

The 40 Inventive Principles.

1. Segmentation

- a. Divide an object into independent parts
- b. Make an object sectional
- c. Increase the degree of an object's segmentation

Examples:

- Sectional furniture, modular computer components, folding wooden ruler
- Garden hoses can be joined together to form any length needed

2. Extraction

- a. Extract (remove or separate) a "disturbing" part or property from an object, or
- b. Extract only the necessary part or property

Example:

- To frighten birds away from the airport, use a tape recorder to reproduce the sound known to excite birds. (The sound is thus separated from the birds.)

3. Local Quality

- a. Transition from a homogeneous structure of an object or outside environment/action to a heterogeneous structure
- b. Have different parts of the object carry out different functions
- c. Place each part of the object under conditions most favorable for its operation

Examples:

- To combat dust in coal mines, a fine mist of water in a conical form is applied to working parts of the drilling and loading machinery. The smaller the droplets, the greater the effect in combating dust, but fine mist hinders the work. The solution is to develop a layer of coarse mist around the cone of fine mist.
- A pencil and eraser in one unit.

4. Asymmetry

- a. Replace a symmetrical form with an asymmetrical form.
- b. If an object is already asymmetrical, increase the degree of asymmetry

Examples:

- Make one side of a tire stronger than the other to withstand impact with the curb
- While discharging wet sand through a symmetrical funnel, the sand forms an arch above the opening, causing irregular flow. A funnel of asymmetrical shape eliminates the arching effect. [add picture here]

5. Combining

- a. Combine in space homogeneous objects or objects destined for contiguous operations
- b. Combine in time homogeneous or contiguous operations

Example:

- The working element of a rotary excavator has special steam nozzles to defrost and soften the frozen ground

6. Universality

Have the object perform multiple functions, thereby eliminating the need for some other object(s)

Examples:

- Sofa which converts into a bed
- Minivan seat which adjusts to accommodate seating, sleeping or carrying cargo

7. Nesting

- a. Contain the object inside another which, in turn, is placed inside a third object
- b. Pass an object through a cavity of another object

Examples:

- Telescoping antenna
- Chairs which stack on top of each other for storage
- Mechanical pencil with lead stored inside

8. Counterweight

- a. Compensate for the object's weight by joining with another object that has a lifting force
- b. Compensate for the weight of an object by interaction with an environment providing aerodynamic or hydrodynamic forces

Examples:

- Boat with hydrofoils
- A rear wing in racing cars which increases pressure from the car to the ground

9. Prior counter-action

- a. Perform a counter-action in advance
- b. If the object is (or will be) under tension, provide anti-tension in advance

Examples:

- Reinforced concrete column or floor
- Reinforced shaft made from several pipes which have been previously twisted to some specified angle

10. Prior action

- a. Carry out all or part of the required action in advance
- b. Arrange objects so they can go into action in a timely matter and from a convenient position

Examples:

- Utility knife blade made with a groove allowing the dull part of the blade to be broken off, restoring sharpness
- Rubber cement in a bottle is difficult to apply neatly and uniformly. Instead, it is formed into a tape so that the proper amount can be more easily applied.

11. Cushion in advance

Compensate for the relatively low reliability of an object by countermeasures taken in advance

Example:

- Merchandise is magnetized to deter shoplifting.

12. Equipotentiality

Change the working conditions so that an object need not be raised or lowered.

Example:

- Automobile engine oil is changed by workers in a pit to avoid using expensive lifting equipment

13. Inversion

- a. Instead of an action dictated by the specifications of the problem, implement an opposite action
- b. Make a moving part of the object or the outside environment immovable and the non-moving part movable
- c. Turn the object upside-down

Example:

- Abrasively cleaning parts by vibrating the parts instead of the abrasive

14. Spheroidality

- a. Replace linear parts or flat surfaces with curved ones; replace cubical shapes with spherical shapes
- b. Use rollers, balls spirals
- c. Replace a linear motion with rotating movement; utilize a centrifugal force

Example:

- Computer mouse utilized ball construction to transfer linear two-axis motion into vector motion

15. Dynamicity

- a. Make an object or its environment automatically adjust for optimal performance at each stage of operation
- b. Divide an object into elements which can change position relative to each other
- c. If an object is immovable, make it movable or interchangeable

Examples:

- A flashlight with a flexible gooseneck between the body and the lamp head
- A transport vessel with a cylindrical-shaped body. To reduce the draft of a vessel under full load, the body is comprised of two hinged, half-cylindrical parts which can be opened.

16. Partial or overdone action

If it is difficult to obtain 100% of a desired effect, achieve somewhat more or less to greatly simplify the problem

Examples:

- A cylinder is painted by dipping into paint, but contains more paint than desired. Excess paint is then removed by rapidly rotating the cylinder.
- To obtain uniform discharge of a metallic powder from a bin, the hopper has a special internal funnel which is continually overfilled to provide nearly constant pressure.

17. Moving to a new dimension

- a. Remove problems with moving an object in a line by two-dimensional movement (i.e. along a plane)
- b. Use a multi-layered assembly of objects instead of a single layer
- c. Incline the object or turn it on its side

Example:

- A greenhouse which has a concave reflector on the northern part of the house to improve illumination of that part of the house by reflecting sunlight during the day.

18. Mechanical vibration

- a. Set an object into oscillation
- b. If oscillation exists, increase its frequency, even as far as ultrasonic
- c. Use the resonant frequency
- d. Instead of mechanical vibrations, use piezovibrators
- e. Use ultrasonic vibrations in conjunction with an electromagnetic field

Examples:

- To remove a cast from the body without injuring the skin, a conventional hand saw was replaced with a vibrating knife
- Vibrate a casting mold while it is being filled to improve flow and structural properties

19. Periodic action

- a. Replace a continuous action with a periodic (pulsed) one
- b. If an action is already periodic, change its frequency
- c. Use pulsed between impulses to provide additional action

Examples:

- An impact wrench loosens corroded nuts using impulses rather than continuous force
- A warning lamp flashes so that it is even more noticeable than when continuously lit

20. Continuity of a useful action

- a. Carry out an action continuously (i.e. without pauses), where all parts of an object operate at full capacity
- b. Remove idle and intermediate motions

Example:

- A drill with cutting edges which permit cutting in forward and reverse directions

21. Rushing through

Perform harmful or hazardous operations at very high speed

Example:

- A cutter for thin-walled plastic tubes prevents tube deformation during cutting by running at a very high speed (i.e. cuts before the tube has a chance to deform)

22. Convert harm into benefit

- a. Utilize harmful factors or environmental effects to obtain a positive effect
- b. Remove a harmful factor by combining it with another harmful factor
- c. Increase the amount of harmful action until it ceases to be harmful

Examples:

- Sand or gravel freezes solid when transported through cold climates. Over-freezing (using liquid nitrogen) makes the ice brittle, permitting pouring.
- When using high frequency current to heat metal, only the outer layer became hot. This negative effect was later used for surface heat-treating.

23. Feedback

- a. Introduce feedback
- b. If feedback already exists, reverse it

Examples:

- Water pressure from a well is maintained by sensing output pressure and turning on a pump if pressure is too low
- Ice and water are measured separately but must combine to total a specific weight. Because ice is difficult to dispense precisely, it is measured first. The weight is then fed to the water control device, which precisely dispenses the needed amount.

24. Mediator

- Use an intermediary object to transfer or carry out an action
- Temporarily connect an object to another one that is easy to remove

Example:

- To reduce energy loss when applying current to a liquid metal, cooled electrodes and intermediate liquid metal with a lower melting temperature are used.

25. Self-service

- Make the object service itself and carry out supplementary and repair operations
- Make use of wasted material and energy

Examples:

- To prevent wear in a feeder which distributes an abrasive material, its surface is made from the abrasive material
- In an electric welding gun, the rod is advanced by a special device. To simplify the system, the rod is advanced by a solenoid controlled by the welding current.

26. Copying

- Use a simple and inexpensive copy instead of an object which is complex, expensive, fragile or inconvenient to operate.
- Replace an object by its optical copy or image. A scale can be used to reduce or enlarge the image.
- If visible optical copies are used, replace them with infrared or ultraviolet copies

Example:

- The height of tall objects can be determined by measuring their shadows.

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

Replace an expensive object by a collection of inexpensive ones, forgoing properties (e.g. longevity)

Examples:

- Disposable diapers

28. Replacement of a mechanical system

- Replace a mechanical system by an optical, acoustical or olfactory (odor) system

b. Use an electrical, magnetic or electromagnetic field for interaction with the object

c. Replace fields

1. Stationary fields with moving fields

2. Fixed fields with those which change in time

3. Random fields with structured fields

d. Use a field in conjunction with ferromagnetic particles

Example:

- To increase the bond between metal coating and a thermoplastic material, the process is carried out inside an electromagnetic field which applies force to the metal

29. Pneumatic or hydraulic construction

Replace solid parts of an object by gas or liquid. These parts can use air or water for inflation, or use air or hydrostatic cushions

Examples:

- To increase the draft of an industrial chimney, a spiral pipe with nozzles was installed. When air flows through the nozzles, it creates an air-like wall, reducing drag.
- For shipping fragile products, air bubble envelopes or foam-like materials are used.

30. Flexible membranes or thin film

a. Replace traditional constructions with those made from flexible membranes or thin film

b. Isolate an object from its environment using flexible membranes or thin film

Example:

- To prevent water evaporation from plant leaves, polyethylene spray was applied. After a while, the polyethylene hardened and plant growth improved, because polyethylene film passes oxygen better than water vapor.

31. Use of porous material

a. Make an object porous or add porous elements (inserts, covers, etc.)

b. If an object is already porous, fill the pores in advance with some substance

Example:

- To avoid pumping coolant to a machine, some of its parts are filled with a porous material soaked in coolant liquid. The coolant evaporates when the machine is working, providing short-term uniform cooling.

32. Changing the color

a. Change the color of an object or its surroundings

- b. Change the degree of translucency of an object or processes which are difficult to see
- c. Use colored additives to observe objects or processes which are difficult to see
- d. If such additives are already used, employ luminescent traces or tracer elements

Examples:

- A transparent bandage enabling a wound to be inspected without removing the dressing
- A water curtain used to protect steel mill workers from overheating blocked infrared rays but not the bright light from the melted steel. A coloring was added to the water to create a filter effect while preserving the transparency of the water.

33. Homogeneity

Make those objects which interact with a primary object out of the same material or material that is close to it in behavior.

Example:

- The surface of a feeder for abrasive grain is made of the same material that runs through the feeder, allowing a continuous restoration of the surface.

34. Rejecting and regenerating parts

- a. After it has completed its function or become useless, reject or modify (e.g. discard, dissolve, evaporate) an element of an object
- b. Immediately restore any part of an object which is exhausted or depleted

Examples:

- Bullet casings are ejected after the gun fires
- Rocket boosters separate after serving their function

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

Change an object's aggregate state, density distribution, degree of flexibility, temperature

Example:

- In a system for brittle friable materials, the surface of the spiral feedscrew was made from an elastic material with two spiral springs. To control the process, the pitch of the screw could be changed remotely.

36. Phase transformation

Implement an effect developed during the phase transition of a substance. For instance, during the change of volume, liberation or absorption of heat.

Example:

- To control the expansion of ribbed pipes, they are filled with water and cooled to a freezing temperature

37. Thermal expansion

- a. Use a material which expands or contracts with heat
- b. Use various materials with different coefficients of heat expansion

Example:

- To control the opening of roof windows in a greenhouse, bimetallic plates are connected to the windows. A change in temperature bends the plates, causing the window to open or close.

38. Thermal expansion

- a. Replace normal air with enriched air
- b. Replace enriched air with oxygen
- c. Treat an object in air or in oxygen with ionizing radiation
- d. Use ionized oxygen

Example:

- To obtain more heat from a torch, oxygen is fed to the torch instead of atmospheric air

39. Inert environment

- a. Replace the normal environment with an inert one
- b. Carry out the process in a vacuum

Example:

- To prevent cotton from catching fire in a warehouse, it is treated with inert gas while being transported to the storage area.

40. Composite materials

Replace a homogeneous material with a composite one

Example :

- Military aircraft wings are made of composites of plastics and carbon fibers for high strength and low weight
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