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Root Cause Identification of Tensile Test

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Abstract: *Every organization faces continuous quality improvement and needs to use an appropriate tools and techniques to achieve that. The basic requirements for success and solving the problems are use of quality tools which will guide you step by step to solve them. Contents of this paper try to use well known root cause identification tool with implementation at laboratory tensile test of reinforced steel, providing mechanical properties of metal specimen. Cause analysis tool are used when you want to discover the cause of a problem or situation or to gain desired results.*

Keywords: *identification, tensile test*

1. INTRODUCTION

The tensile test may be the most widely used test to determine the mechanical properties of structural materials. The key feature chosen to be a favorite test in the material science field is probably the high productivity of a large amount of information even from single test. The specimen material is pulled by tensile load at a constant rate until it fractures. During the test, the tensile load and the elongation of the gage length of the specimen are monitored and recorded. From those data, stress and strain are obtained through simple calculations as well as other mechanical properties such as yield strength, tensile strength, the modulus of elasticity, and qualitative toughness of the material. Understanding fundamental mechanism of the deformation can be easily achieved in the view of the atomic scale. The mechanism of the elastic deformation is the stretching of atomic bonds. On the other hand, the mechanism of the plastic deformation is the distortion and reformation of atomic bonds.

The tensile test is performed according to EU standard EN 10 002-1:1996, at ambiental teperature environment. The loading machine is hidraulic type and manufactured in Russia, 100 tones capacity.

The specimen is made of reinforced stell according to standard: JUS C.K.6.021:1987.

2. TENSILE TEST PROCESS-BASICS

The selection of a material for a machine part or a structural member is one of the decisions the designer is called upon to make. This decision is usually made before the dimensions of the part are determined. After choosing the material and process (the two cannot be divorced), the designer can then proportion the member so that the internal stresses and strains have reasonable and satisfactory values compared with the properties associated with failure of the material.

As important as stress and deflection are in the design of mechanical parts, the selection of a material is not always based upon these factors. Many parts have no loads on them whatever. Parts may be designed merely to fill up space. Members must frequently be designed to resist corrosion. Sometimes temperature effects are more important in design than stress and strain. So many other factors besides stress and strain may govern the design of parts that the designer must have the versatility that comes only with a broad background in materials and processes.

2.1. Static strength

The standard tensile test is used to obtain a variety of characteristics and strengths that are used in design. Figure 2 illustrates a typical tension-test specimen and some of the dimensions that are often employed. The original diameter d_0 and length of the gauge l_0, used to measure the strains, are recorded before the test is begun. The specimen is then mounted in the test machine and slowly loaded in tension while the load and strain are observed. At the conclusion of, or during, the test the results are plotted as a ***stress-strain diagram*** Figure 2.

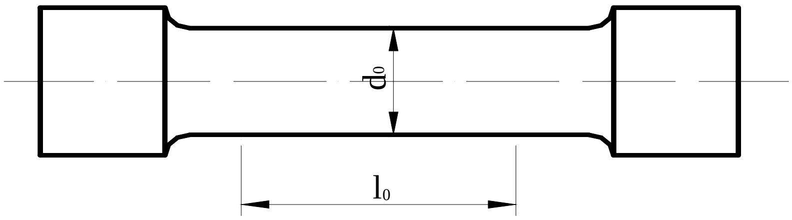

Figure 1. ***A typical tension-test specimen***

Point ***P*** in Figure 2 is called the ***proportional limit.*** This is the point at which the curve first begins to deviate from a straight line. Point ***E*** is called the ***elastic limit.*** No permanent set will be observable in the specimen if the load is removed at this point. Between ***P*** and ***E*** the diagram is not a perfectly straight line, even though the specimen is elastic. Thus Hooke's law, which states that stress is proportional to strain, applies only up to the proportional limit.

During the tension test, many materials reach a point at which the strain begins to increase very rapidly without a corresponding increase in stress. This point is called the ***yield point.*** Not all materials have an obvious yield point. For this reason, ***yield strength*** σ_T is often defined by an ***offset method*** as shown in Figure 2. Such a yield strength corresponds to a definite or stated amount of permanent set, usually 0.2 or 0.5 percent of the original gauge length, although 0.01,0.1, and 0.5 percent are sometimes used.

The ***ultimate,*** or ***tensile, strength*** σ_M corresponds to point ***M*** in Figure 2 and is the maximum stress reached on the stress-strain diagram. Some materials exhibit a downward trend after the maximum stress is reached. These fracture at point ***K*** on the diagram in Figure 2. Others, such as some of the cast irons and high-strength steels, fracture while the stress-strain locus is still rising.

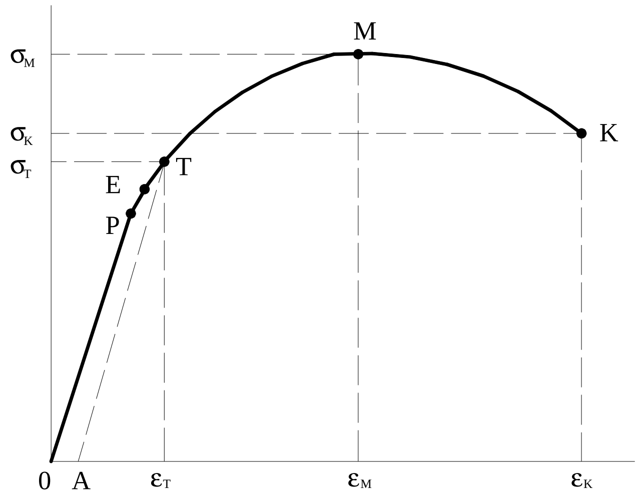

Figure 2. Stress-Strain diagram

As noted, *strength,* is a built-in property of a material, or of a mechanical element, because of the selection of a particular material or process or both. The strength of a connecting rod, for example, is the same no matter whether it is already an element in an operating machine or whether it is lying on a workbench awaiting assembly with other parts.

3. THE QUALITY TOOL MATRIX

The Tool Matrix lists all the tools and categorizes them in three different ways to help find the right one. To search for a tool, some questions should be answered:

1. ***What do we want to do with this tool?*** Quality improvement tools also can be grouped according to how they are used.
   - *Project planning and implementing tools:* When you are managing your improvement project.
   - *Idea creation tools:* When you want to come up with new ideas or organize many ideas.
   - *Process analysis tools:* When you want to understand a work process or some part of a process.

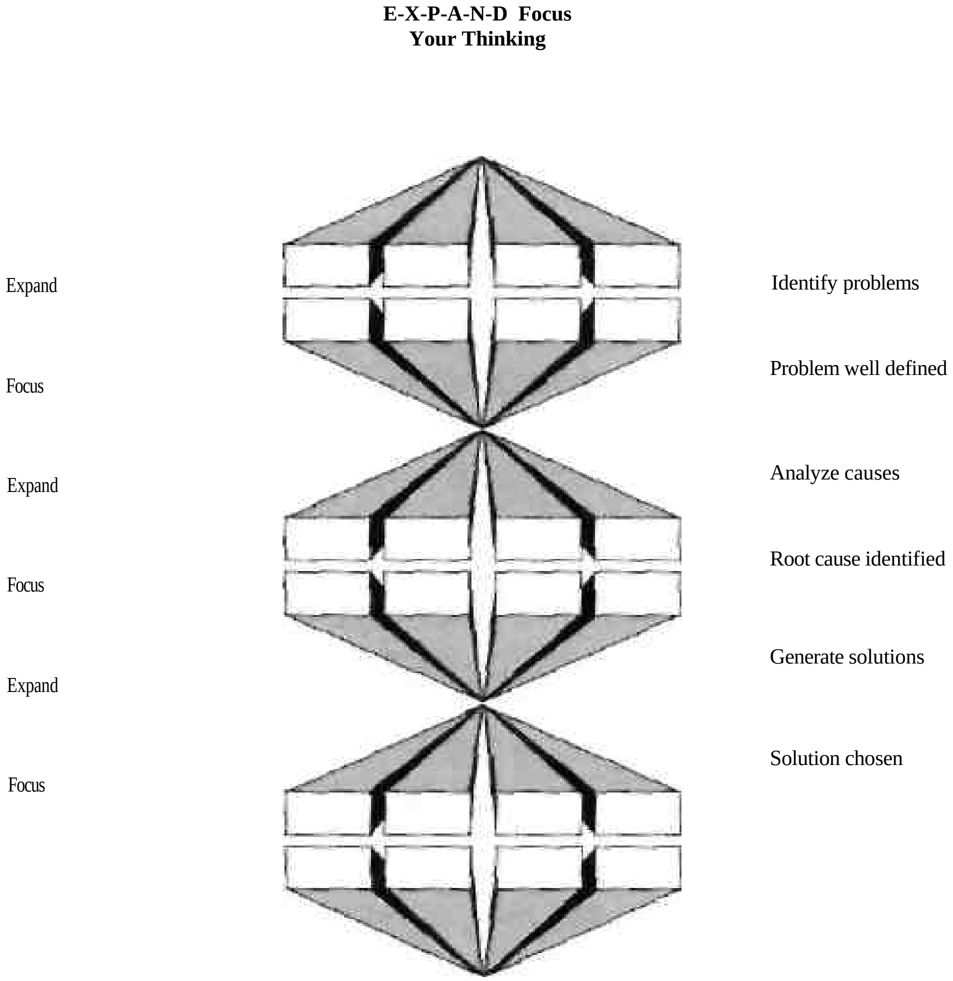

Figure 3. Expand-focus sequence

Data collection and analysis tools: When you want to collect data or analyze data you have already collected.
Cause analysis tools: When you want to discover the cause of a problem or situation.
Evaluation and decision-making tools: When you want to narrow a group of choices to the best one, or when you want to evaluate how well you have done something.

2. *Where are we in our quality improvement process?* Some tools are useful only at certain steps in the quality improvement process. There are ten steps of a general process for quality improvement.
In the Tool Matrix, the columns list the ten steps. Each step of the process in which a tool can be used is marked with an X. The versatile tools that appear in several categories often have different steps marked from category to category, as their use changes.

Table 1. Example of tool matrix

	Tool	**E/F**	**1** Charter & Plans	**2** Customer Needs	**3** Current State	**4** Oppor-tunities	**5** Root Causes	**6** Changes	**7** Do It	**8** Monitor	**9** Stan-dardize	**10** Learnings
Project Planning and Implementing Tools	ACORN test	F	**X**									
	Arrow diagram	F	**X**					**X**	**X**		**X**	
	Balanced scorecard	F	**X**	**X**	**X**			**X**	**X**	**X**		
	Barriers and benefits exercise	**E**						**X**	**X**		**X**	**X**
	Checklist (generic)	F	**X**						**X**	**X**	**X**	
	Contingency diagram	E							**X**		**X**	
	Continuum of team goals	F	**X**							**X**		**X**
	Flowchart (generic)	E/F	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	Force-field analysis	**E**						**X**	**X**		**X**	**X**
	Gantt chart	**F**	**X**					**X**	**X**		**X**	
	Matrix diagram	F	**X**	**X**				**X**	**X**		**X**	**X**
	Meeting evaluation	F	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	Mind map	**E**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**
	Operational definitions	**F**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	Plan-do-study-act cycle	F	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	Plan-results chart	**F**								**X**	**X**	**X**
	Potential problem analysis	E/F						**X**	**X**		**X**	
	Presentation	F	**X**	**X**	**X**		**X**		**X**	**X**	**X**	**X**
	Process decision program chart	E/F						**X**	**X**		**X**	
	Project charter	F	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	Project charter checklist	F	**X**									
	Relations diagram	E/F	**X**	**X**		**X**		**X**			**X**	

3. *Do we need to expand or to focus our thinking?* The process of quality improvement goes through alternating periods of expanding our thinking to many different ideas and focusing our ideas to specifics. The expanding period is creative and can generate new and innovative

ideas. The focusing period is analytical and action oriented. To obtain results, you eventually have to stop considering options, decide what to do, and do it!

See Figure 3 for an illustration of how the expand-focus sequence works. To choose the most worthwhile problem to attack, first expand your thinking to many different problems—big, small, annoying, and expensive problems—by analyzing the process and collecting data. Next, focus your thinking: with evaluation tools, use a set of criteria to choose one well-defined problem to solve.

For purpose for root cause identification of tensile test is used part of tool matrix related to process tool analyses shown in Table 2:

Table 2.

	Tool	E/F	**1 Charter & Plans**	2 Customer Needs	3 Current State	**4 Opportunities**	5 Root Causes	**6 Changes**	7 Do-lt	8 Monitor	9 Standardize	10 Learnings
Process Analysis Tools	Benchmarking	E/F	**X**			**X**		**X**				
	Cause-and-effect matrix	**F**	**X**	**X**								
	Cost-of-poor-quality	E			**X**	**X**	**X**					
	Critical-to-quali	E		**X**	**X**	**X**	**X**					
	Critial-to-	F		**X**	**X**	**X**						
	Failure modes and effects	**E**				**X**	**X**				**X**	
	5W2H	E			**X**	**X**					**X**	

From the list of available tools we can see that the most appropriate quality tools are:

- § Cause-and-effect chart (Fishbone or Ishikawa diagram);
- § Matrix diagram;
- § Five whys and;
- § Fault tree analysis.

4. THE PURPOSE AND APPLICATIONS OF CAUSE AND-EFFECT CHARTS

The name of the cause-and-effect chart tool defines what it is about: a chart that analyzes relationships between a problem and its causes. It combines aspects of brainstorming with systematic analysis to create a powerful technique. The tool is also known as a Fishbone or an Ishikawa diagram, named for its inventor.

In the larger framework of root cause analysis, this tool's main purpose is to understand what causes a problem. It can be used to:

- § Generate and group problem causes.
- § Systematically evaluate the causes and determine which are most likely to be
- § root causes.

4.1. Two types of cause-and-effect charts

The cause-and-effect chart has so far been described as if it were one singular chart, but there are at least two types of cause-and-effect charts:

- § *Fishbone chart.* The traditional method of constructing such charts, where the main product is a chart whose shape resembles a fishbone.
- § *Process chart. More* directly focused on the analysis of problems inside business processes. For each step of the process that is believed to create problems, a fishbone chart is constructed to address all potential causes of less-than-expected performance. After individual charts are designed, a collective analysis is conducted to identify the causes of highest importance.

4.2. The steps in using cause-and effect charts

1. Clearly describe the problem for which causes are sought.
2. Using a whiteboard or some other large surface, draw the problem at the right end of a large arrow. Allow space for the causes to be generated. Do not strive for symmetry and graphic effects.
3. Identify the main categories of causes of the problem and write them on branches emanating from the large arrow.
4. Brainstorm and write all possible causes in the applicable area(s) of the chart. Proceed through the chart one main category at a time. Write causes that belong under more than one category in all relevant positions.
5. Analyze the identified causes to determine the most likely root causes.

4.3. Generic model of cause-and-effect chart

The generic model of cause-and-effect chart is shown on Figure 4.

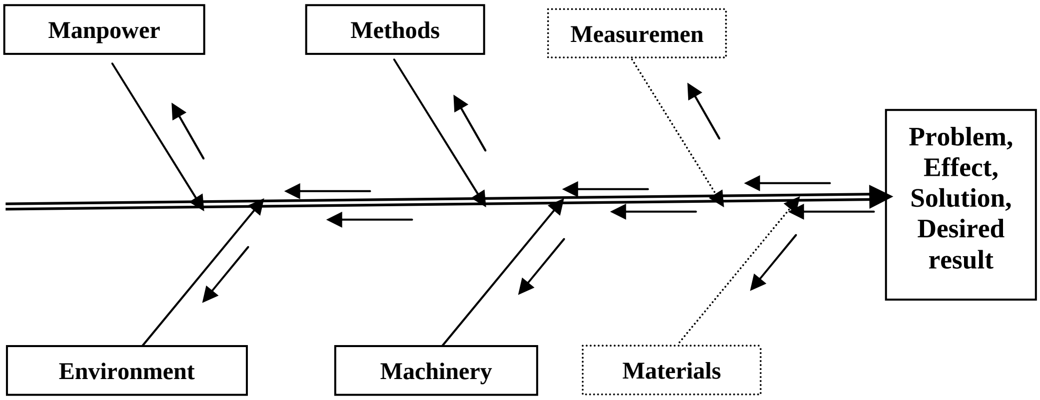

Figure 4. Cause-and-Effect chart example

5. TENSILE TEST CAUSE-AND-EFFECT CHART

The one of goals in proper managing a tensile test process is to obtain appropriate test result. The test report must be as precise as it is possible according to reference data. Such as data must be checked and verified. Also all necessary measures must be implemented to ensure that the management process and obtained data from test, comply with applicable directives and standards.

In this research, the main focus is to analyze and identifies all possible causes which are the most important to perform an effective and valuable process of tensile test of reinforced steel. In that way the causes are divided on several groups:

As the result of cause-and-effect chart is the appropriate and reliable tensile test report.
The recommended cause-and-effect chart is shown on Figure 5.

6. CONCLUSION

Implementing an adequate quality tool on real situation or process is awfully hard task. The tensile test requires that each step in quality improvement should be carefully considered, planed, analyzed, organized and controlled. It is worth spending an appropriate amount of time making sure that you have defined the problem properly before you set out on an improvement project.

Building a Cause-and-Effect chart does not have to be a one-off exercise. The diagram is often used as a working document that is updated as and when more data has been collected and when various solution have been tried. The objective of the project is to gain deeper insight into the problem, not to draw a nice picture.

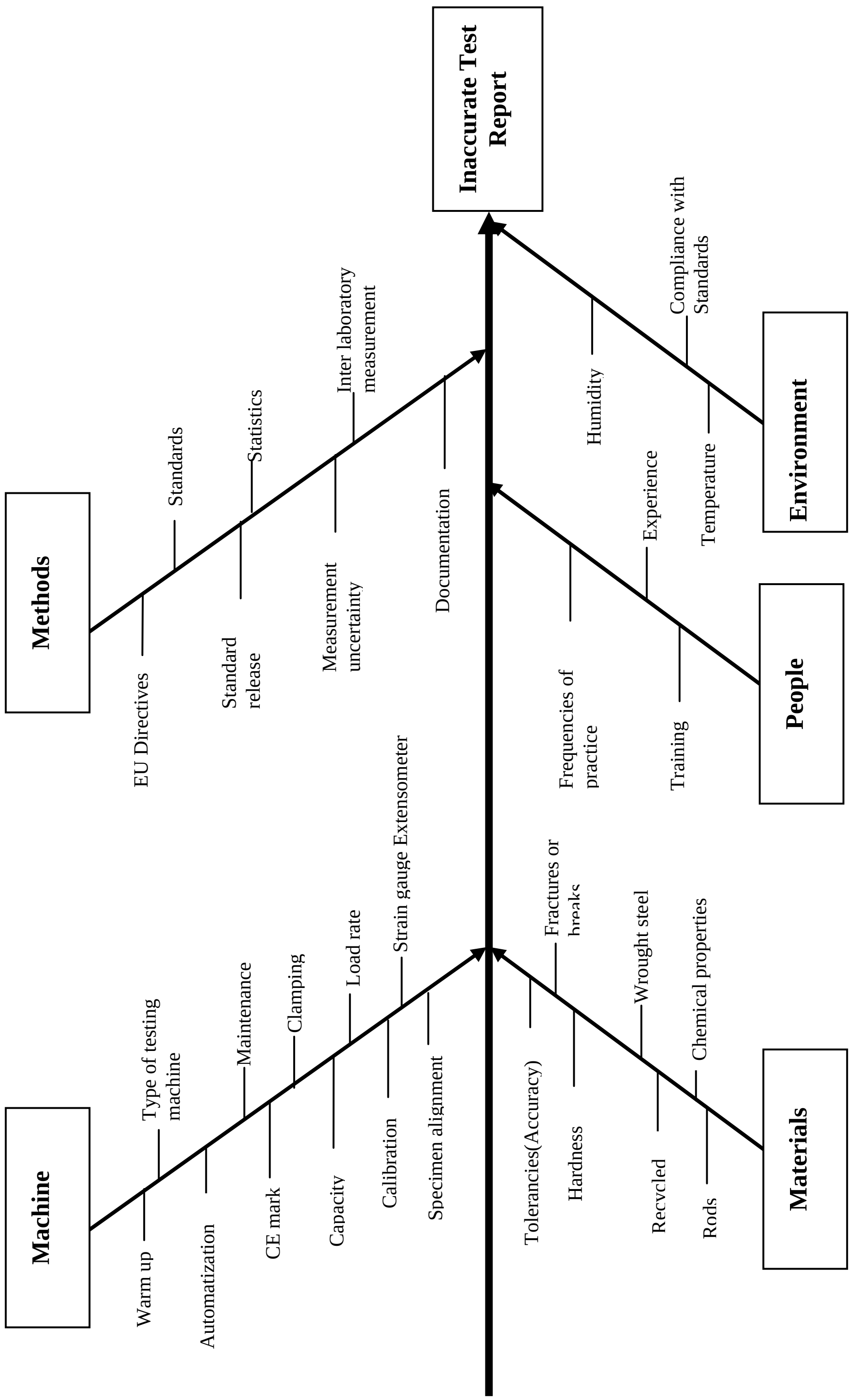

Figure 5. Cause-and-Effect diagram of tensile test

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