eliminate this waste, proper knowledge and use of quality tools are mandatory.

2. General frame

Quality tools are used:

- to provide a step by step procedure that can be repeatable applied to most problems or process improvements;
- to reduce the amount of time to make an improvement or solve a problem;
- to provide a structure to follow that helps ensure positive solving;
- to standardize the mechanism for improvement and problem solution;
- to aid in communication and facilitate learning.

Usually, toolbox is needed:

- when product or process improvements are needed;
- when problems arise in all areas of design, manufacturing, and business processes.

Various problem-solving models have been proposed, but they are generally similar and follow the usual scientific method:

- Identify the problem (state objectives and measures of performance);
- Study the current situation (collect information and data);
- Find root cause(s) (use problem-solving tools);
- Choose solutions (identify and evaluate possible solutions);
- Develop action plan (apply the chosen solution; identify control points and measurement process);
- Do action plan (implement chosen solution);
- Check results (measure results);
- Establish reliable methods and review (modify and monitor processes to ensure fix is permanent);
- Continuously improve products and processes (Identify additional needed improvements).

Logical and thorough implementation of the analytic tools and methods discussed in this document will lead to long-lasting improvements with all the associated benefits.

The tools presented in this document are primarily aimed at product and process improvement and can be used in research, design, manufacturing, and business processes. Generally, the tools emphasize and rely on the collection, analysis and use of data to influence decisions and activities.

However, there are other valuable management and quality methods. These include benchmarking, force field analysis, Quality function deployment (QFD), design of experiments (DOE), activity network diagram, nominal group technique, etc.

3. Problem and innovation approach: old seven tools, advanced quality methods, new tools

Problems are gaps between the actual condition and the desired condition. The innovation is the gap between current situation, which is acceptable and future situation, a better one.

The most important part of problem prevention and problem solving is the fully and completely understanding of the current condition. An unknown author state: "A well defined problem is 50 % solved".

Basic recommendations, valuable for all tools:

- Go and see – understand the situation where the problems occur;
- Gather data and facts;
- Interview people involve in the analysis process the operators and technicians;
- Take Pictures / Video to analyse the situation.

Each process has different factors, which can affect it: Man, Material, Machines, Methods, Mother Nature, Management, and Measurement

The 7 M can cause errors. Errors cause defects. We use problem solving methods to get us back to each M in order to find the root cause, through different tools as Fish bone, the 5 Why, Fault tree and other methods to find the root cause.

After World War II the Japanese adopted 'quality' as a philosophy for economic recovery and, in line with this traditional approach, sought seven tools to accomplish the economic rejuvenation. The seven tools chosen were: Graphs, Check Sheets, Histograms, Scatter Diagrams, Control Charts, Pareto Diagrams, Cause and Effect Diagrams. [3, 6, 8].

3.1. Basic tools: Identify the problem, collect and visualize data

The first five tools are used to collect data and transform it in accessible visual form, in order to help the next steps: analysis and decisions.

Graphs, as Pie Charts and Bar Graphs are used to identify and compare data units as they relate to one issue or the whole, such as budgets, vault space available, extent of funds, etc.

Check Sheets are simple tools for data collection (usually errors), ensure completeness.

The sheet must be very simple and illustrative, easy to use and understand. An example is presented bellow.

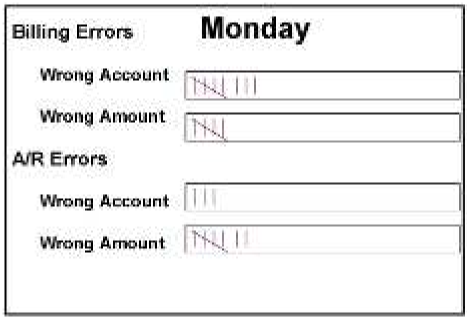

Figure 1. Example of check sheet

Histograms are used to illustrate and examine various data element in order to make decisions regarding them. They are effective when comparing statistical, survey, or questionnaire results.

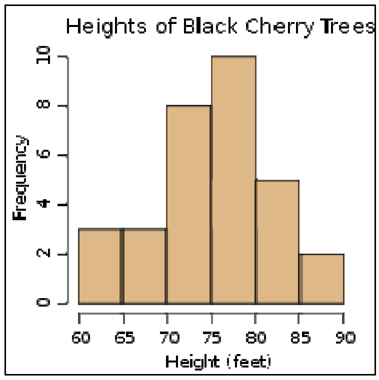

Figure 2. Example of histogram

Scatter Diagrams are used for:

- To illustrate and validate hunches;
- To discover cause and effect relationships, as well as bonds and correlations, between two variables;
- To chart the positive and negative direction of relationships.

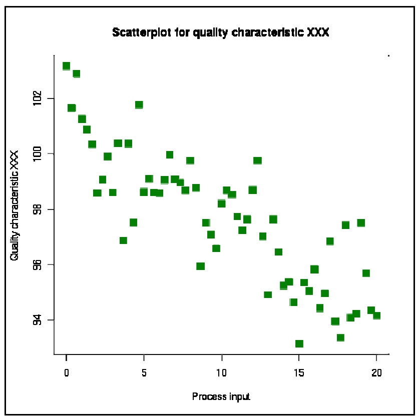

Figure 3. Example of scatter diagram

3.2. Basic tools applications

In order to understand the analysis tools and their applications, some usual situations will be presented.

3.2.1. Pareto, Ishikawa and 5Why

Situation: You have been tasked to lower scrap costs by 50 %. There are over 60 different causes of scrap. What you can do?

There are two approaches:

- Identify the causes that most frequently lead to defects;
- Determine which areas should be addressed first.

The tool is called “Pareto diagram” and looks as follow:

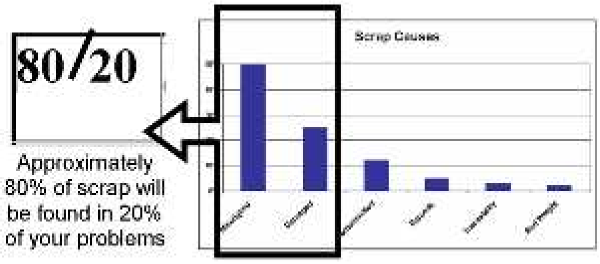

Figure 4. Example of Pareto graph

What should we do next? We have to find and eliminate root cause.

The tool is Fishbone diagram (because of its shape). It is known also as Cause and Effect diagram or Ishikawa diagram (after its inventor Kaoru Ishikawa).

It helps the team to discover all possible causes of a particular problem/effect by using the brainstorming technique. The effect ranked highest by a Pareto Chart provides the starting point for the Fishbone diagram.

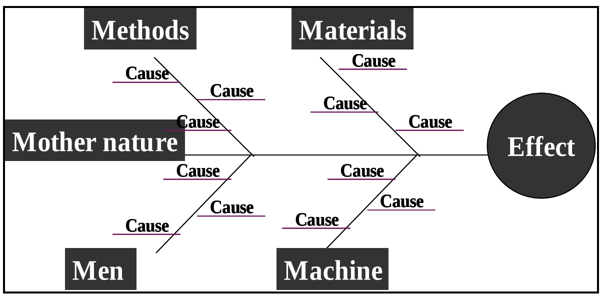

Figure 5. Generic Fishbone diagram

How to construct a Fishbone diagram?

- Form a competent team
- Define the problem
- Gather ideas on possible problem causes (brainstorming – time limited)
- Identify the major causes - main categories (7 **M**’s: Man, **M**achine, **M**aterial, **M**ethod, **M**easure, **M**other Nature, **M**anagement)

Major cause ranking and define priorities, e.g.

A = very probable,
B = possible,
C = improbable.

Use the scientific method to prioritize causes, track progress, and summarize results:

- State the hypothesis,
- Test the hypothesis with an experiment or analysis (Prove or disprove likely causes, turn it on and off),
- Analyze the results,
- Draw a conclusion.

An additional tool is “5 Why”. Asking “why” many times helps us understand problems:

- Ask “why” at least 5 times (generally more),
- Brainstorm all the reasons why the situation exists. Keep asking why until it doesn’t make sense to ask any more,
- If you need more information, get it, and then continue asking why,
- Stop if the likelihood is so remote it’s not worth pursuing, or stop if you have enough information to guide you to a permanent solution,
- Verify that the “whys” are true,
- Gather data, go and see, etc.

3.2.2. SPC, Run chart, Control Chart and histograms

Situation: You have a sensitive production step. An error can cause a defect. 100 % of product cannot be checked, (time consuming, destructive testing, etc.). What can be done?

The tool is SPC. There are four steps:

1. Sample the special characteristic to achieve the required quality;
2. Determine economical and effective frequency of checks, including Control & Specification limits;
3. Carry-out checks and display results graphically (e.g. Run-chart);
4. Continuously assess results, (look for “Drifting” or “Runaway” trends) and adjust to control deviations.

The SPC is a process by which a product/ service is checked during its creation using certain set parameters and statistical techniques to measure and analyze the variation within the process. It is used for monitoring the consistency of product/ service quality and maintains processes to a fixed target as designed and to drive improvement actions within an organization.

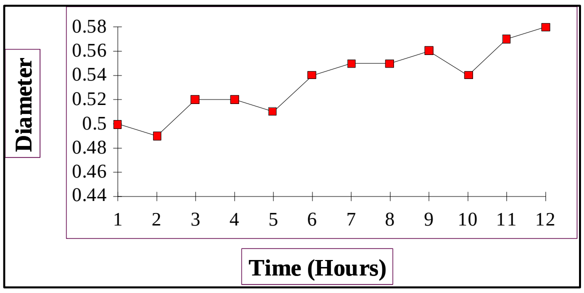

Figure 6. Run Chart

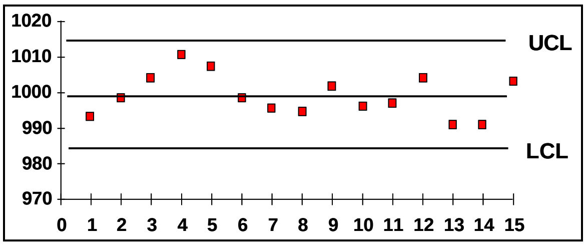

Figure 7. Control Chart

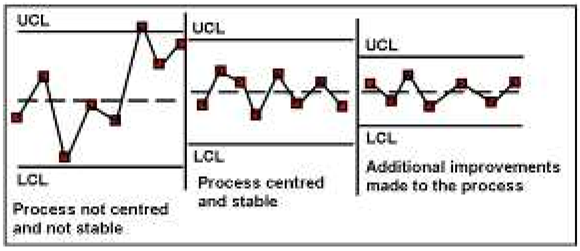

Figure 8. Monitoring improvement

3.3. Advanced quality methods applications

The necessity to go deeper and deeper in order to solve repetitive problems or initiate major improvement leads to the development of new tools or to the modification of old ones. In the following will be presented to the most useful in automotive industry: 8D, Quality Matrix, PDCA / Doing Management, FMEA and Six Sigma.

3.3.1. 8 Disciplines, or 8D

Situation: a customer complaint is received. We are being charged for all sorting costs. Good verbal description of the problem exists, but the cause of the problem is not known. Despite this, a guarantee that no further defective products will reach the customer, effective immediately, must be given What can be done?

The needed tool is 8D:

1. Setup a cross- functional team
2. Describe the problem to all involved
3. Implement temporary corrective actions to limit damage, and check for their effectiveness
4. Determine the actual root-causes
5. Define and justify the permanent corrective actions, (Prove effectiveness)
6. Implement permanent corrective actions, and check for their effectiveness
7. Take steps to prevent re-occurrence and document lessons learned
9. Recognize Success

3.3.2. Quality Matrix

Situation: Various types of defects are regularly found at final inspection. The problem consists on:

- Defective product is passed on,
- Additional value added work is carried out,
- The process step where the defect occurred is unclear,
- Scrap costs are very high.

What can be done? Quality Matrix

Also known as “Quality at the source” the tool has as core philosophy of making each worker responsible for the quality of his or her work. The objective is to catch errors where they occur!

1. Determine at which process the error occurs;
2. Determine at which process the error is identified;
3. Using the chart, identify how quickly the error can be discovered;
4. Improve process to catch errors closer to where they are produced.

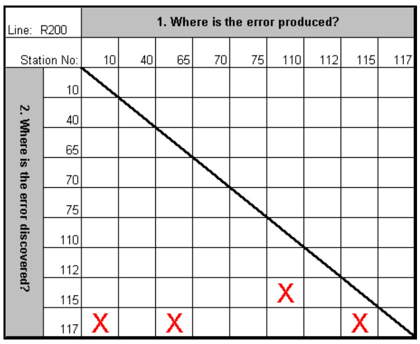

Figure 8. Quality Matrix

3.3.3. PDCA Cycle

Target: no recurrence of faults! (Continual improvement process).

The Plan-Do-Check-Act style of management where each project or procedure is planned according to needs and outcome, it is then tested, examined for efficiency and effectiveness, and then acted upon if anything in the process needs to be altered. This is a cyclical style to be iterated until the process is perfected.

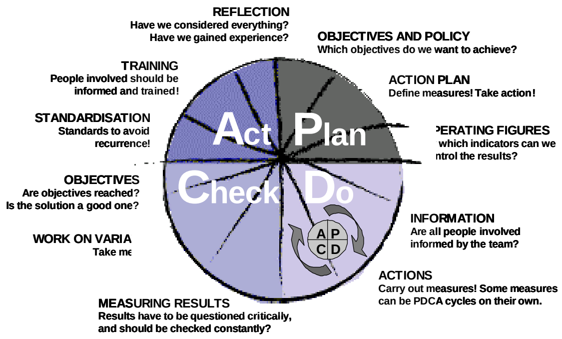

Figure 9. PDCA Cycle

3.3.4. 6 Sigma

Situation:

- The scrap costs on a machine is too high;
-It has been that way from the start of production and we haven't been able to figure it out;
- The process never was capable.

What can be done? 6 Sigma:

- Define the problem,
- Measure the current situation,
- Analyze potential root causes,
- Improve the system with root cause fixes,
- Control the changes made to the process.

3.3.5. FMEA

Situation: a new technology is being launched. The customer expects 0 % defects. There are 3 months until launch. Presently, only a concept is available, with no machines, operators, or materials for line trials. What can be done? FMEA

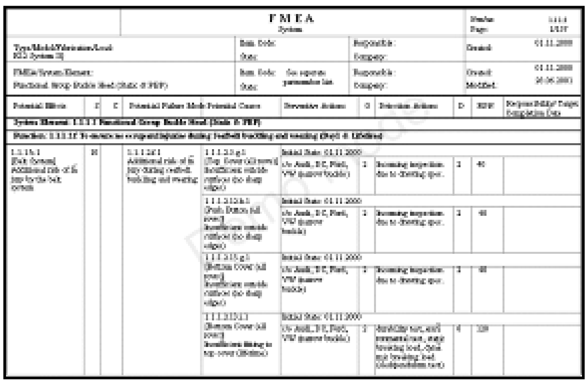

Figure 10. FMEA example

Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service and take reliable countermeasures.

3.3.6. The link between tools and task

In the chapters 3.2 and 3.3 are described common problems, often happening into manufacturing companies. The approach was to link the situation or task assigned with the needed tool. Based on tool description, a correlation between task and needed tool is proposed and presented in table 1.

Table 1. The tool used depends on the actual task

Useful area	**Old 7 tools and advanced quality tools**
Prevention of the problems before and after start of production	FMEA
Prevention of problems during serial production	SPC
Determination of the location where defective product is created	Diagonally Matrix
Determination of the most common problems/ errors	Pareto
Detailed determination of the root-cause of the problem	5-Why
Determination of all possible causes of the problem	Fish bone, mind mapping
Permanent solution to special cause variation problems Prevention of error reoccurrence / continuous improvement	8D process
Permanent solution to common cause variation problems	6 Sigma

Some tools are linked with quality prevention, as FMEA and SPC and the others are more useful in the detection and analyses faze, after the problem occur. The 8D method and 6 Sigma are complex tools, which aimed to avoid reoccurrence and permanent eliminate the cause of variations.

3.4. Seven new management and planning tools

Called also "The seven new quality tools", these tools were presented in this formula in late 80s. Due to space limitations, we cannot go into detail but we can provide an overview [4, 7, 8].

3.4.1. Affinity diagram

This is one of the basic tools used to stimulate creativity and bring structure to the brainstorming process. The affinity diagram is especially useful in any interdepartmental project - it helps put team members at ease with one another because the tool is designed to welcome a diverse range of ideas. Because the innovation process relies heavily on people from different departments working together, the affinity diagram would be powerful in the early stages of the innovation process.

3.4.2. Relations diagrams

This tool displays all the interrelated cause-and-effect relationships and factors involved in a complex problem and describe desired outcomes. The process of creating an interrelationship diagraph helps a group analyze the natural links between different aspects of a complex situation.

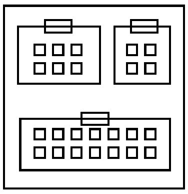

Figure 11. Affinity diagram

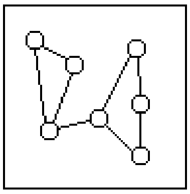

Figure 12. Relations diagram

3.4.3. Tree diagram

This logic based tool, is more focused than the affinity or relations diagrams. It starts with a broad category, theme or problem and attempts to break the issue down into granular levels of detail using a branch system. The logic behind the tree diagram is that as a broad issue is broken down into finer levels, a solution pathway emerges. The tree diagram is effective after developing affinity and relations diagrams because the ideas from these broader tools can be applied to the tree diagram to help find a clear solution. Developing the tree diagram helps one move their thinking from generalities to specifics.

3.4.4. Process decision program chart (PDPC)

When faced with multiple options to solve a problem, the PDPC is useful in assessing all the alternative solutions to find the one that fits best. A PDPC can also be used in a what-if analysis. If a solution or process is already agreed on, the tool can identify what might go wrong if the solution were to be employed. Because a tree diagram might give multiple solutions to the issue at hand, the PDPC is the logical tool to use after the tree diagram to determine which solution has the most promise.

The PDPC is similar to the Failure Modes and Effects Analysis (FMEA) because both identify risks, consequences of failure, and contingency actions.

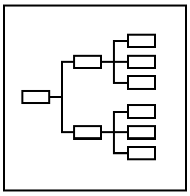

Figure 13. Tree diagram

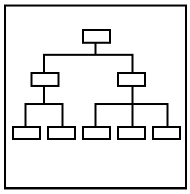

Figure 14. A PDPC example

3.4.5. Arrow diagram

This tool addresses resource problems and bottlenecks during the innovation process. Similar in scope to a Gantt chart, the arrow diagram allows the mapping and scheduling of multiple tasks. The tool is valuable when resources must be allocated across an interdepartmental project.

When significant penalties occur if a project falls behind schedule, resource allocation becomes an important focus.

This tool is used to plan the appropriate sequence or schedule for a set of tasks and related subtasks. It is used when subtasks must occur in parallel. The diagram enables one to determine the critical path (longest sequence of tasks, See also PERT diagram).

3.4.6. Matrix diagram

This tool shows the relationship between items. At each intersection a relationship is either absent or present. It then gives information about the relationship, such as its strength, the roles played by various individuals or measurements. Six differently shaped matrices are possible: L, T, Y, X, C, R and roof-shaped, depending on how many groups must be compared.

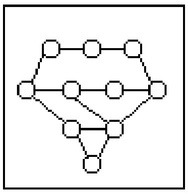

Figure 15. Arrow diagram

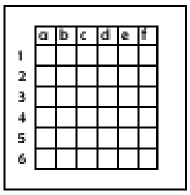

Figure 16. Matrix diagram

3.4.7. Matrix data analysis

This is a mathematical technique known also as Prioritization matrix. It quantifies the interrelated factors created in the matrix diagram. Weights are given to the interrelated factors when hard data are unavailable; software programs using statistical correlation methods are used to quantify the relationship between factors when data is available. Due to the mathematical rigor involved, matrix data analysis is the most complex of the new tools.

3.4.8. New tools evaluation

In the chapters 3.4 are described the new quality tools. A correlation between area where it could be used and the tool is proposed and presented in table 2. The group consists of more soft tools, which could be easy connected with team working, communication kills, and leadership skills. New tools are more relational and network oriented and may take more practice to develop proficiency.

Table 2. The tool used depends on the actual task

Useful area	New Quality Tool
Brainstorming, consensus	Affinity diagram
Cause and effect	Relations diagram
Logic based problem solving	Tree diagram
Identifying the best solutions	Process decision program chart
Resource planning	Arrow diagram
Determining interrelated factors	Matrix diagram
Quantitative analysis	Matrix data analysis

4. Key points for a good implementation

Following are presented three key points for quality tools proper use implementation.

4.1. Develop a robust Training plan

Training would seem to be critical to successful implementation for any quality system. In order to develop a training plan, we need to define areas of training, people involved, and training methods. The following recommendation is developed based on works of Mathew B. [4].

Four areas of training were defined to encompass both the hard and the soft aspects:

1. The seven basic quality tools and advanced methods, e.g. failure mode and effect analysis.
2. New quality tools and soft tools, e.g. team working, communication & leadership skills.
3. Quality awareness and standards, e.g. ISO 9000, quality awards, quality audits.
4. Customer focus, e.g. customer satisfaction customer needs, customer service training.

Several groups of staff must be identified, ranging from top to the shop floor: top management, middle management, group specialist staff, quality staff, shop floor people.

Training methods, which could be taken into consideration: on the job training, external short courses, in-house participative seminars, training manuals, distance learning, internet training, consultants. Personal methods of training are perceived as more effective than impersonal ones because the interaction between trainer and trainees is critical to effectiveness.

4.2. Tools correlation with task and situation

As mentioned at points 3.3.6 and 3.4.8, the tools must be used according with the task and situation in cross-departmental problem solving and innovative process.

According to the life cycle of the product, starting with marketing analysis, customer feedback, continuing with product and process development, engineering, manufacturing, and after service, all steps need interdepartmental meetings. A correlation is illustrated in figure 17 [6].

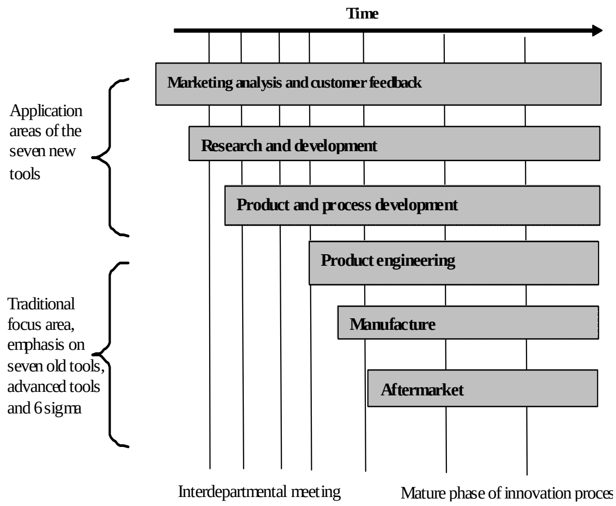

Figure 17. Cross-departmental problem solving and innovative process

4.3. Visualization

Imagine that you enter in one department or on production line, and ask “Which is the main problem of this department?” If the people are ready to explain the problem and to present the status of activities, then there is a focus to the main issue. If there is a visual document and actions follow-up posted on the wall/ board, then the problem is visible, followed and will be solved.

This is why, simple templates, posted near the place where activity is done are recommended.

A proposal is presented in figures 18 and 19.

The solution of different problems, which can occur in similar places, will be deployed in all of these areas.

As soon as possible or, at least quarterly, the organization should present to the employees from all departments, the most important projects in terms of before-after sketches, mentioning the savings.

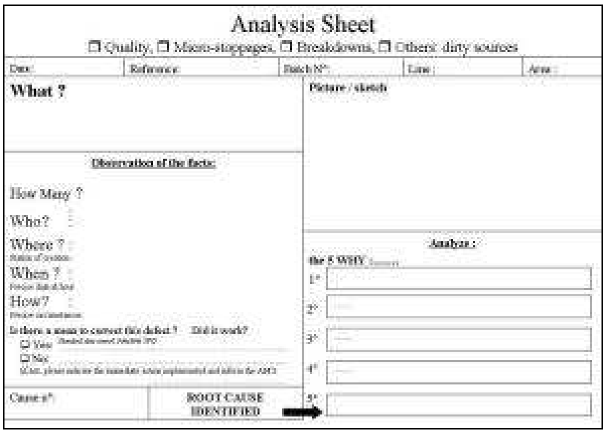

Figure 18. Analysis sheet – page 1

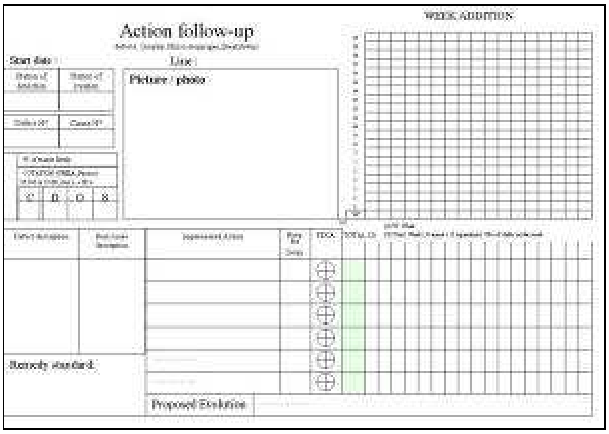

Figure 19. Analysis sheet – page 2

5. Conclusions

Quality tools are systematic approaches for identifying a problem or a needed improvement, finding the root cause of a problem, identifying and evaluating solutions, implementing the solution, measuring the improvement, and ensuring permanent integration of the solution so that the problem will not rise again.

There are a lot of tools but the most used are: “The seven basic quality tools”, “Advanced quality methods” and “New seven quality tools”. They can also be easily integrated into team meetings, organizational reports, and for various other data analysis needs.

Proper integration and use of these tools depend on several critical factors:

- staff knowledge,
- proper correlation of the task or situations with the tool/ tools and,
- team focus and visualization of the problem solving and innovations activities.

The problem solving outputs represents good indicators for each department. The indicators tell about savings but also, about people’s involvement and management support, commitment and resources allocation.

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