TRIZ: A Theory of Inventive Problem Solving

(Overview Presentation)

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TRIZ
Introduction

- People usually face two kinds of problems:
  - Those with generally known solutions
  - Those with unknown solutions

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Introduction

- Those with known solution can usually be solved by information found in books, technical journal, or other subject matter
- The other type of problem is one with no known solution. It is called an inventive problem.
- “TRIZ” is the acronym in Russian (*Теория решения изобретательских задач*) for “Theory of Inventive Problem Solving.”

TRIZ
Background

- Its creator, Genrikh Altshuller, was a patent investigator in Russian Navy in 1946.
- He screened over 200,000 patents and identified patterns frequently used in innovative patents.

TRIZ
Background

- He found out that out of over 200,000 patents that he screened, only 40,000 has somewhat inventive solutions, the rest were straightforward improvements.

TRIZ - Background

He categorized the solutions into five levels.

a) *Level one*. Routine design problems solved by methods well known in industry.
b) *Level two*. Minor improvements to an existing system, by methods well known in industry.
c) *Level three*. Fundamental improvement to an existing system, by methods known outside the industry.
d) *Level four*. These solutions are found more in science than in technology. About 4% of the solutions fall into this category.
e) *Level five*. A rare scientific discovery or pioneering invention of essentially a new system.

TRIZ - Laws

- There are a number of laws in the theory of TRIZ. One of them is the **Law of Increasing Ideality**.
  - This means that technical systems evolve towards increasing degrees of ideality.
  - Normally, when improving a benefit results in increased harmful effects, a trade-off is made, but the law of ideality drives designs to eliminate or solve any trade off's or design contradictions.
  - The ideal final result will eventually be a product where the beneficial function exists but the machine itself does not.

Useful effects

$$Ideality = \frac{\sum Ui}{\sum Hi}$$

Harmful effects

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The TRIZ process: Search for Conflicts

- Search for conflicts.
  - Altshuller extracted from over 150,000 worldwide patents these 39 standard technical characteristics that causes conflict.
    - First, find the principles that needs to be changed.
    - Then, find the principle that is adversely affected, if we change the first principle.
    - Finally, state the technical conflict.

The TRIZ 39 Engineering Parameters

1. Weight of moving object
2. Weight of nonmoving object
3. Length of moving object
4. Length of nonmoving object
5. Area of moving object
6. Area of nonmoving object
7. Volume of moving object
8. Volume of nonmoving object
9. Speed
10. Force
11. Tension, pressure, stress
12. Shape
13. Stability of object
14. Strength
15. Durability of moving object
16. Durability of nonmoving object
17. Temperature
18. Brightness
19. Energy spent by moving object
20. Energy spent by nonmoving object
21. Power
22. Waste of energy
23. Waste of substance
24. Loss of information
25. Waste of time
26. Amount of substance
27. Reliability
28. Accuracy of measurement
29. Accuracy of manufacturing
30. Harmful factors acting on object
31. Harmful side effects
32. Manufacturability
33. Convenience of use
34. Repairability
35. Adaptability
36. Complexity of device
37. Complexity of control
38. Level of automation
39. Productivity

Engineering Parameters Summary

- Things like *weight, length, area, volume, speed, force, tension, shape, durability, energy, all sorts of wastes, power, accuracy, and complexity* quite often come into conflict.
- Resolution of such conflicts is, in the nutshell, the idea behind the inventive problem solving.

Engineering Parameters Conflict Brief Example

- Plane
  - Landing gear of a plane
    - Need to land
    - Disadvantages for a take-off because of dragging
  - Increase the size of engine
    - Increasing power of an engine (+) requires increase of size of engine (-) => inventor considers partial power increase to reduce the negative effect (compromise).
    - Increasing speed of the an airplane needs a new powerful engine. This causes weight increase, so wings can no longer support the take-off. Increasing the wings' length, increases drag slowing the airplane down.

From Contradictions to Conflict Resolution

- The examples presented are called technical contradictions because they happen inside the technical systems.
- The 40 principles are used to resolve the technical contradictions.

TRIZ: 40 Inventive Principles

- Altshuller extracted 40 inventive principles from the world-wide patents.
- These principles can help an engineer find highly inventive solutions to the problem.

The TRIZ 40 Inventive Principles

1. Segmentation
2. Extraction
3. Local quality
4. Asymmetry
5. Merging/Combining
6. Universality
7. Nesting
8. Counterweight
9. Prior counteraction
10. Prior action
11. Cushion in advance
12. Equi potentiality
13. Inversion
14. Spheroidality
15. Dynamicity
16. Partial or overdone action
17. Moving to a new dimension
18. Mechanical vibration
19. Periodic action
20. Continuity of useful action
21. Rushing through
22. Convert harm into benefit
23. Feedback
24. Mediator
25. Self – service
26. Copying
27. An inexpensive short – lived object instead of an expensive durable one
28. Replacement of a mechanical system
29. Use a pneumatic or hydraulic construction
30. Flexible film or thin membranes
31. Use of porous material
32. Changing the color
33. Homogeneity
34. Rejecting and regenerating parts
35. Transformation of physical and chemical states of an object
36. Phase transition
37. Thermal expansion
38. Use strong oxidizers
39. Inert environment
40. Composite materials

Examples
Inventive Principles

Principle 1. Segmentation

- Divide an object into independent parts.
  - *Replace mainframe computer by personal computers.*
  - *Use a work breakdown structure for a large project.*
  - *Modular furniture*
  - *Quick disconnect joints in plumbing*

Examples
Inventive Principles

Principle 2. Taking out

- Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.
  - *Use the sound of a barking dog, without the dog, as a burglar alarm.*

Examples
Inventive Principles

Principle 3. Local quality

- Make each part of an object function in conditions most suitable for its operation.
  - *Lunch box with special compartments for hot and cold solid foods and for liquids*

- Make each part of an object fulfill a different and useful function.
  - *Pencil with eraser*
  - *Hammer with nail puller*
  - *Multi-function tools*

Examples
Inventive Principles

Principle 5. Combining/Merging

- Bring closer together (or merge) identical or similar objects, assemble identical or similar parts to perform parallel operations.
  - *Personal computers in a network*

- *Make operations contiguous or parallel; bring them together in time.*
  - *Medical diagnostic instruments that analyze multiple blood parameters simultaneously*

Examples
Inventive Principles

Principle 6. Universality

- Make a part or object perform multiple functions; eliminate the need for other parts.
  - *Child's car safety seat converts to a stroller .*
  - *Handle of a toothbrush contains toothpaste*

Principle 7. Nesting/"Nested doll"

- Place one object inside another; place each object, in turn, inside the other.
  - *Extending radio antenna*
  - *Extending pointer*
  - *Zoom lens*
  - *Seat belt retraction mechanism*

Examples
Inventive Principles

Principle 10. Preliminary action

- Perform, before it is needed, the required change of an object (either fully or partially).
  - *Sterilize all instruments needed for a surgical procedure on a sealed tray.*

Principle 11. Beforehand cushioning

- Prepare emergency means beforehand to compensate for the relatively low reliability of an object.
  - *Back-up parachute*

Examples
Inventive Principles

Principle 13. Inversion/'The other way round'

- Invert the action(s) used to solve the problem (e.g.instead of cooling an object, heat it).
  - *Bring the mountain to Mohammed, instead of bringing Mohammed to the mountain.*

Principle 21. Skipping

- Conduct a process , or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.
  - *Use a high speed dentist's drill to avoid heating tissue.*

Examples
Inventive Principles

Principle 22. Convert harm into benefit / "Blessing in disguise" or "Turn Lemons into Lemonade"

- Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.
  - *Use waste heat to generate electric power.*

Principle 31. Porous materials

- Make an object porous or add porous elements (inserts, coatings, etc.).
  - *Drill holes in a structure to reduce the weight.*

Examples
Inventive Principles

Principle 33. Homogeneity

- Make objects interacting with a given object of the same material (or material with identical properties).
  - *Make a diamond cutting tool out of diamonds.*

Examples
Inventive Principles

Principle 35. Parameter changes

- Change an object's physical state (e.g. to a gas, liquid, or solid.)
  - *Change the concentration or consistency.*
    - *Liquid hand soap is concentrated and more viscous than bar soap.*
  - *Change the temperature.*
    - *Raise the temperature of food to cook it. (Changes taste, aroma, texture, chemical properties, etc.)*
    - *Lower the temperature of medical specimens to preserve them for later analysis.*

Examples
Inventive Principles

Principle 38. Strong oxidants

- Replace common air with oxygen-enriched air.
  - *Scuba diving with Nitrox or other non-air mixtures for extended endurance*

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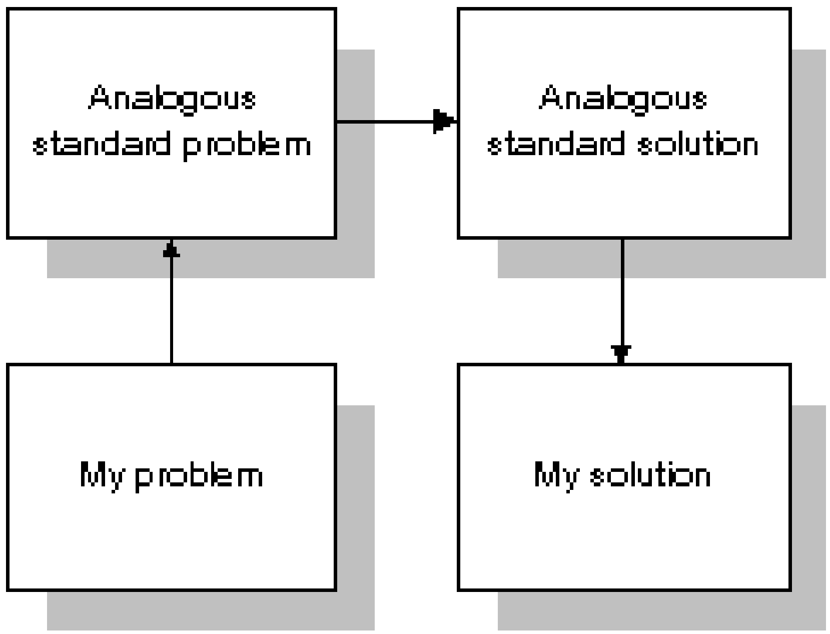
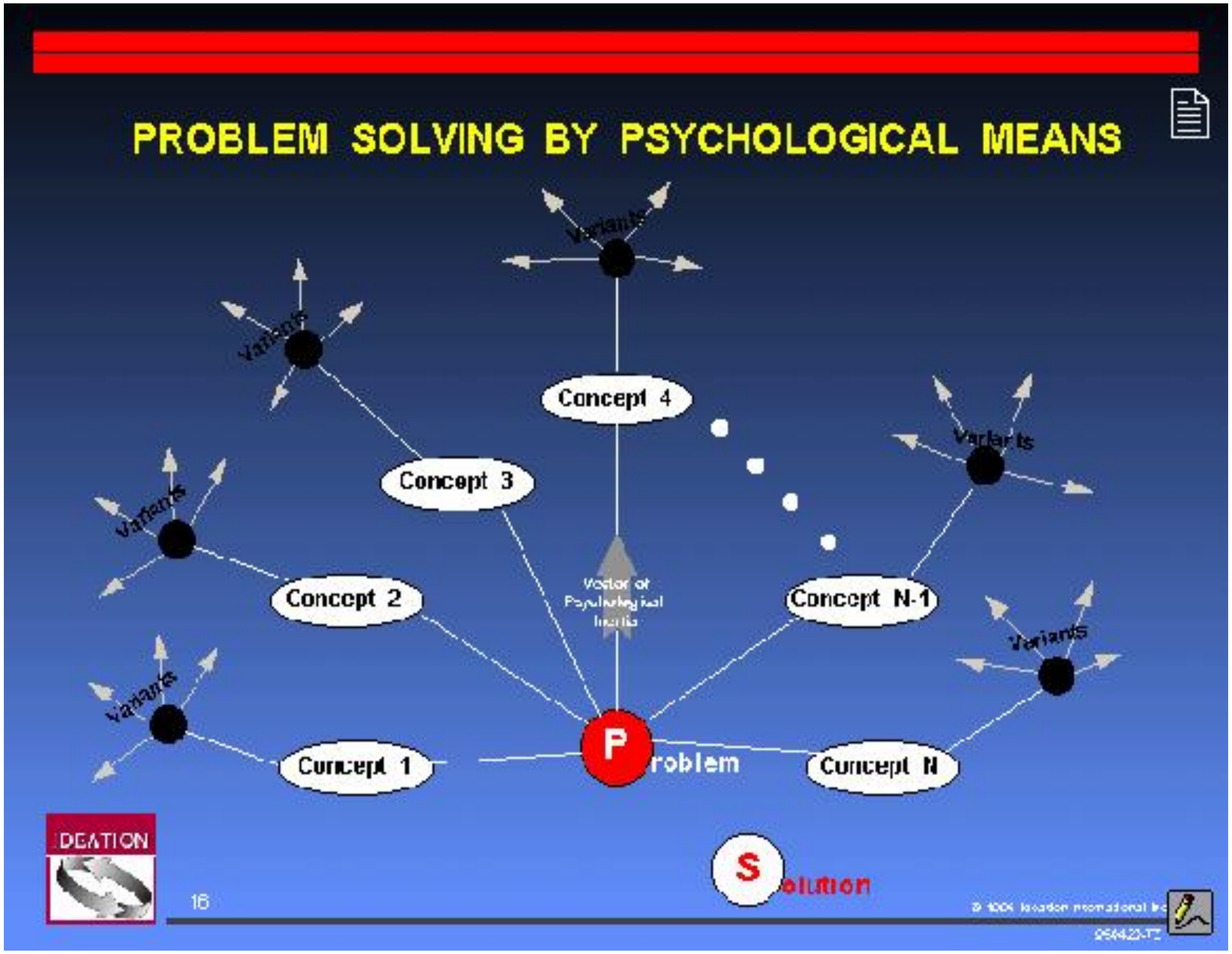
The TRIZ process step-by-step

- Identify the problem
- Formulate the problem: the Prism of TRIZ
  - Restate the problem in terms of physical contradictions.
  - Identify problems that could occur.
- Search for previously well-solved problem
- Look for *analogous* solutions and adapt to your solution.

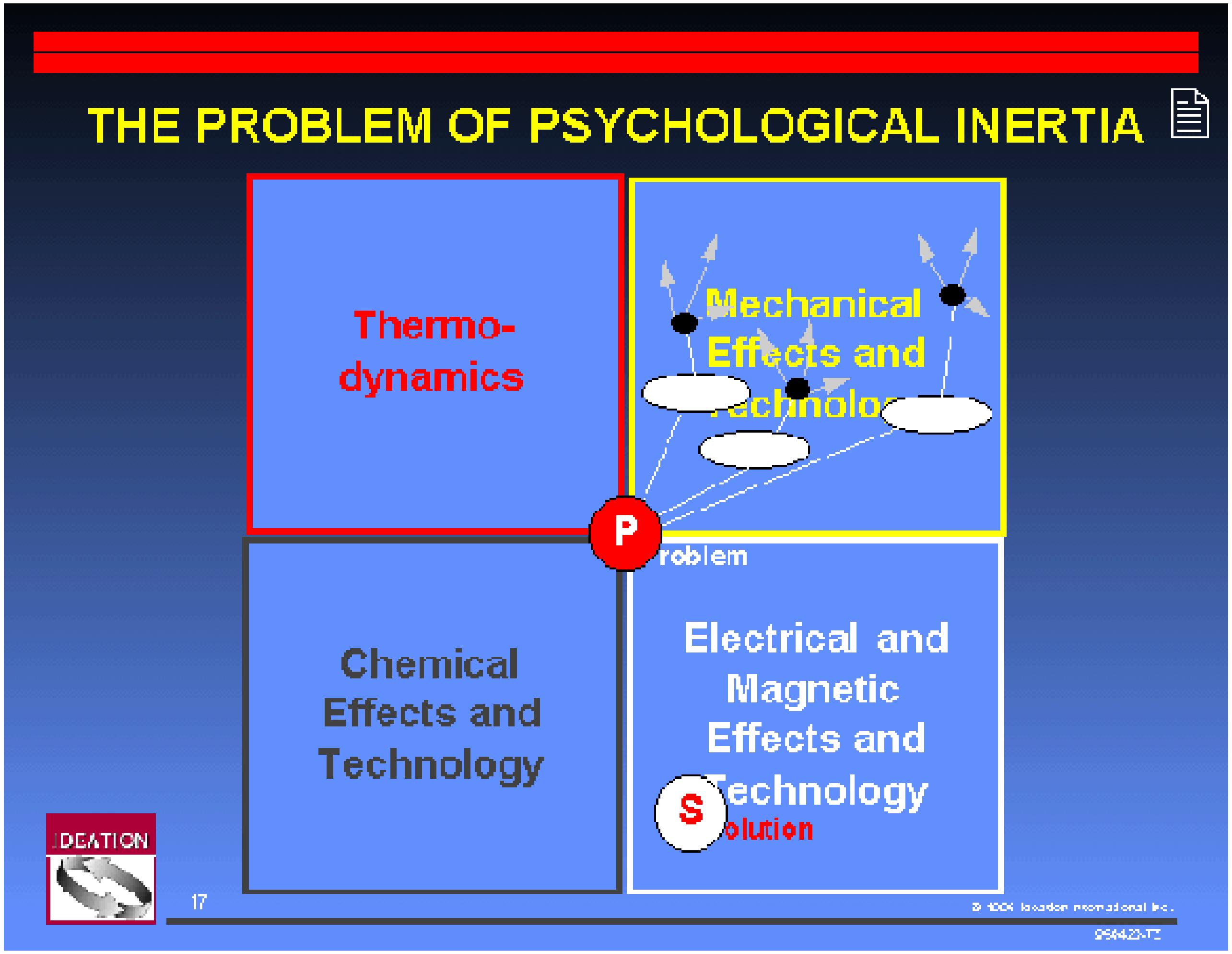
General Problem Solving Model



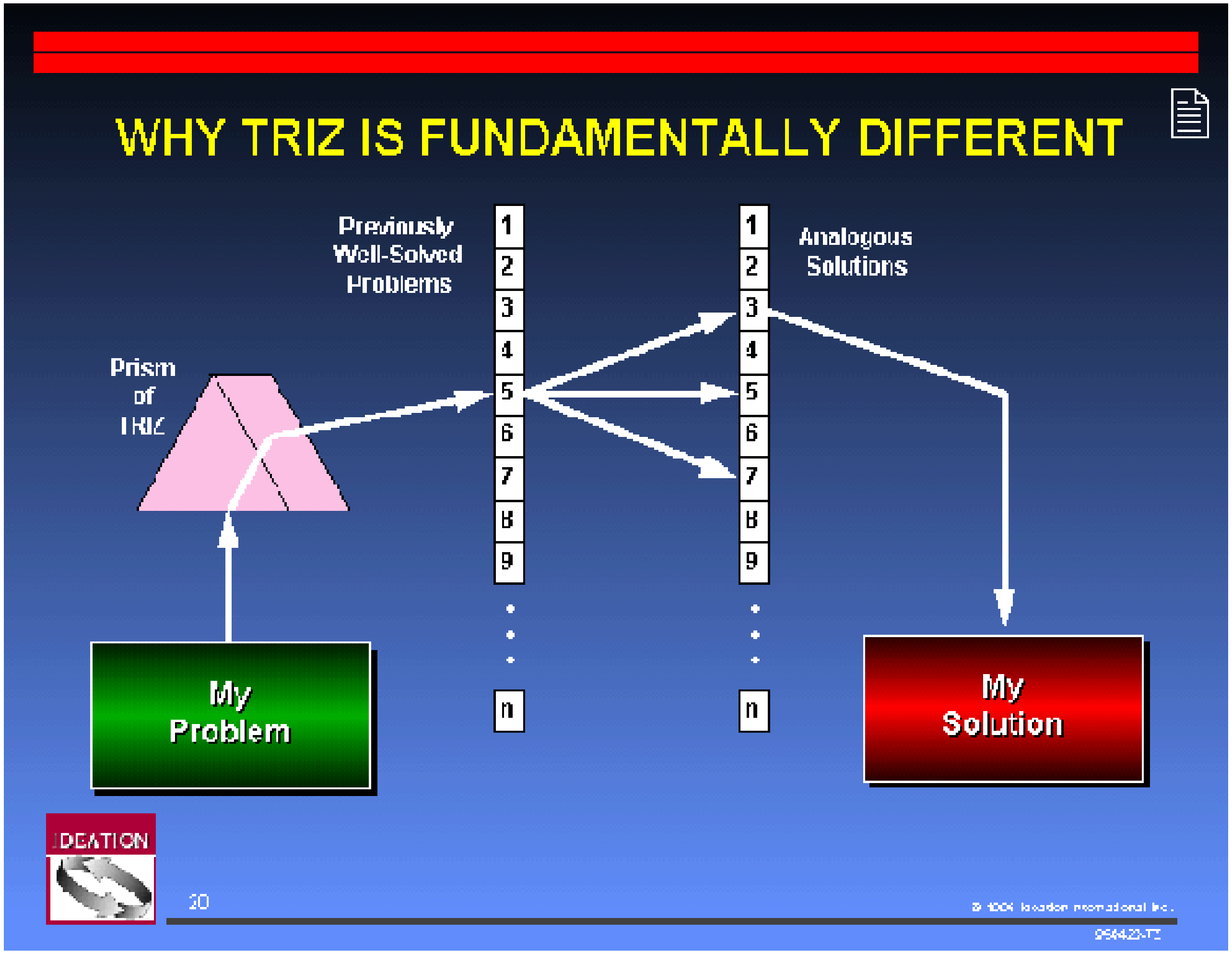
Limiting Effects of Psychological Inertia



Ideal Solution May Be Outside Your Field



TRIZ Approach to Problem Solving



TRIZ

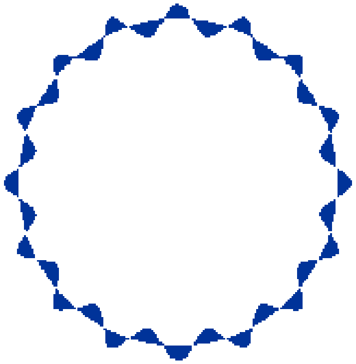
Example

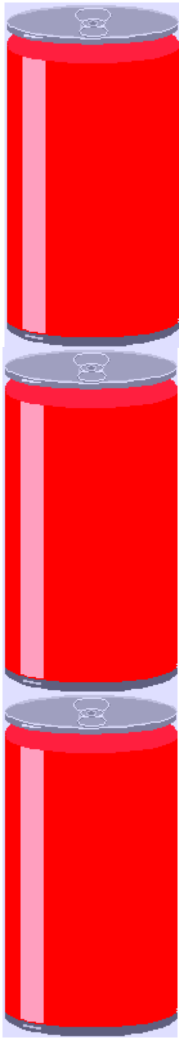
- We cannot control the height to which cans will be stacked.
- The price of raw materials compels us to lower costs.
- The can walls must be made thinner to reduce costs, but if we make the walls thinner, it cannot support as large a stacking load.
- Thus, the can wall needs to be thinner to lower material cost and thicker to support stacking-load weight.
- This is a physical contradiction. If we can solve this, we will achieve an ideal engineering system.
- The standard engineering parameter that has to be changed to make the can wall thinner is “length of a nonmoving object.”
- Here, “length” can refer to any linear dimension such as length, width, height, diameter, etc.
- If we make the can wall thinner, stacking-load weight will decrease.
- The standard engineering parameter that is in conflict is "*tension, stress*”.

TRIZ

Example

- The standard technical conflict is:
  - the more we improve the standard engineering parameter “length of a nonmoving object,”
  - the more the standard engineering parameter “stress” becomes worse.
- When we look at the Principle 1 “Segmentation”, we can separate the object into independent parts.
  - Consider the wall of the can, its surface can be changed from smooth and continuous to corrugated or wavy.
- This would increase the edge strength of the wall yet allow a thinner material to be used.





TRIZ Conclusion: Strengths

- A structured way of guiding a designer towards *systematic innovation*.
- The law of ideality encourages the designer to move towards making the system ideal.
- The concept of contradiction gives the designer focus to concentrate his ideas.
- The presence of 40 principles of Innovation gives the designer help to surpass psychological inertia.
- TRIZ is a very good method of designing solutions up to level 4.
- TRIZ is being used to supplement QFD.

Conclusion: Companies Using TRIZ

- Some companies using TRIZ:
  - Allied Signal Aerospace Sector
  - Chrysler Corp.
  - Emerson Electric
  - Ford Motor Co.
  - General Motors Corp.
  - Johnson & Johnson
  - Rockwell International
  - UNISYS
  - Xerox Corporation

Conclusion: TRIZ Software

- TRIZ Software
  - ARIZ (Algorithm for Inventive Problem Solving)
  - Improver
  - Ideator
  - Eliminator (Appetizer)
  - Innovation Workbench (IWB)

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