TRIZ: Structured Innovation for Inventive Problem Solving and Product Development
Creativity as an Exact Science
Dr. Noel León Rovira, ITESM, Campus Monterrey
OBJECTIVES

– To understand the nature of the TRIZ methodology

– To understand the importance of this methodology to your company/organization

– To understand how are TRIZ and Six Sigma process related

– To understand how to utilize this methodology and what actions you can take to get results

Give your company the Innovation Advantage
Syllabus

• TRIZ and innovation
• The ideal final result
  • The principle of searching resources inside the system
  • Solving Problems with IFR
• Basic TRIZ Concepts
• Levels of solutions
• Technical Contradictions
• The Technical Contradictions Matrix
• Physical Contradictions,
  • Solving Physical Contradictions
TRIZ: Structured Innovation for the Millennium

The vast majority of products and services that will be commercialized to continue corporate profitability into the new millennium do NOT yet exist.
TRIZ: Structured Innovation for the Millennium

• Where will these products or services come from?
• These products and services will result from the culmination of and reduction to practice of the INNOVATION process.

Yes, INNOVATION process.
• Innovation and Creativity in an organization have commonly been described by the following:
EUREKA!!!
ENIGMATIC
UNPREDICTABLE
TRIAL and ERROR
UNTRAINABLE
Creativity as an Exact Science

• The modern corporation needs an amplifier in the idea generation and problem resolution phases so that creativity and innovation become:
  – predictable
  – reproducible
  – a core competency
  – commonplace

• This amplifier is TRIZ
• Corporations recognize this—almost every mission statement I have seen references a strong dependence on INNOVATION

• How is this reliance on INNOVATION supported?

• Sadly enough—usually not at all
A CHARACTERISTIC OF TODAY’S BUSINESS WORLD

Ever-increasing diversification of products in the market today due to:

- Rapidly accelerating technological innovation
- Shortened product life-cycles
- Diversification of customer needs

*New technology spawns new markets*
ADMINISTRATIVE CYCLE OF THE PRODUCT

Innovation cycle time

Cash flow

Opportunity occurs
Opportunity Perceived
Project activity begins
First customers are satisfied
Product is released to production
Break-even time

Net Profit Period

Product becomes extinct

Time

From: Accelerated Innovation by Marvin Patterson

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TODAY’S INNOVATION PROCESS

STRONG WEAK STRONG

Identify Problem
Formulate Problem
Develop Concepts
Evaluate
Implement

Reliability study
QFD
Trial-and-error
Robust Design
CAD/CAM/CAE

Market research
Brainstorming

WIDELY USED TECHNIQUES

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¿What is TRIZ?

TRIZ is the Russian acronym for

Теория Решения Изобретательских Задач

In English it means

Theory of Inventive Problem Solving

Systematic methodology for reducing creativity and innovation to a set of principles and algorithms
History and State of the Art

Henry Altshuller, the creator

1926 Was born in Russia

1940 Made his first invention

1946 Started his work on TRIZ

1948 Sent to a Gulag

1954 Comes out of the Gulag and starts wide spreading his ideas

1982 First private TRIZ school is grounded
Kishinev School: Boris Zlotin and Alla Zusman
Minsk School: Valeri Tsurikov

1990-1992 TRIZ is introduced in USA

1994 TRIZ is introduced in Mexico by ITESM

Ideation International

Invention Machine
WHY TRIZ WAS DEVELOPED?

Altshuller sought to aid engineers in solving difficult inventive problems and sought to develop a methodology meeting the following criteria:

- Provide a step-by-step, systematic procedure
- Capable of guiding an inventor through the solution space and directing them to areas offering the most ideal solutions
- Provide an inventor with reliable and repeatable results that do not depend upon personal (psychological) abilities/factors
What is TRIZ? : 
Fundamental Premises

Why some people invent and other no?
Is it because they follow a method?
Most of the problems already have been solved previously
The solutions can be classified and ordered so that they can easily be accessible
True problems are those that contain a contradiction
The Technological Systems do not evolve randomly, but they follow certain Laws of Evolution
TRIZ METHODOLOGY

- TRIZ has resulted in a methodology rooted in technology – not psychology
- TRIZ generalizes worldwide experience in invention
- TRIZ systematizes successful methods of solving technological problems
- TRIZ reveals regularities in the evolution of technological systems
Accelerating the Innovation by means of Structured Procedures

Initial Point

Practical deadline

Decision point

An EXHAUSTIVE group of options

Number of required options to make a reasonable decision

Opciones Posibles

Gradual accumulation of the practical knowledge

Fast development of the practical knowledge

Limit for taking a decision

Tiempo

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PROBLEM SOLVING BY PSYCHOLOGICAL MEANS

Problem

Concept 1

Concept 2

Concept 3

Concept 4

Concept N-1

Concept N

Variants

Vector of Psychological Inertia

Solution
PSICHOLOGICAL INERTIA

Termo-dinamic

Mechanical

Chemical

Electronic

Solution

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LEVELS OF SOLUTIONS

LEVEL 1: Apparent (no invention)
- Established solutions
- Well-known and readily accessible

LEVEL 2: Improvement
- Small improvement of an existing system, usually with some compromise

LEVEL 3: Invention inside paradigm
- Essential improvement of an existing system

LEVEL 4: Invention outside paradigm
- A concept for a new generation of an existing system, based upon changing the principle of performing the primary function

LEVEL 5: Discovery
- Pioneer invention of an essentially new system

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ALTSHULLER FOUND THAT

To Achieve this Level of Invention

<table>
<thead>
<tr>
<th>Level of Invention</th>
<th>Solutions Considered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Apparent Solution</td>
<td>10</td>
</tr>
<tr>
<td>2. Improvement</td>
<td>100</td>
</tr>
<tr>
<td>3. Invention within paradigm</td>
<td>1,000</td>
</tr>
<tr>
<td>4. Invention outside paradigm</td>
<td>100,000</td>
</tr>
<tr>
<td>5. Discovery</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

Clearly, for high levels of invention, the trial-and-error method is impossibly inadequate.
Why Another Methodology?

- Six Sigma assumes the solution to the problem is inherent in the process...
- DMAIC and DMADV assume that innovative ideas are the foundation for improvement...
- What if these assumptions are wrong?
- Existing Creativity Methods are Emotionally based

TRIZ is Empirically based!
Six Sigma Vision $f(X)$

- Let $Y$ be innovation
- Let $X$ be those inputs that effect $Y$ through the transfer function, $f$
- What are the $X$’s for emotional and psychological based creativity methods?
  - peer pressure
  - personality conflicts
  - dietary needs
  - energy levels
  - team dynamic
  - communication skills
  - emotional states
Six Sigma Vision $f(X)$

• What are the X’s for the TRIZ creativity method?
  – structured problem definition
  – contradiction identification
  – Inventive Principles and Separation Principles
  – Substance-Field Modeling
  – Algorithm for Inventive Problem Solving

• What are the basis of the transfer function using TRIZ?
  – Analogic Thought
  – Abstraction
Venn Diagramming the Solution Space

S is a Solution
P is the Problem

Solution Space For a Solver

Presumptions Boundary

The Best Solution

Knowledge Boundary

Real Boundary Constraints
The Ideal Final Result (IFR) and Ideality (I)
Ideal Final Result (IFR)

• The IFR is the imagined ultimate outcome of the problem solving process.
  – An element of the system or an element in the environment surrounding the system will perform the desired function(s) by itself with no cost(s) or harmful effect(s).
Ideal Final Result (IFR)

• The IFR has the following 4 characteristics:
  1. Eliminates the deficiencies of the original system
  2. Preserves the advantages of the original system
  3. Does not make the system more complicated (uses free or available resources).
  4. Does not introduce new disadvantages
Evolution Towards Ideality

- Each system performs useful and harmful functions
- TRIZ follows to maximize the ideality: Ideal Final Result (IFR)

\[ \text{IDEALITY} = \frac{\text{All useful functions}}{\text{All harmful functions} + \$} \]
Ideal Final Result

IFR provides solutions that are near to the ideality
IFR does not increase the complexity of the system

1. A system performs a function without existing
2. The function is performed without introducing new resources in the system: using existing resources, (physical, chemical, geometric etc.)
“Ideality” measures progress toward the IFR

Ideal
Final
Result

Start
Conventional Approach
IFR
Inventive Approach

• No harmful effects
• No Cost
• Satisfies Customer needs

Ideal
Final
Result

Start

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Evolution Focused to the Increase of the Ideality
EXAMPLE: BRAKING OF AN AUTOMATIC WELDER DRUM

Automatic welding machines use a steel wire unreeled from a rotating drum as an electrode. The wire is pulled by a special motor located in the welding head. When welding is interrupted the motor stops, but the drum continues to rotate under its own momentum and entangles the wire.
EXAMPLE: BRAKING OF AN AUTOMATIC WELDER DRUM

To avoid this, the machine may be provided with a drum braking feature that necessitates a more powerful pulling motor and, hence, a heavier welding head. Braking can be computer-controlled, but doing so is expensive.
EXAMPLE: BRAKING OF AN AUTOMATIC WELDER DRUM

The solution: The drum's rotary shaft can be fixed, with movement only allowed along a groove cut at an angle of 1 to 3 degrees with the horizontal plane.

When the drum is not subject to the pulling force of the wire, its shaft is in the lowermost position, and the drum's side surfaces are pressed to brake plates under its own weight.

When the wire is under tension, the drum shaft moves along the groove and away from the brake plates.
EXAMPLE: Extruding aluminum cans

Aluminum cans are extruded by forcing them onto a cylindrical steel die. The problem is that removing the cans from the cylinder is difficult.
EXAMPLE: USING A COILED DIE

To solve this problem, the die can be made from a roll of sheet steel. The outer edge of the sheet is welded to next layer of the roll so the outside of the roll forms the desired cylinder. When the inner layers of the roll are uncoiled, they bear against the outer layer and stiffen it so it can be used to form the cans. After extrusion is completed, the system coils the inner layers. The outer layer then becomes flexible, and the can is easily removed.
EXAMPLE: METHOD OF COLORING ACETATE THREADS

Acetate threads are made by twisting thin fibers produced by extruding a liquid solution through spinnerets.

The threads are colored by adding dye to the solution. To change the dye, the system (including the pipes and spinnerets) must be cleaned, which is time-consuming and laborious.
EXAMPLE: METHOD OF COLORING ACETATE THREADS

It is suggested that the thread be made of red, green, blue and transparent fibers. Any desired color can be obtained using combinations of these colored fibers.
EXAMPLE: TRANSPORTATION OF BOBBINS

Due to loading requirements, large bobbins containing rope or wire must be transported in train cars, resting on their ribs.

In this position, however, the bobbins can roll due to bumps, and the walls of the bobbins can become damaged as a result.

To prevent rolling, special wooden supports must be made, installed, and removed.
EXAMPLE: TRANSPORTATION OF BOBBINS

An alternative method to prevent rolling is to simply join two adjacent bobbins with one or two struts.
EXAMPLE: TRANSPORTATION OF BOBBINS

Short struts reduce costs
Contradiction Theory
Conflicts in new products cycles
Fundamental TRIZ Principles  
(Contradiction Theory)

- All inventive problems involve the resolution of technical or physical contradictions

Benefits:
- Identify Contradictions
- Directs Thought to General Inventive Solutions
- Utilization of “New” Scientific Effects
- Increased solution density and strength
GENERAL APPROACH TO PROBLEM SOLVING

Analogous Problem \arrow{>}{\text{My Problem}} \arrow{<}{\text{Analogous Solution}} \arrow{<}{\text{My Solution}}

Example: Measuring cables with a normal rule

“Simply” a matter of finding the previously well-solved problem analogous to the problem at hand
Abstract

TRIZ

Systematic Innovation

Trial and error

TRIZ

Systematic Innovation

Trial and error

Resolve

Particularize

\[ aX^2 + bX + c = 0 \]

\[ X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

\[ X = -3, \quad X = 2 \]
Some inventive principles

• Doing it the other way around
• Doing it less
• Changing the physical state of an object
• Using physical properties
• Using an auxiliary substance
• Local solution
• Using a copy
• Nesting
• STC operators
Inventive Problems

Exercises

• Applying inventive principles for problem solutions
1. Making holes in a hose

• When trying to drill holes a hose it is deformed.

• This leads to deformed holes

• Look for a solution to this problem

  – Tip: Change the physical state
2. Oil is missing in a car tank

- In a car tank with 3000 liter capacity 20-30 liter are being missed systematically during discharge
- The situation has been analyzed thoroughly
  - Measurement instrument have been checked => OK
  - Leakages were sought => NO
  - A theoretic thought suggested that the thin oil layer... => NO
  - Volumetric changes due to temperature? => NO
  - The driver became suspicious.
  - He was followed up to the delivery... => NO

- How was oil going lost?
  - Tip: Doing it before
3. Cutting welded tubes (1)

- In the production of welded tubes in a continuous rolling-welding machine, these are cut to a length of 12 feet, by means of a cut mechanism that travels with the tubes at a speed of 2 fps.
- Whenever a tube is cut the mechanism returns 12 feet and begins a new cutting cycle.
- This principle works correctly. But if it is desired to increase the productivity of the machine and that its speed is increased, for example to the double, the cutting speed is insufficient.
3. Cutting welded tubes (2)

- The process time for cutting one tube consists of the cutting time $t_c$ and the return time $t_r$ and this is equal or smaller to 6 sec for the first case.
- In the second case $t_c$ would have to be smaller than 3, but such speed is not possible to achieve.
- Find a new solution for these case.
- Note: The principle of “do it before”, as to have sheets previously cut would increase the costs of the process, because the machine would not work in a continuous way.
- Tip: Do it a little less.
4. Putting a compressed spring within a device

- It is required to put compressed springs within a device, but that this should be freed after introducing it.
- Sometimes the process can be made helping the compression and assembly with other components.
- However, in some cases compressing the springs with other components during the assembly is not feasible.
- Find a way…

Tip: Changing the physical state of a substance.
5. Manufacturing glass filters

- It is required to manufacture glass filters of 1m diameter and 2m height, with 1 cm holes (See figure)
- To drill these holes is excessively expensive.
- Find an economic method to obtain the filters with the given dimensions.

- Tip 1: To do it the other way around.
- Tip 2: Fragmentation and consolidation
6. Testing material samples

• In order to verify the resistance to acids, test samples are introduced in acid during certain time to analyze the effect of acid in their surface.

• The container of acid for the tests is problematic and expensive.

• Find an economic way to make the tests.

• Tip: To do it the other way around.
6. Testing material samples (2)
6. Testing material samples (3)

Ácido

Sample
6. Testing material samples (4)
7. Clearing iron shavings from a permanent magnet

- On a permanent magnet of huge size (d = 1m, h = 2m), iron shavings fell accidentally (d=0.1 mm).
- To clear these shavings becomes complicated. The polished surface of the magnet can be damaged if it is scraped.
- Find a reliable and effective a method to clear the shavings.
- Tip 1: To use auxiliary materials.
- Tip 2: Field-Substance Diagrams.
8. Ice in electricity transmission lines

- During the winter in cold countries the risk arise of ice forming around electricity transmission lines.
- The weight of the ice may cause breakage of these lines.
- If a line is used whose resistance produces heat, the losses of energy are too great. In addition, during the summer the heating can be excessive.
- To put ferrite rings each certain distance, causes heat by magnetic induction, but this also it happens during the summer.
- Find a physical principle that allows to avoid the heating in summer.
- Tip: Magnetic properties.
9. High precision valve

• A high precision valve is required for metering the components in an industrial process.
• The required precision exceeds the possibilities of screw valves.
• Develop a principle of regulation (not based on screws) for the opening of a valve that allows to control differences of the order of thousandths of millimeter.
• **Tip: Physical principles.**
GENERAL APPROACH TO PROBLEM SOLVING

Analogous Problem

Analogous Solution

My Problem

My Solution

“Simply” a matter of finding the previously well-solved problem analogous to the problem at hand

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Contradictions push development forward
Technical Contradiction

- Parameter A improves
- Parameter B deteriorates
- Temperature vs. Waste of Energy
- Amount of Substance vs. Reliability, etc.

• Invention surmounts the contradiction, achieving both

A ↑ B ↑
What is an inventive problem?

• It contains one or more technical contradictions

• It suggests new ways or even unknown ways of solution

  ▪ **Real understanding can come solely through the light of self-awareness which is inherent in every human being.**
# 40 Inventive Principle

<table>
<thead>
<tr>
<th></th>
<th>Principle of segmentation</th>
<th></th>
<th>Principle of introducing protection in advance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Principle of removal</td>
<td>11</td>
<td>Principle of equipotentiality</td>
</tr>
<tr>
<td>2</td>
<td>Principle of local quality</td>
<td></td>
<td>12 Principle of opposite solution</td>
</tr>
<tr>
<td>3</td>
<td>Principle of asymmetry</td>
<td></td>
<td>13 Principle of spheroidality</td>
</tr>
<tr>
<td>4</td>
<td>Principle of joining</td>
<td>14</td>
<td>Principle of dynamism</td>
</tr>
<tr>
<td>5</td>
<td>Principle of universality</td>
<td>15</td>
<td>Principle of partial or excessive action</td>
</tr>
<tr>
<td>6</td>
<td>The nesting principle</td>
<td>16</td>
<td>Principle of moving into a new dimension</td>
</tr>
<tr>
<td>7</td>
<td>Principle of counterweight</td>
<td>17</td>
<td>Principle of periodic action</td>
</tr>
<tr>
<td>8</td>
<td>Principle of preliminary counteraction</td>
<td>18</td>
<td>Use of mechanical vibrations</td>
</tr>
<tr>
<td>9</td>
<td>Principle of preliminary action</td>
<td>19</td>
<td>Principle of periodic action</td>
</tr>
<tr>
<td>10</td>
<td>Principle of preliminary action</td>
<td>20</td>
<td>Principle of uninterrupted useful effect</td>
</tr>
</tbody>
</table>
## 40 Inventive Principle

<table>
<thead>
<tr>
<th></th>
<th>Principle of rushing through</th>
<th></th>
<th>Using porous materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Principle of turning harm into good</td>
<td>31</td>
<td>The principle of using color</td>
</tr>
<tr>
<td>22</td>
<td>The feedback principle</td>
<td>32</td>
<td>The principle of homogeneity</td>
</tr>
<tr>
<td>23</td>
<td>The go between principle</td>
<td>33</td>
<td>The principle of discarding and regenerating parts</td>
</tr>
<tr>
<td>24</td>
<td>The self service principle</td>
<td>34</td>
<td>Changing the aggregate state of an object</td>
</tr>
<tr>
<td>25</td>
<td>The copying principle</td>
<td>35</td>
<td>The use of phase changes</td>
</tr>
<tr>
<td>26</td>
<td>Cheap short life instead of expensive longevity</td>
<td>36</td>
<td>Application of thermal expansion</td>
</tr>
<tr>
<td>27</td>
<td>Replacement of a mechanical pattern</td>
<td>37</td>
<td>Using strong oxidation agents</td>
</tr>
<tr>
<td>28</td>
<td>Use of pneumatic or hydraulic solutions</td>
<td>38</td>
<td>Using an inert atmosphere</td>
</tr>
<tr>
<td>29</td>
<td>Using flexible membranes and fine membranes</td>
<td>39</td>
<td>Using composite materials</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

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Altshuller Parameters

1. Weight of moving object
2. Weight of stationary object
3. Length of moving object
4. Length of stationary object
5. Area of moving object
6. Area of stationary object
7. Volume of moving object
8. Volume of stationary object
9. Velocity
10. Force
11. Stress or pressure
12. Shape
13. Stability of object's composition
14. Strength
15. Duration of action generalized by moving object
16. Duration of action generalized by stationary object
17. Temperature
18. Brightness
19. Energy consumed by moving object
### Altshuller Parameters

<table>
<thead>
<tr>
<th>Altshuller Parameter</th>
<th>Description</th>
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<tbody>
<tr>
<td>20</td>
<td>Energy consumed by stationary object</td>
</tr>
<tr>
<td>21</td>
<td>Power</td>
</tr>
<tr>
<td>22</td>
<td>Energy loss</td>
</tr>
<tr>
<td>23</td>
<td>Substance loss</td>
</tr>
<tr>
<td>24</td>
<td>Information loss</td>
</tr>
<tr>
<td>25</td>
<td>Waste of time</td>
</tr>
<tr>
<td>26</td>
<td>Quantity of a substance</td>
</tr>
<tr>
<td>27</td>
<td>Reliability</td>
</tr>
<tr>
<td>28</td>
<td>Accuracy of measurement</td>
</tr>
<tr>
<td>29</td>
<td>Manufacturing precision</td>
</tr>
<tr>
<td>30</td>
<td>Harmful actions affecting the design object</td>
</tr>
<tr>
<td>31</td>
<td>Harmful actions generated by the design object</td>
</tr>
<tr>
<td>32</td>
<td>Manufacturability</td>
</tr>
<tr>
<td>33</td>
<td>User friendliness</td>
</tr>
<tr>
<td>34</td>
<td>Repairability</td>
</tr>
<tr>
<td>35</td>
<td>Flexibility</td>
</tr>
<tr>
<td>36</td>
<td>Complexity of design object</td>
</tr>
<tr>
<td>37</td>
<td>Difficulty to control or measure</td>
</tr>
<tr>
<td>38</td>
<td>Level of automation</td>
</tr>
<tr>
<td>39</td>
<td>Productivity</td>
</tr>
</tbody>
</table>
Contradictions Matrix

| Case | 1 | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
|------|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|      |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

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Contradictions Matrix

- Possible contradictions 39 X 39

![Contradictions Matrix Diagram](image)

Possible solutions:
1. Replacement of a mechanical pattern
2. Cheap short life instead of expensive longevity
3. Use of mechanical vibrations
4. Composite Materials
Inventive Principle

1 Segmentation

Divide the object into independent parts that are easy to disassemble,

increase the degree of segmentation as much as possible

*Example:*

1 Segmented furniture, modular computer components, foldable rule

2 Garden hoses may be joined to form a longer length
Inventive Principle

Reducing jamming with asymmetry

When an ordinary funnel is used, loose material tends to collect and block the outlet. This occurs because the funnel’s cross-section is circular and material moves symmetrically about the funnel axis.

**Obtain space resource using asymmetry.** A funnel with an asymmetric cross-section (i.e., where the distance from the axis is 35-50 percent greater on one side) can be used.

**The result:** Loose material does not collect and jam the funnel, and the pouring rate is increased.
Inventive Principle
Using physical principles

Economical painting of surfaces

Spray-painting results in a certain amount of waste which occurs when the paint misses the surface to be painted.

To prevent this waste, opposite electrical charges can be imparted to the paint and the surface to be painted, causing the latter to attract the paint drops.
Inventive Principle
Using physical principles

Controlling flames with electricity

A flame is a plasma that contains ionized gas, therefore, flames can be controlled by electric fields. For example, an electric field can be used to adjust the flames in a furnace that burns liquid or solid fuel. Such a field can raise the efficiency of the furnace by 10-30 percent and thus reduce its pollution output. An electric field can be used either to enhance or to retard the burning process.
Inventive Principle
Using physical principles
Principle of opposite solution

Drying foundation walls

To remove dampness from the foundation walls of a building, electrodes can be inserted in the outer face of the walls, below ground level. Another set of electrodes is driven into the ground near the building. The wall electrodes are connected to the positive pole of a d-c electric supply. The ground electrodes are connected to the negative pole. Moisture will then migrate out of the walls into the surrounding ground.

When the walls are thoroughly dry, they can be saturated with a sealing material to prevent more moisture from entering. The result: the walls can be effectively dried.
Components on prototype circuit boards may have to be repeatedly soldered and unsoldered. But integrated circuit devices and other components can be damaged by the heat used in unsoldering.

An alternative method for removing components is to touch each soldered joint with a probe cooled by liquid nitrogen. When cooled by this probe, the tin in the joint changes state, from white to gray tin – and increases in volume by 27 percent. The solder becomes a fine gray powder that can simply be shaken off.
Physical Contradictions
Physical Contradiction (PC)

- Parameter A must be maximized
- Parameter A must also be minimized

• An innovative solution surmounts the contradiction, achieving both

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Physical
Contradictions

A characteristic must be high and low (opposed)

Example 1: An airplane wing must have a great area for an easy takeoff and small for high speed

Example 2: A pen end would have to be acute to draw fine lines, but flat to avoid to break the paper

A characteristic must be present and absent

Example 3: In order to clean with sand blasting the abrasive must be present (to make the abrasion) but it is not wanted that it remains in the product

Example 4: The undercarriage is necessary to land but unnecessary in the flight
Coating metallic parts

Metallic surfaces are chemically coated as follows: the metallic part is immersed in a bath consisting of a metal salt solution (e.g. nickel, cobalt, etc.).

During the reduction reaction, metal from the solution precipitates onto the part surface.

The higher the temperature, the faster the process; however, the solution decomposes at high temperatures, and up to 75% of the chemicals are wasted, settling on the bottom and walls of the bath.

Adding stabilizers is not effective, and conducting the process at a low temperature sharply decreases production.
Coating metallic parts

- When coating parts chemically, the increase of the temperature is necessary only in the proximities of these.

  the same parts can be warmed up, instead of warming up the solution

  In this case, the chemical solution is hot where it is near the part, but cold elsewhere.

  Also, the part can be heated by applying an electric current to it during the coating process.
TRIZ looks for eliminating the physical contradictions by separation of the contradictory requirements:

1. Separation in space
2. Separation in time
3. Separation between the parts and the whole
4. Separation according to some condition
Separation in space

A characteristic becomes large in a place and small in another place
A characteristic is present in a place and absent in another place

Example 1:
The submarines that have sound detector to measure depth but the noise of the submarine interferes. Put the detector several thousands of feet of the submarine with a cable, to separate the detector of the noise of the submarine

Example 2: The bifocal lenses
Separation according to some condition

If something is contradictory it has to be it right under the same circumstances?

Lenses have to be clear to be able to see through them, however when there is much sun I put others with dark crystals. Soon the crystals have to be clear and dark. They have to be the clear and dark lenses under the same circumstances? NO, they only have to be dark when there is much light.

Solution

Photosensitive lenses
Separation in time

• A characteristic becomes large at certain moment and small to another moment.
• A characteristic appears at certain moment and is absent at another moment

Example 1: The pillars of concrete must be pointed to bury them easily but they do not have to be pointed to support to a load. => take control of the pillars’ ends, which, after being inserted, may be destroyed by means of an internal explosive.

Example 2: Considering the problem of abrasive sand accumulation to use dry ice particles as abrasive. After the effect of abrasion, the particles simply disappear by subliming.
Separation between the parts and the whole

If something is contradictory, can we cause that although the parts make a thing individually the total result is indeed the opposite?

yes  yes  yes  yes  yes  yes  yes
yes  yes  yes  yes  yes  yes
yes  yes  yes  yes  yes  yes  yes
yes  yes  yes  yes  yes  yes  yes
yes  yes  yes  yes  yes  yes  yes
yes  yes  yes  yes  yes  yes  yes
yes  yes  yes  yes  yes  yes  yes
yes  yes  yes  yes  yes  yes  yes
Separation between the parts and the whole

• A characteristic has a value at the system level and the opposed value at the component level

• A characteristic exists at the system level but it does not exist at the component level (or vice versa)

Example 1: A bicycle chain is rigid at micro level to have resistance, and is flexible at the macro level

Example 2: Epoxy resin and hardener are liquid before they are mixed, when already mixed both solidify.
Separation between the parts and the whole
Gripping work pieces with complex shapes

It can be difficult, using an ordinary vise, to grip work pieces with complex shapes.
Separation between the parts and the whole

Gripping work pieces with complex shapes

This problem can be solved with a vise whose jaws are each composed of a number of hard bushings.

Each bushing is free to move horizontally to conform to the shape of the work piece.
Separation according to some condition

A characteristic is high within a condition and low within another condition.

A characteristic is present within a condition and absent in another condition.

Example 1: A kitchen strainer is porous with the water and solid with the food.

Example 2: The water is “soft” when entering at it at low speed. However, if somebody jumps of a height of 10 meters, water feels as considerably hard.

This way, the speed of the interaction of the bodies with the water is the condition to be considered when asking for hardness
Technical Contradiction:
Heating increases the productivity (A),
but wastes material (B)
Parameter of control C - temperature

Physical Contradiction: The temperature (C) would have to be **high** to increase the productivity and **low** to avoid waste
Turning Technical Contradictions to Physical Contradictions

A

B

C should be large, and C should be small

\{ Physical contradiction \}

Control Parameter, C

Technical Contradiction
Technical contradictions

Exercise:

1. Identify the conflicting parameters in your present problem
2. Match the conflicting parameters with the parameters of the Altshuller matrix
3. Select the solution principles that are derived from the identified conflicts
4. Try to apply the solution principles selected to the specific problem
Physical contradictions

Exercise

1. In case of not being able to turn to solutions the selected inventive principles
2. Identify possible physical contradictions
3. Analyze the possibilities of applying some of the principles of separation to the specific problem
4. Finally, consider applying some of the 40 inventive principles to the specific problem
THE ADDED VALUE OF TRIZ

Additionally, TRIZ brings structure to the innovation process, thus – Systematic Innovation
THE ADDED VALUE OF QTC+ 6σ

STRONG

Define | Measure | Analyze | Design | Verify

Parametric Analysis | QFD | TRIZ | Robust Design | CAD/CAM

QFD | Trial y error | Brain storming | Robust Design | CAD/CAM

CAE

DFMA

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The implementation and deployment of TRIZ in an organization will allow the application of INNOVATION to be described as:
SYSTEMATIC
PREDICTABLE
PRACTICAL
TRAINABLE
Additional Information

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