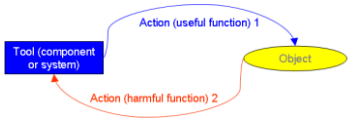
INNOMATION CORP
Systematic Technology & Business Innovation

What is an Engineering contradiction?

An improvement in one characteristic of a system results in the degradation of another characteristic.

- Traditionally addressed by compromise, sacrifice or trade-off.
- An engineering contradiction is a situation in which an attempt to improve one parameter of a system leads to the worsening (impairment) of another parameter.
- It can be reflected in a positive and negative interaction between two or more components



Finding ENG Contradictions Really Fast !

1. Identify the Ideal Final Result
2. Identify the Main Useful Function of the Engineering System
3. What are the gaps preventing the Ideal Final Result?
4. List the engineering contradictions. (Improving and worsening parameters)
5. List the Principles
6. Suggest solutions based on the principles

39 Parameter Definitions

#1 - Weight of Moving Object - The mass of or gravitational force exerted by a moving or mobile object. 'Moving' includes any situations where there is any degree of relative motion or mobility between two or more parts related to the problem. This may be linear or rotational, a few microns or a considerable distance.

#2 - Weight of Stationary Object - The mass of or gravitational force exerted by a stationary object. 'Stationary' includes any situations where there is no form of relative motion between two or more parts related to the problem.

#3 – Length (or Angle) of Moving Object - linear or angular dimension relating to a moving or mobile object. 'Moving' includes any situations where there is any degree of relative motion or mobility between two or more parts related to the problem. This may be linear or rotational, a few microns or a considerable distance.

#4 – Length (or Angle) of Stationary Object - Any linear or angular dimension relating to a stationary object. 'Stationary' includes any situations where there is no form of relative motion between two or more parts related to the problem.

#5 – Area of a Moving Object - Any dimension related to surfaces or surface area. These may be internal or external. They may also include contact area as well as actual surface area. 'Moving' includes any situations where there is any degree of relative motion or mobility between two or more parts related to the problem. The relative motion may be a few microns or considerable amounts.

#6 – Area of Stationary Object - Any dimension relating to surfaces or surface area. These may be internal or external. They may also include contact area as well as actual surface area. 'Stationary' includes any situations where there is no form of relative motion between two or more parts related to the problem.

#7 – Volume of Moving Object - Anything related to the cubic measure of space occupied by an object or the space around it. 'Moving' includes any situations where there is any degree of relative motion or mobility between two or more parts related to the problem. This relative motion may be a few microns or a considerable distance.

#8 – Volume of Stationary Object - Anything related to the cubic measure of space occupied by an object or the space around it. 'Stationary' includes any situations where there is no form of relative motion between two or more parts related to the problem.

#9 – Speed - The velocity or speed of an object or the rate of any kind of process or action. The speed may be relative or absolute, linear or rotational.

#10 – Force (a.k.a. Torque) - Any interaction that is intended to change an objects condition. Can be linear or rotational; the term applies equally well to torque.

#11 – Stress / Pressure - Force exercised on a unit area. Stress is the effect of forces on an object. Stresses can be tensile or compressive, static or dynamic. Parameter also includes strain – provided length is not the main issue, in which case Parameters 3 or 4 should be used.

#12 – Shape - The internal or external contour or profile of a component or system as required for ergonomic and function rather than aesthetic reasons.

#13 – Stability of the Object's Composition - The integrity of a system; the relationship of a system's constituent elements. The parameter can be applied at the macro (component) or micro (atomic) level. Chemical decomposition, dissociation, and increasing entropy should all be interpreted as issues concerning 'stability'.

#14 – Strength - The extent to which an object is able to resist changing in response to force. Resistance to breaking. Can mean elastic limit, plastic limit, or ultimate strength; tensile or compressive; linear or rotational. Also includes toughness and hardness.

#15 – Duration of Action by Moving Object - The time that an object or system takes to perform an action. The action may take place over a few milliseconds, or over several years or more. The parameter is different from 'reliability' (Parameter 35) which is connected to the idea of the time to failure of a system – here it is specifically only the time duration aspect that is at issue. 'Moving' includes any situation where there is any degree of relative motion between two or more parts related to the problem. The relative motion may be a few microns or considerable distances.

#16 – Duration of Action by Stationary Object - The time that an object or system takes to perform an action. The action may take place over a few milliseconds, or over several years or more. The parameter is different from 'reliability' (Parameter 35) which is connected to the idea of the time to failure of a system – here it is specifically only the time duration aspect that is at issue. 'Stationary' includes any situation where there is no form of relative motion between two or more parts related to the problem.

#17 – Temperature - Measured or perceived thermal condition of an object or system. Includes other thermal parameters, such as heat capacity, conductivity, radiation and convection.

#18 – Illumination Intensity - Light flux per unit area, also any other related characteristics of the system such as color, brightness, light quality, etc. The parameter applies to both the brightness of a source and illumination of an object.

#19 – Use of Energy by Moving Object - The measure of an object's capacity for doing work. This parameter focuses on the actual amount of energy (rather than the efficiency of its use, see 27). 'Moving' includes any situation where there is any degree of relative motion between two or more parts related to the problem. The relative motion may be a few microns or larger amounts.

#20 – Use of Energy by Stationary Object - The measure of an object's capacity for doing work. This parameter focuses on the actual amount of energy (rather than the efficiency of its use, see 27). 'Stationary' includes any situation where there is no form of relative motion between two or more parts related to the problem.

#21 – Power **-** The rate at which work is performed. The rate of use of energy. Rate of energy output.

#22 – Loss of Energy - Loss of waste of energy that does not contribute to any of the useful functions being performed. Inefficiency. Can be partial or complete, permanent or temporary.

#23 – Loss of Substance - Loss or waste of elements of a system or its surroundings – substances, materials, sub-systems, products, fields, etc. Can be partial or complete, permanent or temporary.

#24 – Loss of Information - Loss or waste of data or to a system. Also inability to access data, includes data associated with any of the 5 senses – visual, auditory, kinesthetic, olfactory, or gustatory (VAKOG). Can be partial or complete, permanent or temporary. Can also mean the amount, quantity or number of a system's resources. This is a derivative of the 'loss of information' definition above, the focus however is on "Amount of Information" should be interpreted in its most generic form to include ay form of information that might be passed between two or more objects or systems.

#25 – Loss of Time - Time inefficiencies – waiting periods, slack time, etc. Can be partial or complete, always or occasional.

#26 – Quantity of Substance - The amount, quantity or number of a system's materials, substances, parts, fields or sub-systems. 'Substance' is used in its most generic form in the TRIZ context to include any physical or temporal 'thing'.

#27 – Reliability (Robustness) - A system's ability to perform its intended functions in predictable ways and conditions. Also includes durability and issues related to the performance or degradation in performance of an object or system over prolonged periods.

#28 – Measurement Accuracy - Degree of precision or accuracy. The closeness of a measured value to an actual value of a property of a system. Measurement error.

#29 – Manufacturing Precision (Consistency) - The degree to which the actual characteristics of a system or object match in specified or required characteristics. Accuracy.

#30 – Object Affected Harmful Factors - This parameter is designed as a catch-all for any form of action or phenomenon in or around a system that manifests itself as a harmful effect on something in the system.

#31 – Object Generated Harmful Factors - This parameter is designed as a catch-all for any form of inefficiency internal to or around a system that manifests as a harmful effect on something around the system. Can also mean any form of pollutant or environmental emission generated by a system or object. This is a derivative of the 'loss of substance' definition above, the focus however is on "harmful emissions" this aspect is on the production of chemicals, etc. that were not one of the original substances contained within the system.

#32 – Ease of Manufacture (Manufacturability) - Issues related to manufacture, fabrication and assembly and issues associated with an object or system. Ease of manufacture.

#33 – Ease of Operation (Manufacturability) - The extent to which a user us able to learn how to operate, operate or control a system or object. Convenience of use.

#34 – Ease of Repair (Repairability) - Quality characteristics such as convenience, comfort, simplicity, and time to repair faults, failures, or defects in a system. Includes issues associated with need for special tooling or equipment required to achieve repair. Also think about conditions associated with in-situ repair.

#35 – Adaptability or Versatility - The extent to which a system/object is able to respond to external changes. Also, relates to a system capable of being used in multiple ways or under a variety of circumstances. Flexibility of operation or use. Customizability.

#36 – Device Complexity - 'System' Complexity – The number and diversity of elements and element interrelationships within and across the boundaries of a system. The user may be an element if the system that increases the complexity. Includes issues like number of functions, number of interfaces and connections, excessive number of components. 'Control' Complexity – complexity of the control system – either physical components or the algorithms that it contains- used to control a system in delivering useful functions.

#37 – Difficulty of Detecting and Measuring - How difficult it is to make measurements on an object or system. Complex costly, time consuming, labor-consuming inspection or analysis operations. Increasing cost of measuring to a satisfactory quality level. Also includes ease of inspection.

#38 – Extent of Automation - The ability of a system or object to perform its functions without human interface or intervention. Level or extent of automation.

#39 – Productivity - The number of useful (value-adding) functions or operations performed by a system per unit time. The time per unit function or operation. Useful output per unit of time. Cost per unit output, or amount of useful output. (See 'Speed' – #14 - which is more focused on issues of dynamics rather than output of product.)

40 Inventive Principles With Examples

Principle 1. Segmentation
- A. Divide an object into independent parts.
- B. Make an object easy to disassemble.
- C. Increase the degree of fragmentation or segmentation.

Principle 2. Taking out
- A. Separate an interfering part or property from an object, or single out the only necessary part (or property) of an object.

Principle 3. Local quality
- A. Change an object's structure from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.
- B. Make each part of an object function in conditions most suitable for its operation.
- C. Make each part of an object fulfill a different and useful function.

Principle 4. Asymmetry
- A. A. Change the shape of an object from symmetrical to asymmetrical.
- B. If an object is asymmetrical, increase its degree of asymmetry.

Principle 5. Merging
- A. Bring closer together (or merge) identical or similar objects, assemble identical or similar parts to perform parallel operations.
- B. Make operations contiguous or parallel; bring them together in time.

Principle 6. Universality
- A. Make a part or object perform multiple functions; eliminate the need for other parts.

Principle 7. "Nested doll"
- A. Place one object inside another; place each object, in turn, inside the other.
- B. Make one part pass through a cavity in the other.

Principle 8. Anti-weight
- A. To compensate for the weight of an object, merge it with other objects that provide lift.
- B. To compensate for the weight of an object, make it interact with the environment (e.g. use aerodynamic, hydrodynamic, buoyancy and other forces).

Principle 9. Preliminary anti-action
- A. If it will be necessary to do an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects.
- B. Create beforehand stresses in an object that will oppose known undesirable working stresses later on.

Principle 10. Preliminary action
- A. Perform, before it is needed, the required change of an object (either fully or partially).
- B. Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery.

Principle 11. Beforehand cushioning
- A. Prepare emergency means beforehand to compensate for the relatively low reliability of an object.

Principle 12. Equipotentiality
- A. In a potential field, limit position changes (e.g. change operating conditions to eliminate the need to raise or lower objects in a gravity field).

Principle 13. 'The other way round'
- A. Invert the action(s) used to solve the problem (e.g. instead of cooling an object, heat it).
- B. Make movable parts (or the external environment) fixed, and fixed parts movable).
- C. Turn the object (or process) 'upside down'.

Principle 14. Spheroidality - Curvature
- A. Instead of using rectilinear parts, surfaces, or forms, use curvilinear ones; move from flat surfaces to spherical ones; from parts shaped as a cube (parallelepiped) to ball-shaped structures.
- B. Use rollers, balls, spirals, domes.
- C. Go from linear to rotary motion, use centrifugal forces.

Principle 15. Dynamics
- A. Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition.
- B. Divide an object into parts capable of movement relative to each other.
- C. If an object (or process) is rigid or inflexible, make it movable or adaptive.

Principle 16. Partial or excessive actions
- A. If 100 percent of an object is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.

Principle 17. Another dimension
- A. To move an object in two- or three-dimensional space.
- B. Use a multi-story arrangement of objects instead of a single-story arrangement.
- C. Tilt or re-orient the object, lay it on its side.
- D. Use 'another side' of a given area.

Principle 18. Mechanical vibration
- A. Cause an object to oscillate or vibrate.
- B. Increase its frequency (even up to the ultrasonic).
- C. Use an object's resonant frequency.
- D. Use piezoelectric vibrators instead of mechanical ones.
- E. Use combined ultrasonic and electromagnetic field oscillations.

Principle 19. Periodic action
- A. Instead of continuous action, use periodic or pulsating actions.
- B. If an action is already periodic, change the periodic magnitude or frequency.
- C. Use pauses between impulses t o perform a different action. .

Principle 20. Continuity of useful action
- A. Carry on work continuously; make all prts of an object work at full load, all the time.
- B. Eliminate all idle or intermittent actions or work.

Principle 21. Skipping
- A. Conduct a proc ess , or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.

Principle 22. "Blessing in disguise" or "Turn Lemons into Lemonade"
- A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achi eve a positive effect.
- B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.
- C. Amplify a harmful factor to such a degree that it is no longer harmful.

Principle 23. Feedback
- A. Introduce feedback (referring back , cross -checking) to improve a process or action.
- B. If feedback is already used, change its magnitude or influence.

Principle 24. 'Intermediary'
- A. Use an intermediary carrier article or intermediary process.
- B. Merge one object temporarily with another (which can be easily removed).

Principle 25. Self -service
- A. Make an object serve itself by performing auxiliary helpful functions
- B. Use waste resources, energy, or substances.

Principle 26. Copying
- A. Instead of an unavailable, expensive, fragile object, use simpl er and inexpensive copies.
- B. Replace an object, or process with optical copies.
- C. If visible optical copies are already used, move to infrared or ultraviolet copies.

Principle 27. Cheap short -living objects
- A. Replace an expensive object with a multiple of inexpensive objects, comprising certain qualities (such as service life, for instance).

Principle 28 Mechanics substitution
- A. Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means.
- B. Use electric, magnetic and electromagnetic f ields to interact with the object.
- C. Change from static to movable fields, from unstructured fields to those having structure.
- D. Use fields in conjunction with field -activated (e.g. ferromagnetic) particles.

Principle 29. Pneumatics and hydraulics
- A. Use gas and liquid parts of an object instead of solid parts (e.g. inflatable, filled with liq uids, air cushion, hydrostatic).

Principle 30. Flexible shells and thin films
- A. Use flexible shells and thin films instead of three dimensional structures .
- B. Isolate the o bject from the external environment using flexible shells and thin films.

Principle 31. Porous materials
- A. Make an object porous or add porous elements (inserts, coatings, etc.).
- B. If an object is already porous, use the pores to introduce a useful substanc e or function.

Principle 32. Color changes
- A. Change the color of an object or its external environment.
- B. Change the transparency of an object or its external environment.

Principle 33. Homogeneity
- A. Make objects interacting with a given object of the same material (or material with identical properties).

Principle 34. Discarding and recovering
- A. Make portions of an object that have fulfilled their functions go away (discard by dissolving, evaporating, etc.) or modify these directly during operation.
- B. Conver sely, restore consumable parts of an object directly in operation.

Principle 35. Parameter changes
- A. A. Change an object's physical state (e.g. to a gas, liquid, or solid.
- B. Change the concentration or consistency.
- C. Change the degree of flexibility.
- D. Change the temperature.

Principle 36. Phase transitions
- A. Use phenomena occurring during phase transitions (e.g. volume changes, loss or absorption of heat, etc.).

Principle 37. Thermal expansion
- A. Use thermal expansion (or contraction) of materials.
- B. If thermal expansion is being used, use multiple materials with different coefficients of thermal expansion.

Principle 38. Strong oxidants
- A. Replace common air with oxygen -enriched air.
- B. Replace enriched air with pure oxygen.
- C. Expose air or oxygen to ionizing radiat ion.
- D. Use ionized oxygen.
- E. Replace ozonized (or ionized) oxygen with ozone.

Principle 39. Inert atmosphere
- A. Replace a normal environment with an inert one.
- B. Add neutral parts, or inert additives to an object.

Principle 40. Composite materials
- A. Change fro m uniform to composite (multiple) materials.

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