Theory of Inventive Problem Solving (TRIZ)

Applications of TRIZ

- Concept Generation
- Solving problems of contradictions in functional requirements.
- Ex. More Engine Power means heavy engine, but it means more Fuel consumption. Solutions: Anti weight, Porous Material, Phase Transitions and Strong Oxidants.

Introduction

- TRIZ (Teoriya Resheniya Izobreatatelskikh Zadatch) developed in Russia in late 1940's.
- 1500+ person years of research experience and successful patents around the world over studied.
- Psychological aspects of Human creativity studied.
- Dr. Genrich S Altshuller created TRIZ principles.

Inventive Problems

- Altshuller defined an inventive problem as “one in which the solution causes another problem to appear, such as increasing the strength of a metal plate causing its weight to get heavier”.
- Usually, inventors must resort to a trade-off and compromise between the features and thus do not achieve an ideal solution.
- In his study of patents, Altshuller found that many described a solution that eliminated or resolved the contradiction and required no trade-off.

Introduction

- Altshuller studied 200,000 successful patents selected 40,000 as representative of innovative solutions.
- All inventions contain at least one contradiction.
- Level of inventiveness depends on how well this contradiction is resolved.
- Outstanding inventions are often featured by complete resolution of contradictions, not merely a trade off and compromise on contradictions.

Introduction

- Outstanding innovations transform harmful elements in the system to useful resources.
- Technological innovations trends are predictable.
- Most innovations are based on very small number of inventive principles and strategies.
- Five levels of degree of inventiveness observed.

Levels of Inventiveness.

Level	Degree of inventiveness	% of solutions	Source of knowledge	Approximate # of solutions to consider
1	Apparent solution	32%	Personal knowledge	10
2	Minor improvement	45%	Knowledge within company	100
3	Major improvement	18%	Knowledge within the industry	1000
4	New concept	4%	Knowledge outside the industry	100,000
5	Discovery	1%	All that is knowable	1,000,000

What is TRIZ

- TRIZ is a combination of methods and tools and a way of thinking with ultimate goal to achieve absolute excellence in design and innovation.
- **5 Philosophical elements of TRIZ:**

1. *Ideality – Ultimate criterion for system excellence*
2. Functionality – How system works, useful & Harmful effects and costs
3. Resource – Maximum utilisation of resources
4. Contradictions – Inhibitor for increasing functionality
5. Evolution – Evolution trend of technological developments in Infancy,growth,mature and decline phases (S-shape curve)

Contradictions

- Technical contradiction: Improving one technical attribute deteriorates another technical attribute.
- Physical contradiction: Subject(on which action is taken) or Object(result of action) is to be in two mutually exclusive physical states. Ex. Wedge to be driven in ground is to be sharp for easy driving but blunt to hold firmly.
- Problems with Technical contradictions can be resolved by either trade off or over coming the contradiction.

Contradictions

- Trade-off or compromise solution do not eliminate the contradiction but rather softens them, thus retaining harmful effect or shortcoming of the system.
- Typical contradictions observed after study of 40,000 innovations, despite immense diversity of innovative problems, are 1250.
- These contradictions are expressed as a table of 39 Design parameters.

DESIGN 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

DESIGN PARAMETERS

- 11. Tension, pressure
- 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

DESIGN PARAMETERS

- 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

DESIGN PARAMETERS

- 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

Resolution/Separation Principles

- Primarily contradictions look like Technical contradictions. But after digging deeper one can observe the underlying physical contradictions.
- Useful and Harmful effects existence.
- Physical contradictions relate to space/ position or time.
- Four approaches for resolution: 1)Separation in space, 2)Separation in time, 3)Separation between components and 4) separation between set of components.

Resolution/Separation Principles

- 39 Contradictions are expressed in a matrix of 39*39 Design parameters.
- 40 Principles of resolution of these contradiction prepared by Altshuller.
- Sub principles for the main principles are given in some cases.
- Total 86 sub principles are given.

40 Inventive Principles

- 1. Segmentation
- 2. Extraction
- 3. Local Quality
- 4. Asymmetry
- 5. Combining
- 6. Universality
- 7. Nesting
- 8. Counterweight
- 9. Prior counter-action
- 10. Prior action

40 Inventive Principles

- 11. Cushion in advance
- 12. Equipotentiality
- 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 a useful action

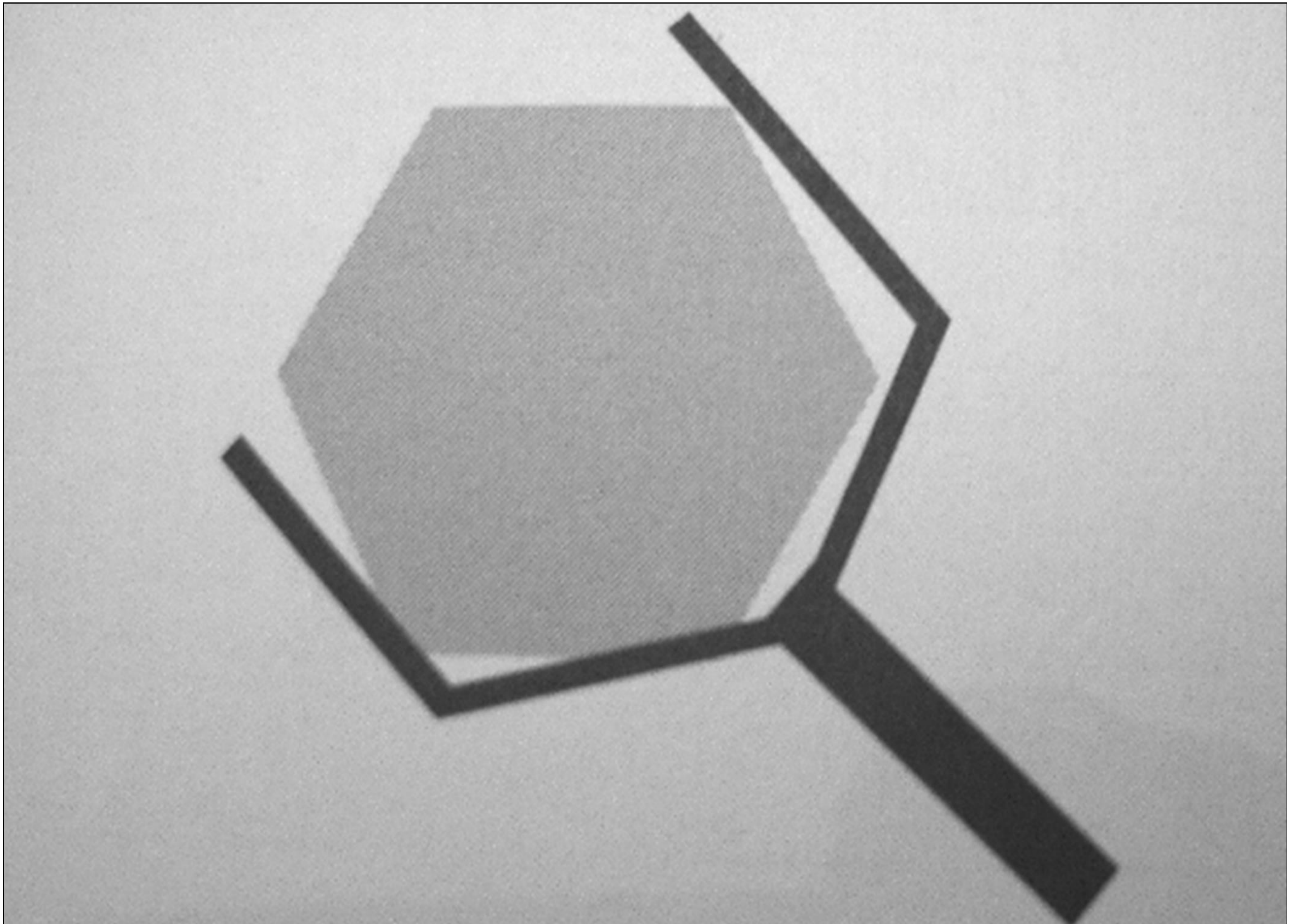
40 Inventive Principles

- 21. Rushing through
- 22. Convert harm into benefit
- 23. Feedback
- 24. Mediator
- 25. Self-service
- 26. Copying
- 27. Inexpensive, short-lived object for expensive, durable one
- 28. Replacement of a mechanical system
- 29. Pneumatic or hydraulic construction
- 30. Flexible membranes or thin film

40 Inventive Principles

- 31. Use of porous material
- 32. Changing the color
- 33. Homogeneity
- 34. Rejecting and regenerating parts
- 35. Transformation of the physical and chemical states of an object
- 36. Phase transformation
- 37. Thermal expansion
- 38. Use strong oxidizers
- 39. Inert environment
- 40. Composite materials

What should be improved? / What is deteriorated ?	14. Strength	15. Duration of moving object's operation	16. Duration of fixed object's operation	17. Temperature	18. Illumination	19. Energy expense of movable object	20. Energy expense of fixed object	21. Power	22. Waste of energy	23. Loss of substance	24. Loss of information
1. Weight of movable object	28 27 18 40	5 34 31 35		6 29 4 38	19 1 32	25 12 34 31		13 36 18 31	6 2 34 19	5 35 3 31	10 24 35
2. Weight of fixed object	28 2 10 27		2 27 19 6	28 19 32 22	35 19 35		18 19 28 1	15 19 18 22	18 19 28 15	5 8 13 30	10 15 35
3. Length of movable object	8 35 29 34	19		10 15 19	32	8 35 24		1 35	7 2 35 39	4 29 23 10	1 24
4. Length of fixed object	15 14 28 26		1 40 35	3 35 38 18	3 25			12 8	6 28	10 28 24 35	24 26
5. Area of movable object	3 15 40 14	6 3		2 15 16	15 32 19 13	19 32		19 10 32 18	15 17 30 26	10 35 2 39	30 26
6. Area of fixed object	40		2 10 19 30	35 39 38				17 32	17 7 30	10 14 18 39	30 16
7. Volume of movable object	9 14	6 35		34 39	10 13	35		35 6	7 15 13 16	36 39 34 10	2 22

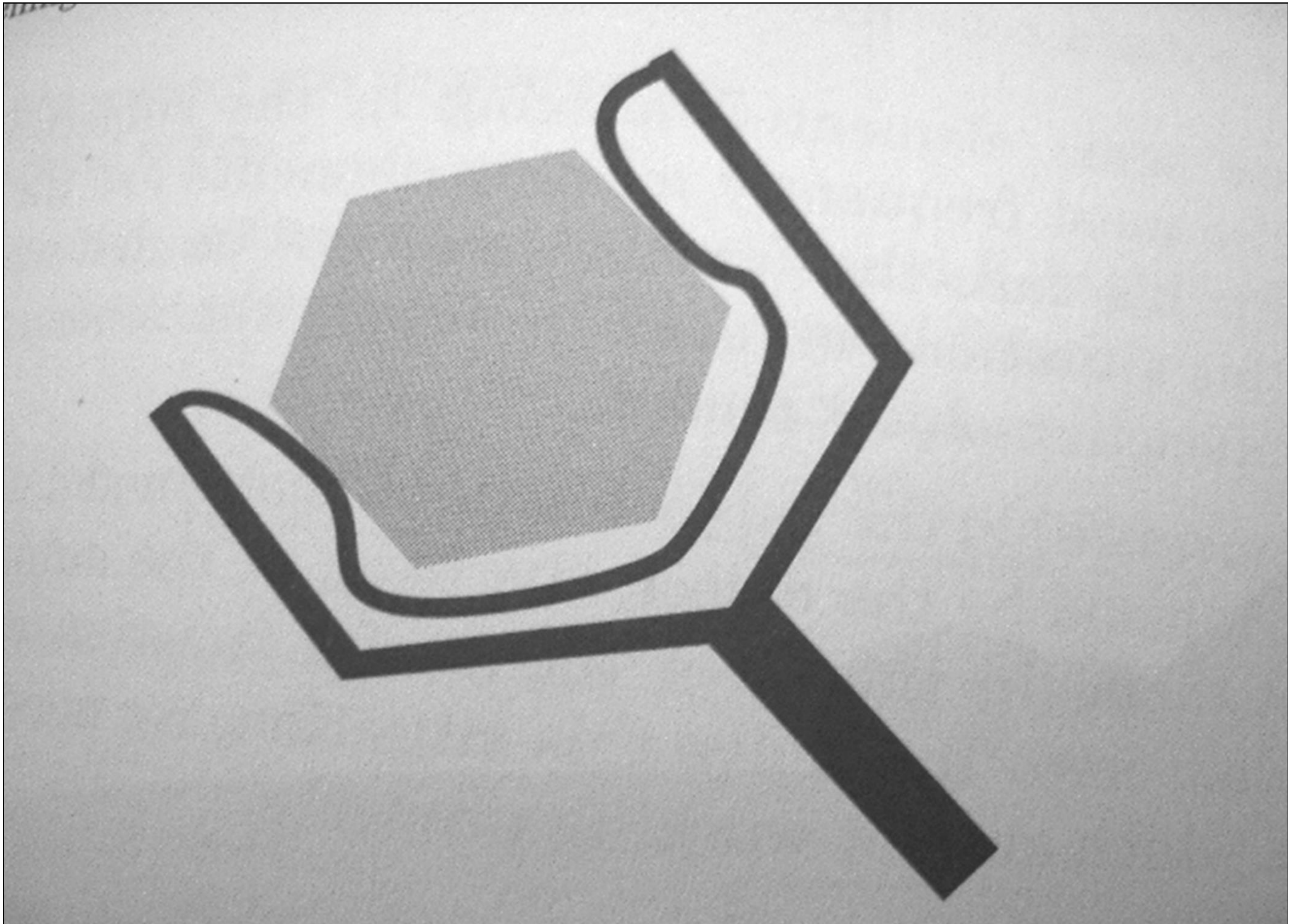


EXAMPLE

- Problem: Corners of the nut wear out quickly as there is concentrated load.
- Possible solution: Reduce clearance between wrench and nut. But it will cause difficulty to fit in.
- Contradiction: Improve reliability(27) reduces ease of operation(33)
- TRIZ solutions: 17, 27 & 40.

EXAMPLE

- 17 (Another Dimension)- a) Move an object in two-or-three dimensional space, b) use a multistory arrangement of objects, c) Tilt or reorient the object and d) Use another side of given area.
- 27 (Cheap short-living)- Replace expensive object with inexpensive object.
- 40 (Composite material) – Change from uniform to composite material



EXAMPLE

- TRIZ solution :
- Working surface of the wrench redesigned applying principle 17.
- Using 27 & 40 TRIZ principles Soft metal or plastic pads are put on the wrench while working on surfaces of expensive nuts.