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Using modified TRIZ approach for quality improvement

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Abstract: TRIZ was developed in the former Soviet Union by G. Altshuller. TRIZ is a powerful and well used tool for generating new ideas for solving technical problems in quality improvement (QI). This study attempts to modify the TRIZ methodology and extend it to a broader application, namely resolving problems concerning the management of quality improvement. This study comprises three stages: 1. investigating and analyzing the requirements of QI; 2. using TRIZ tools to analyze and resolve QI problems; 3. building an action plan for achieving resolution.

Keywords: Quality Improvement, TRIZ

1. Introduction

Due to the progress on manufacturing technology and rapid decrease of product life cycle, the enhancement of product quality has become an important factor for the global competition.The master of quality control, Juran, said that century 21st will be a “century of quality”. Facing customers’ strict demands on qualities, quality control plays a determinative role if a business wants to have a place in the world’s competitive market.The product continual quality improvement is the effective approach for the enterprise to enhance its productcompetitiveness [1].

Quality improvement is not limited to the conformance of the product or service to specification; it is also involves the inherent quality in the design of the system. Many quality improvement and problem solving techniques were presented by the scholar or enterprise practitioner: The Deming cycle (plan-do-check-act); the Juran trilogy diagram (quality planning, quality control, and quality improvement); the Ishikawa’s tools of quality (histogram, Pareto chart, cause-and-effect diagram, check sheet, scatter diagram, flowchart, and control chart); the seven new tools for improvement (affinity diagram, interrelationship digraph, tree diagram, prioritization grid, matrix diagram, process decision program chart, and activity network diagram); the five Ss (seiri, seiton, seiso, seiketsu, and shitsuke); the six sigma (define, measure, analyze, improve, and control) were all effectiveness and efficiency tools for improving quality in order to satisfy customer requirements [2].

This study attempts to extend and modify the TRIZ methodology to make it more broadly applicable and applicable in a non-technological area. This study proposes methods of quality improvement.TRIZ provides people with a dialectic method of thinking, which helps understand the problem as a system, visualize the ideal solution, and promote product performance by solving contradictions.The core of TRIZ comprises the 40 ‘inventive principles’ and the ‘contradiction matrix’ between 39 ‘engineering parameters’. Additionally, a ‘prediction’ tool is available that helps managers improve product quality. Furthermore, another tool is the ‘effects’ database, which provides users with technical solutions for achieving a given functionality. Utilizing these sub-tools, TRIZ helps managers develop methods of improving product quality, not only technological problems.

2. Systematic Problem Solving Methodology

There are several different ways to solve problems generally exist [3-5]:

1. Experience – solutions that have previously worked, or at least been considered. Brainstorming, cause-effect analysis, and Pareto analysis are usually used.

2. Advice – consultant recommendations and expert suggestions. Nominal group techniques, benchmarking, concurrent engineering and experimental design are generally used.

3. Computer assistance – the powerful calculating and processing capabilities of computers can simulate a situation to help in analysis and decision making. Expert systems,

decision support software packages, and simulation systems are generally used.

The Deming cycle, comprises four main stages: plan, do, check, and act (PDCA) is the classic problem-solving and loop learning model for Total Quality Management (TQM) improvement [6-8]. The seven management and planning tools (the affinity diagram, the interrelationship digraph, the tree diagram, the matrix diagram, matrix data analysis, the process decision program chart, and the arrow diagram) are designed to facilitate the organization and communication of information [9-10]. These tools make management understandable and simplify management and were introduced to a number of corporations with excellent results in numerous applications. The tools are especially useful in analyzing qualitative information.

Thinking process (TP) of theory of constraints (TOC) developed by Goldratt and Cox is a systematic thinking approach and a powerful tool for dealing with paradigm constraints in problem solving [11]. TP provides five tree-type logic tools: the current reality tree (CRT), conflict resolution diagram (CRD), future reality tree (FRT), prerequisite tree (PRT), and transition tree (TT), to answer three questions, namely what to change, what changes to make, and how to effect the change. Each of the five logical tools of TP can be used individually, or in concert, as an integrated full thinking process analysis (FTPA) [12-15]. System thinking proposed by Senge is a discipline for analyzing and perceiving wholes [16-17]. This approach is a conceptual framework, a body of knowledge and tools, and a language for describing and understanding that has been developed to clarify the full patterns of problem and to help develop effective ways of changing them. System thinking encompasses an extensive and fairly amorphous body of methods, tools, and principles, all oriented to examining the interrelatedness of forces, and seeing them as part of a common process. The tools of systems thinking namely archetypes, causal loop diagrams, and computer models allow us to talk about interrelationships more easily. Lepore& Cohen [18] integrate Deming's main philosophy the theory of profound knowledge (TPK) and TOC as a knowledge tree and develop a ten-step comprehensive map called the Decalogue to guide and sustain organizations in a knowledge-based continuous improvement pattern. Yang [10] integrates seven management and planning tools, the system thinking of the fifth discipline, and the thinking process of TOC to create a practical problem solving procedure.

3. The Modified TRIZ

3.1. TRIZ

TRIZ (the Russian acronym for the 'theory of inventive problem solving') was developed in the former Soviet Union by G. Altshuller. TRIZ is a powerful tool for generating new ideas for problem-solving, and incorporates the knowledge and experiences of the finest inventive minds in the world. For a given problem, TRIZ can always identify and formulate a generic problem, then use an appropriate tool to obtain generic solutions, and finally interpret those generic solutions to choose a specific solution. TRIZ theory, based on technical system evolution, comprises various types of methods, calculations of aspects of solving technical problems, and innovative exploration, and represents a comprehensive problem solving system. The basic constituents of TRIZ are the contradictions, 40 inventive principles, matrix, and laws of evolution, substance-field analysis modeling, ideal final result, substance field resources, scientific effects and ARIZ (the Russian acronym for 'inventive problem solving algorithm'). TRIZ is a scientific principle for solving problems and achieving technical innovations, but recent studies have shown that TRIZ principles can also be applied to product innovation and management [19-24].

3.2. Modified Contradiction Matrix

This study summarizes the literature on quality improvement to identify the indicators, and identified two aspects of technology and management. By administering an expert questionnaire to industry executives and education researchers, this study determined the adoption of indicators.

3.2.1. Parameter

This study selected the five most important quality improvement indicators of technology and management dimensions from the expert questionnaire, and described them as follows.

(1). Management dimension.

- Return on inventory: a performance measure used to evaluate the investment efficiency or compare (efficiency among investments).
- Customer acceptance: customer acceptance ensures understanding and acceptance of all that can occur during an Internet marketing campaign.
- Professional competence: providing the skills and expertise of service and manufacturing.
- Maintenance capability: product maintenance of speed and skill.
- Cost of quality: the cost of producing, finding, correcting or preventing defects.

(2). Technology dimension.

- Defect rate: shows the average number of production errors.
- Process ability: the process of manufacturing the product, including personnel ability, materials, instruments and methods presented.
- Material stability: the quality of materials provided by suppliers.
- Product functional: describes the specific working ability of the product.
- Product reliability: develops a framework which links reliability specifications and product performance in the context of new product development.

3.2.2. Contradiction matrix

A situation in problem solving where improving one parameter of a system negatively impacts another parameter is called a contradiction. To simplify the search for the most applicable principle, Table 1 for contradiction matrix was developed. Table 1 for contradiction is a matrix containing ten parameters organized on two axes. Parameters must be selected to improve on the vertical axis and the parameters that suffer from improvements achieved the horizontal axis. The intersections of the selected parameters refer to the recommended principles.

Table 1.*Contradiction matrix*

Deterioration	Improve	Management				Technology					
		return on inventory	customer acceptance	professional competence	maintenance capability	cost of quality	defective Rate	process ability	material stability	product functional	product reliability
Management	return on inventory					2,1	1,10	23,1			10
	customer acceptance			3,16	10,2	3,2,5	35,3	1		3,4,1	32,3, 11,23
	professional competence		28, 32		11,1, 2,9			10,1			11,28
	maintenance capability		1,32,11	11,3							1,11
	cost of quality	1,11	1,2,	10,5,2,18	1,11		1,3, 23,2	11, 23	11,2	11,2	2,11
Technology	defective Rate		1	23				10,3,1	2,1		11,1,2
	process ability								1,23		23,2
	material stability						11,26,2				
	product functional		3,2		11,10,1, 16	1					3
	product reliability		5,11,1,23	11,3				2			

3.2.3. The principles

Thirteen principles can be met in this study for quality improvement. These principles are implemented, via TRIZ contradiction analysis or standalone analysis, as stimuli for driving thinking.

Principle 1. Segmentation

- Six Sigma - Define, Measure, Analyze, Improve, and Control (DMAIC).
- Quality costs analysis.
- Use PERT or Gantt chart for projects.
- Failure mode and effect analysis (FMEA)
- Fault tree analysis (FTA)
- Statistical Process Control (SPC)
- Design of experiment (DOE).
- Process for Lean Six Sigma.
- Cause and effect diagram
- Critical Chain Project Management (CCPM)
- Advanced Product Quality Planning (APQP).
- Minimization &Modulization.
- Total quality management (TQM).

Principle 2. Taking out

- Lean manufacturing –a variation on the theme of efficiency based on optimizing flow.
- Remove the defective parts of product or service.
- The survey of customer satisfaction.
- Material Requirement Planning (MRP).
- Enterprise Resource Planning (ERP).
- The survey of customer satisfaction.
- Testing and sampling the product or material.
- Quality cost analysis.
- Reliability design.

Principle 3. Local quality

- Use the Pareto diagram.
- Strength, Weakness, Opportunity and Threat (SWOT) analysis.
- Use quality functional deployment (QFD) for customer needs.
- Select the target groups of customers.
- Pareto principle (the 80/20 principle)
- Quality improvement planning.
- Establish a standard operation procedure(SOP).

Principle 4. Asymmetry

- Word-of-mouth marketing.

Principle 5. Merging

- Put customer feedbacks into product/service design to enhance customer satisfaction.
- Concurrent engineering (CE).

Principle 9. Preliminary anti-action

- Mistake-proofing (Poka-Yoke) - help an equipment operator avoid mistakes.
- Advanced Product Quality Planning (APQP).
- Quality audit- ISO 9000.

Principle 10. Preliminary action

- Concurrent engineering (CE)
- Staff training.
- Use PERT or Gantt chart for projects.
- Use just-in-time (JIT)

Principle 11. Beforehand cushioning

- On-the- job training.
- Orientation program.
- Response to customer complaints and analysis of the problems.
- Emergency quality or material planning.
- Second source suppliers.
- Use material management.
- Pre-assessment of equipment and raw materials..

Principle 16. Partial or excessive actions

- Acceptable quality level (AQL) –measure of the level of quality routinely accepted by that sampling plan.

Principle 18. Mechanical vibration

- Quality control circle (QCC)
- Co-design.

Principle 23. Feedback

- Failure analysis – FMEA, FMECA, FTA.
- Statistical process control (SPC).
- Quality system (QS).

Principle 28. Mechanics substitution

- E-business.
- E-Commerce Solution.
- Principle 35. Parameter changes
- Change the R&D team structure.

4. Case Study

An example is presented below to demonstrate problem solving with TRIZ and its tools. Given increasingly stringent quality control conditions, domestic and foreign manufacturers are requiring near zero defects. Managers used all kinds of quality improvement methods to keep their product qualities stable. The keys to achieving product quality are manufacturer process stability, vendor process capability and plant management. When the process was abnormal and made the qualities out of range and then defective that will raise quality cost. Manufacturers decrease the defect rate of product to meet the needs of customer companies and reduce quality cost to increase its profit.

Step 1: Establish Contradiction and select principles

Reducing product defect rate can change the appearance, product materials, or manufacturing methods. This action reduced cost of quality and caused conflicts. Table 1 lists the variables, including the product defect rate requiring improvement and the cost of quality in which deterioration is to be avoided. Contradiction matrix can be used to identify the conflicting property grid.

The principles of the Contradiction Matrix are: 1.Segmentation; 2.Taking out; 3. Local quality; 23. Feedback.

Step 2: Appling principles for solution development

After brainstorming different principles, the following principles drive the solution:

Principle: Segmentation

Total Quality Management (TQM) is regarded as a total organizational approach for meeting customer needs and expectations that involves all managers and employees in using quantitative method to improve continuously the organization's processes, products, and services. It strategically plans and organizes the technical, managerial, and human resources of the firm to design superior products and processes, to ensure quality during production, and to continuously improve the quality of processes and products. A major focus of these efforts is on improving the product quality (e.g., lower defect rate and higher customer satisfaction), and in turn improve the overall business performance (e.g., higher market share and higher profitability).

5. Conclusion

In today's world of global competition, companies must develop acustom-oriented approach to quality, studying how their product or service is used from the moment a customer first comes in contact with the product or service until the moment that the product is disposed of or the service is complete. In this study, the TRIZ theory can allow managers to quickly and accurately solve problems, and introducing the theory to improve quality based on the TRIZ can conventionalize problem solution, and make it easier to follow rules.

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