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The 40 TRIZ Principles

Inventive problems!!! – Apply the 40 TRIZ principles

Invention is perceived as going hammer and tongs on your brain! Something that requires you to be an Albert Einstein or Alexander Graham Bell! The general opinion is that invention is thanks to a sudden idea/event i.e. brainstorming. It took an apple, falling down from a tree, to convince Sir Isaac Newton to think on gravity. Most researchers believe that it is often stray thoughts that facilitate invention. Or is it? Sir Genrich Saulovich Altshuller certainly does not agree that invention is a product of brainstorming.

Genrich Altshuller was the man who developed the popular concept of TRIZ (Theory of inventive problem solving).

TRIZ the buzz word!

According to TRIZ, any inventive problem can be solved by a systematic approach!

TRIZ is a creative problem solving technique that relies on the following to achieve creative solutions:

- Understand the problem as a system
- Devise an ideal solution first
- Solve contradictions

Prior to TRIZ, it was believed that inventions resulted from an accidental finding or a sudden idea. Traditionally, inventive methodology was more trial and error and had no precise function or theory to support it. TRIZ provided inventors a theory that could solve problems efficiently if used precisely.

To conceptualize TRIZ, Genrich Altshuller analyzed over 20,000 patents. This detailed study helped him devise solutions to various inventive problems. First the problem is classified based on its nature and then a corresponding theory or TRIZ principle is applied to it.

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

Altshuller developed 40 TRIZ principles. He believed they would help solve any inventive problem.

Thumb rule – The 40 TRIZ principles are based on Genrich Altshuller’s observation of 20,000 patents. While applying them however, the basis of the problem should be first identified.

1. Segmentation

This principle looks to divide or classify a system’s subparts into simpler independent systems. These systems can be joined together to solve the problem.

For instance, one can develop a system of any length by joining systems of smaller length. With systems that measure 2, 3, 4 and 5 units, one can develop systems with the range of minimum 2 to maximum 14 (2+3+4+5). Segmentation is the best way to build complex structures using simple systems.

2. Extraction

This principle looks at distributing/disturbing or altering the shape, size weight or composition of a system. Simply put it is all about *take some from here and throw some there*. Often by removing an unnecessary part/subsystem one can improve system performance.

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For instance, if a plane can take off due to too much self weight then use lighter metal like aluminum to manufacture the aircraft structure/fuselage.

3. Local Quality

This principle looks to combine two attributes into a single system. In technical language, the same can be written as - Transition from a homogeneous structure to a heterogeneous structure.

It is basically about infusing different characteristics into a single element.

1. For instance, a pencil with an eraser can used both to perform writing and erasing.
2. A classical example is the use of fine mist of water to reduce dust in coal/gold mines. Droplets of water can reduce visibility. The trick it is to reduce the size of water droplets. Fine sprays can be used to achieve this objective. The idea is to optimize the efficiency of the system (namely, fine mist of water), without encouraging its negative attribute i.e. reduced visibility.

4. Asymmetry

Asymmetry helps to break the norms of conventional systematic/geometric arranging, with asymmetry.

While manufacturing boats/ships, it would be better to build the lower half (hull) stronger so it can withstand ocean waves than uniformly build the ship to strength. In short, make one side of the ship stronger to withstand impact.

To quote another example, when wet sand discharges through a symmetrical funnel; it forms an arch above the opening, blocking the flow. An asymmetrical shaped funnel can be used to eliminate the arching effect.

5. Combining

Instead of using two separate systems to perform continuous operations, join/combine them.

For instance, take a rotary drilling machine. In order to drill efficiently, the ground has to be first softened. Only then will the drilling be easy and efficient. Modern drillers, use special steam nozzles to soften the frozen ground.

6. Universality

Versatile systems are preferred to systems that perform one task at a time. They eliminate the need for multiple systems.

For instance, a chair, converts into a sofa, a mobile phone plays the radio, a foldable seat on a car can be expanded or folded depending on the cargo. Typical examples are those 5-in-1 music systems that play tape, audio CD, Video CD, Mp3 CDs and the radio.

7. Nesting

This principle deals with hiding one object in another. This principle primarily helps to save space in constrained environments.

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For instance, lead pins stacked inside a pencil.

8. Counterweight

The counterweight principle is used to equate the effects of weight. In simple words, counterweight is generally used to compensate the self-weight of an object.

For instance, the use of counterweights in lifts.



Its use in The City Corp Center is a classic example of counterweight. It stands 59 stories tall and often experiences fierce winds. The tower top Tuned Mass Damper -- in effect, a 360 metric ton, 9 times 9-metre concrete block on an oiled plate moved by computers -- that lessens with its inertia the sway caused by strong winds to about half.

9. Prior counter-action

Perform a counter action to an action. For instance if the object is under tension then infuse anti-tension.

For instance re-enforcement of concrete columns and beams.

10. Prior action

Execute few operations so that it is easier to do succeeding work. In short, arrange objects to go into action in a timely matter and from a convenient position. Keep everything ready so that the main task is initiated without any delay.

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For instance, a groove on the knife blade that facilitates sharpening when the blade is blunt.

11. Cushion in advance

Improve system/object reliability through backups that prevent system failure.

For instance, magnetize merchandise and set up security systems that prevent shoplifting or burglary.

12. Equipotentiality

Often we find organizations trying to purchase new equipment to improve working conditions. A cost economical way of solving the problem is to change the working atmosphere so that new equipments are not required.

For instance, creating a pit in the garage so that workers can work from the pit and repair the car instead of using elevating equipment to lift the car.

13. Inversion

Genrich Saulovich found that inversion of environment/object was an effective way to solve inventive problems.

For instance, reverse the working of an existing system. Make it do the opposite. Make the moving part the non-moving part and the non-moving part the moving part, turn the system up-side down and so on.

Assume circular impressions are to be made on an object. The traditionally the tool is fixed and then the work object moved in the circular. What if the working object is too heavy? To solve such problems it is better to move the tool than the working object. This arrangement depends on the weight and size of both the working object and the tool. The idea is to change the working so as to execute the desired task easily.

14. Spheroidality

This principle recommends the replacement of flat surfaces with curved shapes. In mathematical terms replace cubical shapes with spherical shapes. Pens for instance, require ink to flow through their tips. This demands a smooth rotary motion and hence the pen rollers at the tip. This helps impart rotary motion on the system, which in turn can be used to improve system performance.

The best example is the computer mouse ball that performs numerous functions at different angles thanks to its ability to do both linear rotary motions.

15. Dynamicity

The object/system should automatically adjust to the changes in working environment thereby keep performance optimum at all times. Or create a system such that all the subsystems adjust their positions relative to one another. They can thus accommodate any changes in the working environment. So if an object is fixed make it movable and interchangeable.

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For instance, take a 10 liter rigid structured cylindrical that stands 10 meters tall. When filled only to half its capacity, 5 liters, the cylinder is still 10 meters. In short, at all times the cylinder needs 10 meters of vacant space during transportation. To avoid such problems make the cylinder body flexible so that it adjusts its size depending on the load. This offers better transportation and flexibility.

16. Partial or overdone action

Some times it is difficult to achieve the 100% desired effect.

For instance it is not possible to paint through all parts of a complex shaped object. The best way is to dip the object in paint and then remove the excess paint by rotating the object.

17. Moving to a new dimension

Consider a three-dimensional plane with axes X, Y and Z. The idea is to move an object/system along the X-axis. If this action interferes with another system then try moving it along the Y or the Z-axis. The principle also recommends the use of multi-layered assembly of objects if a single layered assembly fails to deliver.

For instance, consider a lighthouse. In order to improve the lightning on the northern part of the lighthouse, install a reflector on the eastern side where the sun rises.

18. Mechanical vibration

While analyzing the 20,000 patents Genrich Althsuller discovered that by altering mechanical vibration levels, many problems were solved. Mechanical vibration is a very critical attribute of any technical system. It affects system performance significantly.

Typical issues associated with mechanical vibration are oscillating a system and increasing the frequency of vibration to extract better performance,

Shake a casting mould to improve material flow, improve casting mixture quality and reduce the cracks in the casting.

19. Periodic action

Make the action/event periodic. Reduce the frequency of vibration. In simpler words, replace a continuous action with a periodic one.

For instance – consider a flash or a warning light! As it flashes periodically it is more eye-catching/visible than the conventional continuously lit lamp.

20. Continuity of a useful action

This principle recommends the going hammer and tongs at an activity. In short, all systems involved in an operation should be working simultaneously at full capacity. Thereby they can eliminate stoppages.

For instance consider a drill. It works best when it rotates at a very high speed in a short time, no stoppages!

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21. Rushing through

Execute dangerous operations at very high speed. The idea is reduce the time involved in performing hazardous operations.

For instance cutters used for cutting thin plastic pipes operate at very high speeds so they cut the pipes even before it deforms.

22. Convert harm into benefit

Use negative effects of a system to generate a positive effect. Or combine two negative effects to generate a positive effect. Or increase the negative effect so much that it is no longer harmful.

For instance, when metals are subjected to high frequency current, the top layer becomes hot. This was an accidental discovery. Today it is used for surface heat-treating of metals.

23. Feedback

Systems must have a feedback. It helps in understand the performance related factors.

For instance, water pressure in a well can be measured by monitoring the output pressure. This can in turn be used to shut the pump if the pressure is too high or operate the pump if the pressure is too low.

24. Mediator

This principle recommends the use of a mediator to dilute a crisis or carry out an action.

For instance while heating liquid metal, enormous heat loss occurs. To avoid this, cooled electrodes with another liquid metal (low melting point) are used. This absorbs the heat loss and transfers it on to the liquid metal that is being heated.

25. Self-service

Make objects/systems intelligent. Simply put they should operate on their own.

For instance, bearings and rollers require lubrication to reduce friction from rotary motion. In other words bearings may seize without lubrication. Thus maintaining lubrication is necessary. Ideally this can be avoided by manufacturing bearings with metals/alloys that generate minimum friction. So there is no need for lubrication.

26. Copying

This principle is about duplicating, like taking a photo copy instead of writing/creating the document all over again.

For instance, instead of tediously measuring the height of a building or a tall object it is better to measure the length of its shadow.

27. Inexpensive, short-lived object for expensive, durable one

Instead of investing on long term, highly reliable objects, use short term, fairly durable and inexpensive objects.

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28. Replacement of a mechanical system

Replace mechanical systems with electronic/electromagnetic, acoustic, optical or olfactory (smell-based) systems.

For instance - Audiocassettes are magnetic tapes wound around cylindrical plastic reels. In an audio system the tap is mechanically run over the magnetic tape head. The magnetic tape head reads the sound waves. However, the new generation is a world of CDs. The CD technology reduces the use of mechanical devices. In here, the laser lens technology is used to generate the sound wave. This reduces mechanical rotation of devices. Simply put, with technological progresses eliminating mechanical devices from systems.

29. Pneumatic or hydraulic construction

In the past, mechanical devices were used to impart motion or force on a system. Gradually, fluid/hydraulic or gas systems have replaced these devices. These systems use air/some form of gas or liquid to inflate/push systems.

For instance, in the past, airplanes used mechanical levers to control ailerons and wing flaps. The airline industry soon realized that these mechanically controlled levers were prone to failure. Hence they substituted them with hydraulic or gas transmissions systems.

30. Flexible membranes or thin film

Replace conventional rigid systems with flexible systems (Membranes/thin film).

Earlier easy chairs were made with rigid wooden sheets that were joined together. Today these sheets have been replaced with thin membranes/plastic films. They serve two purposes; they eliminate the unnecessary joints and enhance seating comfort.

31. Use of porous material

Some objects have pores (due to their natural structure). Fill these pores with elements that improve system performance.

For instance, instead of using coolants for the entire machine, some parts of a machine are filled with porous material dipped in the coolant. The coolant evaporates when the machine is working and so it eliminates the need to pump the coolant frequently.

32. Changing the color

Visibility and color are interrelated. The white color has the highest visibility and is best visible in the dark due to its high reflective index. Thus to improve visibility, the color needs to be changed or a luminescent traces added to the color.

Suppose, a system is operating in the sun/outdoors, surface heat is a critical issue. Color the system white or install a white plastic curtain surrounding the system to protect it from the sun.

33. Homogeneity

Allow homogenous objects to interact with one another. Simply put - facilitate interaction between objects that have the same functional behavior.

For instance a diamond is used to cut another diamond.

34. Rejecting and regenerating parts

Systems deteriorate with time. Once the subpart of a system has completed its life cycle reject, modify or dissolve it. Simply put - restore old parts with new parts.

For instance, bullet casings are separated once the bullet is fired similarly rocket boosters are separated from the launch vehicle once their purpose is served.

35. Transformation of the physical and chemical states of an object

Alter the physical and the chemical/molecular state of an object to sustain/improve performance.

Consider a drill. Over a period of time the drill bore loses its molecular structure and thins up due to mechanical friction. Reinforce it with a new casting or change the drill bore.

36. Phase transformation

Create an effect during the physical transition of a substance to improve system reliability and ease the transition process.

For example, in a hot climate, objects that are sensitive to heat expand especially during transportation. This can reduce the molecular structural strength. To avoid this, the objects can be filled with water and cooled to a freezing temperature.

37. Thermal expansion

Manufacture objects with materials that expand/contract when subjected to heat. This reduces the need for application of physical force to achieve the same.

For instance, a bimetallic strip is used to control air conditioning temperature. If the temperature reaches the desired level then the bimetallic strip contracts thus breaking the circuit. Similarly, when the temperature changes the bimetallic strip again expands thus forming the circuit, turning on the air conditioning.

38. Use strong oxidizers

Normal/atmospheric air has low oxygen content. Replace it with enriched air if required.

For instance, to increase thermal radiation from a torch, use enriched air. It has a higher percentage of oxygen and thus increases the flame temperature.

39. Inert environment

Use inert air/environments to reduce the chance of fire.



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For instance, cotton is treated with an inert gas to make it fire retardant, especially during transportation.

40. Composite materials

If substantial increase in strength is desired then use composite materials.

For instance, composite plastics and carbon fibers are used to increase the strength of aircraft structures that experience maximum force, like the wings, the nose cone and the belly.

Conclusion

Thanks to TRIZ many comprehensive techniques (such as Functional Diagramming, Su-Field Analysis, ARIZ, Patterns of Evolution, and Anticipatory Failure Determination™) have been developed to solve inventive problems. The 40 principles help analyze and solve inventive problems. Therefore to improve strength of the system/object use the 40th principle.

TRIZ has great potential in solving industrial problems as it focuses on eliminating issues hindering system performance. Efficient application of TRIZ will help increase savings and productivity. Moreover, it ensures the effective utilization of resources and above all reduction in technical problems/contradictions.