INSIGHTS *into* ROOT CAUSE ANALYSIS

INCREASING THE SCIENTIFIC RIGOR OF YOUR INVESTIGATIONS

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qbs Quality for Business Success, LLC.

Chapter 2.6 Excerpt

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Chapter 2.6: TRIZ – Solving for T and F

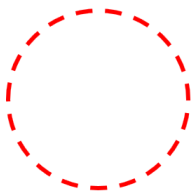
TRIZ is a Russian acronym that roughly translates into the **Theory of Resolution of Invention-related Problems**. The methodology is based on the analysis and synthesis of millions of patents. By identifying patterns of invention, TRIZ allows inventors and problem-solvers to accelerate the innovation process.

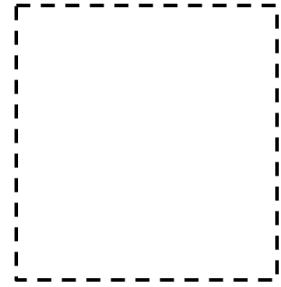
The full breadth of TRIZ is beyond the scope of this book. Yet, TRIZ's unique approach to root cause analysis is worth discussing. It is especially valuable for problems that have a strong technical or scientific component. Since TRIZ is an invention methodology, its approach to finding the root cause of a problem is to suggest that you design for the problem.

Before we plunge into the specifics of how to do this, we need to cover some basic TRIZ nomenclature.

Understanding How TRIZ Sees the World

Place a coin on top of the circle shown below.





Now move the coin inside the square.[1]

[1] If your coin is too large to fit, move it on top of the square. Try doing this before you turn the page.

How did you get it there? Did you push it with a pen or a highlighter? Did you slide it towards the square with your finger? Did you lift it from the circle and place it on the square? Did you slightly shake the book (or your electronic reader) to get it there?

There's probably another dozen ways to get a coin into the square. Regardless of how you got it there, you turned "a coin outside the square" into "a coin inside the square."

In TRIZ terminology, the process of turning an outside coin into an inside coin can be modeled[2] as follows:

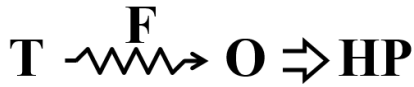
$$T \xrightarrow{F} O \Rightarrow UP$$

This is the equation for a Useful Function, where:

- **UP** stands for **Useful Product** – the useful outcome you are pursuing. *In the exercise above, **UP** = the coin inside the square*.
- **O** stands for the **Object** being transformed into the UP. *In our exercise, **O** = the coin outside the square.*
- **F** stands for the **Field** that acts on **O** and transforms it into **UP**. In our exercise, *examples of **F** are friction and gravity.*
- **T** stands for the **Tool** that provides **F**. *In our exercise, **T** could be your finger.*

[2] The TRIZ modeling nomenclature used in this chapter follows the method taught by Zinovy Royzen in Designing and Manufacturing Better Products Faster Using TRIZ © 2002 TRIZ Consulting Inc.

When dealing with problems, this nomenclature changes a bit. A patch of oil on the floor is not a "useful product." TRIZ denotes unwanted outcomes – i.e., an error, a defect, a discrepancy, a gap between what you want and what you are getting – as harmful products and they are modeled, using the equation for a Harmful Function , as follows:



Where:

- **HP** stands for **Harmful Product** – the error, defect, or harmful outcome.
- **O** stands for the **Object** being transformed into the **HP**.
- **F** stands for the **Field** that acts on **O** and transforms it into **HP**; the field that damages **O**, the cause that created the **HP**.
- **T** stands for the **Tool** that provides **F**; the source of the damaging **F**.

A zigzagged arrow is used in place of a straight arrow to denote a harmful function.

Everything that happens can be modeled using one of these two functions.

In our oil-patch example, we can use the Harmful Function to model various elements of the problem. For example, a good gasket (O) is transformed into a leaking gasket (HP); oil-inside-the-conveyor-motor (O) is transformed into oil-on-the-floor (HP); a clean floor (O) is transformed into a floor-with-oil (HP).

Each of these transformations occur because a field acts upon the object. Our task, in RCA, is to find T and F.

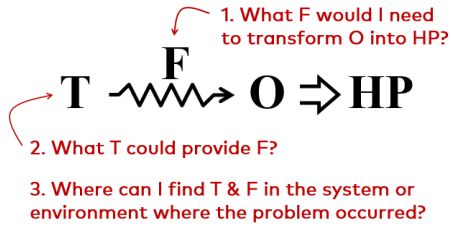
TRIZ and RCA

To find T and F for a given effect, TRIZ suggests that you design for the problem. In other words, it prompts you to create the unwanted effect using the resources available in the environment where the effect appears.

To design for the problem, the general strategy entails:

1. Understanding the technical/scientific mechanism behind the defect or discrepancy being studied.
2. Using the available resources to create the effect.

The specific questions you need to answer are:



The actual procedure requires four steps:

1. Model the problem.
2. Understand the failure mechanism.
3. Inventory the Tool and Field (T and F) combinations within the boundaries of the problem that can produce the failure mechanism.
4. Test your potential T and F combinations against the facts.

Let's see how this works in a real case.

Problem: The tablet[3] production process of a pharmaceutical company is yielding 5 broken tablets per batch of 10,000 tablets; this equates to 500 defects per million (DPM). The expected operating specification is 5 DPM.

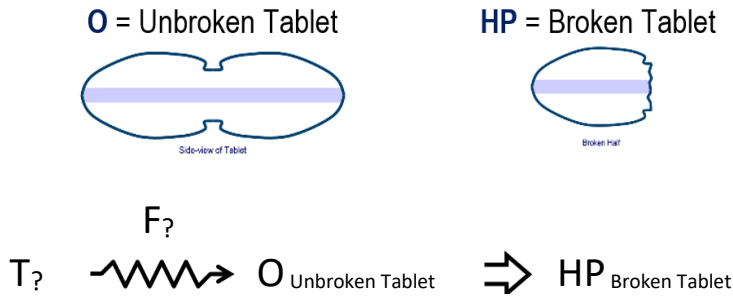
The tablets are breaking at the middle. Operators have seen chipped tablets in the past but had never seen broken tablets. The problem surfaced during last month's production.

The general appearance of the tablet is shown here. It's an elongated pill with a slit in the middle.[4]

We assembled a team to identify the root cause of broken tablets and decided to attack the problem using TRIZ.

Step 1: Model the Problem

The following diagram illustrates a side view of the tablet.



[3] Tablets (contrary to capsules, which are filled) are made by compressing the ingredients into a tight unit. In this case, once compressed, the tablets are coated and dried in a tumbler and then packaged in bottles.

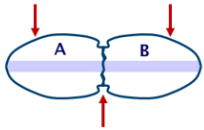
[4] In the past, many tablets were compressed with a slit in the middle to make it easy for pharmacists to dispense half a dosage by splitting the tablet in half. Today, the slit has become a cosmetic feature, part of the tablet's design.

Step 2: Understand the Failure Mechanism

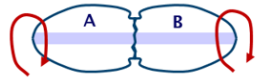
Once you've modeled the problem, the question becomes: What type of field (F) can cause the problem and how? A mechanical force? A thermal force or source of energy? A chemical reaction? An electric field? A magnetic field? An electromagnetic field?

After studying the broken halves under a microscope, the team determined that the field causing the problem was a mechanical force.

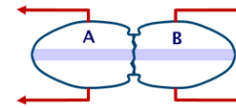
The breakage "signature" left on the broken halves suggested one of the following mechanisms:



Mechanism A



Mechanism B



Mechanism C

Step 3: Inventory Possible Sources of T and F

In this step, you want to ask yourself: What object or tool (T), within the boundaries of the problem, can source the harmful or unwanted field (F) required to reproduce the failure mechanism?

We went off to study the production line where the broken tablets appeared (the system), the plant that encompassed the production line (the supra-system), and the surrounding environment. Our mission was to find a T and F combination that could produce any of the mechanisms we formulated in Step 2.

We found that there are no items or objects in the process and its surroundings that could put into effect mechanisms B or C.

We were able to create two potential T and F combinations for mechanism A:

Combination 1: The coating and drying process in the tablet coater – i.e., a combination of the spinning tumbler, tablets dropping inside the tumbler, and the coating nozzles.

Combination 2: The random configuration of tablets during bulk storage after the coating process, with tablets at the bottom of the heap yielding to the weight of tablets above.

Step 4: Test your Potential T and F Combinations Against the Facts

The team went off to determine if they could reproduce the effect using the T and F combinations suggested in Step 3.

Broken tablets were found inside the bulk containers used to transport the tablets from the coater to the packaging area. No broken tablets were found at the coating and drying station. We also discovered that the company had recently adopted the use of larger containers. Larger containers allowed for a taller (and heavier) column of tablets. The timing of this change correlated with the increase in broken tablet incidents.

We found that process data supported Condition 2. We progressed from probability, to possibility, to certainty. Once the root cause was identified, the solution was obvious: discontinue use of the larger bulk containers.

The agency that produced the effect you are investigating resides within the system and its environment. Designing for the defect, using only the available resources, forces you to understand how to create the defect and to search for the agents that created it.

Notes on TRIZ – Rules for Revealing the Cause

- Reserve TRIZ for scientific or technical problems where the root causes are not obvious.
- Often, the effect is a result of a chain or a combination of

  equations.

  In such instances, use more than one equation to model the effect you are trying to reproduce.
- There are many Ts and Fs we tend to take for granted – e.g., a room's temperature and humidity, the earth's gravity, friction inside a mechanical system. Be aware that the failure mechanism may be caused by these "invisible" Ts and Fs.

Exercise 6

Identify useful and harmful functions around you – writing with a pencil, opening a drawer, water boiling, a bulb heating up. Model these functions using TRIZ nomenclature.

Practice modeling functions with TRIZ every day. It will help improve your proficiency with this technique.

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