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# TRIZ-based approach for accelerating innovation in chemical engineering

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ABSTRACT

In the 21st century, the pace of technological innovation is increasing exponentially and companies feel more and more pressure to adapt quickly to new problems, new technologies and new demands on skills. To ensure such continuous capability improvement, a systematic understanding of technological problem framing and problem solving is a must. TRIZ-based methodologies, typically associated with systematic innovation, have been used for decades across different industries to dramatically improve products and manufacturing processes. These methodologies have been used by leading corporations throughout the world to develop breakthrough ideas, reduce risk associated with innovation and accelerate innovation. One common misconception about TRIZ, however, is that since it was developed for mechanical systems it cannot be used for chemical problems. The objective of this article is to demonstrate that, in fact, TRIZ-based methodologies are well-suited for the chemical industry by presenting (1) relevant statistics (almost 60% of all projects performed by our company over the last 8 years involved improving chemical or bio-chemical products and technologies), (2) specific TRIZ-based case studies from the fields of chemistry and chemical engineering and (3) general reasoning on the areas of chemical engineering in which TRIZ should be most effective.
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## 1. A brief history of TRIZ

Classical TRIZ, the Russian acronym for "Theory of Inventive Problem Solving", is a collection of problem-solving and technology forecasting tools such as ARIZ (Marconi, 1998), Contradiction Matrix with the 40 principles of solving technical contradictions and Trends of Engineering Systems Evolution (TESE) Analysis (Altshuller, 2000). These tools are derived from an analysis of the world's body of patents to identify global patterns in inventions across a broad range of industries. Originally developed in 1956 by Soviet inventor Genrich Altshuller, TRIZ is based on the following core ideas:

- Patterns of technical evolution are repeated across industries.
- Problems and solutions are repeated across industries.
- Innovation can be taught and learned.

TRIZ has evolved considerably over time and modern TRIZ approaches such as GEN3 TRIZ (GEN3 Partners, Inc.) incorporate both well-known traditional tools and the newest problem-solving and analytical tools. Examples of the widely used traditional tools are Function Analysis, Cause–Effect Chain Analysis (CECA), and TESE Analysis. Some recently developed tools, for example, Feature Transfer and Function

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Oriented Search (FOS) (Litvin, 2005), are powerful analytical (Feature Transfer) and problem-solving (FOS) tools, while Analysis of Main Parameters of Value (MPV) (Litvin, 2011) connects business challenges and objectives to technical information.

TRIZ has been adapted for various applications including new product development, product improvement, technology forecasting, and IP strategies. The methodology has been successfully used for improving products and manufacturing processes in heavy industry and consumer goods industry.

Today, TRIZ is a globally accepted approach for developing innovative solutions to complex technical problems. Its governing body, The International TRIZ Association (MATRIZ), has over 70 Regional Associations in 16 countries and 5 continents (MATRIZ Web site). Individual TRIZ experts and TRIZ-consulting companies exist in many more countries.

Due to its recognized efficiency, the TRIZ-based systematic innovation approach has been adopted by such leaders in technical innovation as GE, Intel, Siemens, Samsung, and P&G. It has also been adopted by universities worldwide and sponsored by governments, including Germany, South Korea, China, and Colombia. Each year a number of TRIZ conferences are held around the globe.

## 2. TRIZ application in modern industry

At present TRIZ is generally recognized by engineers as a methodology that effectively aids in resolving difficult technical problems (Gadd, 2011).

### 2.1. *TRIZ innovation roadmap*

The TRIZ roadmap for innovation (Fig. 1) generally follows a traditional innovation roadmap, but with two major differences:

First, there is a special emphasis on system analysis which ensures that the right questions are asked, and, second, the practical tools provided for ideation and problem solving go well beyond brainstorming.

At the high level, the innovation process typically begins with a Portfolio Analysis which aims to select products, or product categories, to which innovation investment will be allocated. As any product or process is characterized by many parameters, the next step is to select innovation targets whose parameters, MPVs, should be improved. Following this, a system is thoroughly analyzed from different angles to go beyond the superficial initial goal to a number of very specific, nontrivial problems and to make sure that the problems addressed are indeed those problems that should be solved. The methodology then offers a number of tools for problem solving and conceptual design. Feasibility studies and substantiation of the ideas are followed by a prototyping stage.

### 2.2. *TRIZ and existing best industry practices*

It is worth mentioning that modern industry has developed its own best practices such as the Stage-Gate process (Stage-Gate International) and Failure Mode and Effects Analysis (Quality-One International), which are widely used for reducing risk associated with developing new products and new technologies. These practices do demonstrate superior efficacy relative to 'undisciplined innovation process', which explains their popularity.

Further enhancement of best industry practices is typically achieved by including well-known innovation methodologies like Lean (Melton, 2005) and Six Sigma (Pyzdek and Keller, 2014), which are targeted at minimizing waste (in the broad sense: waste of materials, energy, labor, etc.) and making production technologies more efficient and less costly.

If, on the other hand, a new product or technology is truly innovative and requires solving difficult innovation problems, best industry practices frequently introduce great delays or even fail as they do not have the appropriate tools to timely identify and solve such problems. It has been shown, though, (Abramov, 2014) that these practices, specifically the Stage-Gate process, can be greatly enhanced by integrating TRIZ tools into their standard roadmap. Such integration yields a much more robust TRIZ-assisted innovation process, thereby reducing risk far more than the existing best industry practices could do alone.

Using TRIZ is especially critical in the first stages of the innovation process, until after a working prototype of the new product/technology has been built and successfully tested. In the final stages, though, when the product is being prepared for launch, using TRIZ is normally less critical. At this point Lean and/or Six Sigma may be successfully employed to polish the manufacturing process, build supply chains, etc.

Even though TRIZ does not typically address issues in basic science, market research, optimization or discovery of new materials, overall it is a powerful methodology that can reliably identify and solve virtually any engineering problem, thus considerably accelerating innovation and reducing risks.

Despite the fact that years of practice in TRIZ-consulting has proved that TRIZ and GEN3 TRIZ tools are highly effective across a range of industries, there is still a common misconception about TRIZ: since it was originally developed for mechanical systems, it surely cannot be used in modern chemical, electronic or IT industries.

In this paper the authors will focus on the applicability of TRIZ to the chemical industry and on the specifics of using TRIZ in this area. The research here is based on a statistical analysis of TRIZ-consulting projects performed by GEN3 Partners in 2007–2014.

## 3. Research: can TRIZ really be used in the chemical industry?

### 3.1. *Statistical analysis of TRIZ projects*

In order to discover if a TRIZ-based approach is applicable to chemistry-related innovations, a pool of 225 consulting projects that were successfully performed by GEN3 Partners in 2007-1014 was analyzed. In all of these projects GEN3 TRIZ methodology was used to improve either a product or a technology in some specific area of industry.

From this pool, only chemical projects were selected – that is, those projects in which either chemical problems were analyzed or chemical solutions were generated. Not only were projects directly related to chemical engineering chosen, but so were most of the projects concerning biochemistry, microbiology, pharmaceutical and food industries.

The results of our statistical analysis are given below in Figs. 2 and 3:

- Fig. 2 shows that the average share of chemical projects in GEN3 TRIZ consulting is surprisingly high and, in fact, more

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