This is a modified version of the article first published in the proceedings of the ETRIA TRIZ Futures 2005 conference, Graz, Austria, November 2005.

PROGRESS AND IDEALITY

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Abstract

Authors present the theoretical aspects about Law of Ideality Increasing – the most important law of technical systems evolution. The means and the kinds of idealization and of the ideal objects are shown.

Keywords: Ideal, Ideality, Law System, TRIZ

1.General

Guenrich Altshuller was the first to realize that the direction of progress, or technical evolution, is defined by increasing the ideality level [1-6]. The totality of Altshuller's laws, and their influence on the idealization process, is presented in [7].

An Ideal system does not exist, but all of its functions are fulfilled at the right time and at the right place — without energy, substance, or other resources, and without any ill effects.

The idealization level formula (1) can be shown as:

$$I = \alpha \frac{\sum F_i Q_i}{\sum C_j + \sum \beta_k H_k} \Rightarrow \infty; \qquad (1)$$

Here
I – idealization level (dimensionless performance);
F – useful function (effect);
Q – quality of useful function;
C – time and mean cost for useful function implementation;
H – nuisances;
α,β– accommodation coefficients.

Common sense suggests that the value of useful functions should increase, and the cost and nuisances should decrease. Then, the ideality increases. When the numerator approaches infinity or the denominator approaches zero, this will occur.

It is usually considered that the growth of ideality is an attribute of progress, and therefore, the traditional way the numerator grows and the denominator decreases seem justified.

A.Seredinski has suggested expanding this concept [8].

If one looks at the formula of ideality from a mathematical point of view, it becomes necessary to analyze all other opportunities. We shall present the formula in a simplified way (2):

$$\mathbf{I} = \frac{\text{Numerator}}{\text{Denominator}} \qquad (2)$$

Values of numerator and denominator can change. They can decrease, remain constant, or increase. We shall consider all of the possibilities and construct a table (1) where the rows will specify the types of "behavior" of a numerator, and the columns — of a denominator. The arrow, when pointing upwards, means growth, and when pointing downwards —

means reduction. In cells where a line and column cross, we shall mark the “behavior” of ideality. Double arrows mean strong change.

Numerator F	Denominator P		
	↓	=	↑
↓	? 1	↓ 2	↓↓ 3
=	↑ 4	= 5	↓ 6
↑	↑↑ 7	↑ 8	? 9

Table 1. Idealization level «behavior»

Let's look at all 9 cells.

The increase in degree of ideality is traditional, and is considered to be a simultaneous increase of the numerator and decrease of the denominator — as shown in cell #7. Cells #4 and #8 also characterize growth of ideality, though it is as not as fast as in cell #7.

Cell #3 shows the worst alternative. If the sum of useful functions decrease, and the harmful functions and costs increase — it leads to a sharp decline in ideality. Ideality also decreases in cells #2 and #6, though not as fast as in cell #3.

A constant ideality is shown in cell #5.

What is happening in the cells located on the ends of a diagonal, cells #1 and #9? The answer is not obvious. What occurs if the numerator and denominator either increase or decrease simultaneously?

For the answer to this question we will use simple reasons.

Let us assume that the numerator has increased by 4 times, and the denominator by 2 times. Naturally, the factor of ideality will increase by 2 times, and vice-versa.

Therefore, it seems that ideality can also grow when both the numerator, and the denominator, change “in the same direction,” i.e., both either increase or decrease.

Let us consider ways, and kinds, of idealization by changing each of the parameters of the formula (1). Also, we shall show different ways of idealization.

2. Ways, and kinds, of idealization

The increase of ideality, according to formula (1), is carried out by an increase in the numerator (increase in quantity and qualities of useful functions) and a decrease in the denominator (reduction of costs and harmful effects). Shown below are conclusions, based on examples [7, 8].

2.1. Ways to increase the numerator

2.1.1. Increase in the quantity of system functions.

The increase in the quantity of functions performed can be realized by different ways (Figure 1).

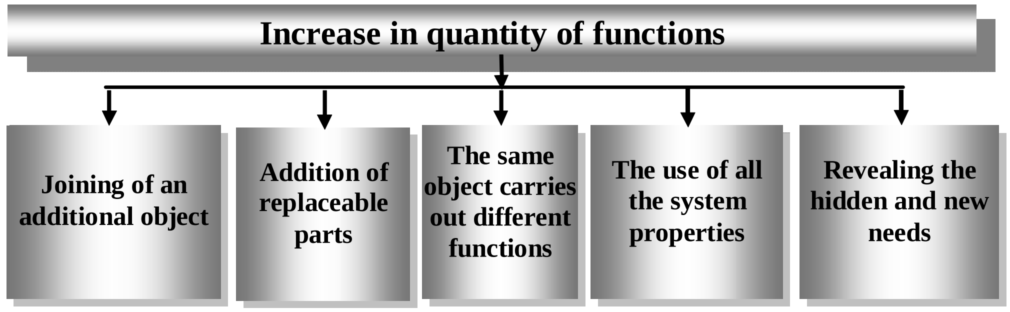

Figure 1. Increase in quantity of functions

Let's show some ways.

2.1.1.1. Joining additional objects.

<u>Example</u>*: Clocks are added to many domestic products.*

2.1.1.2. Addition of replaceable parts.

<u>Example</u>: *Drill with removable screwdrivers, keys, grinding circles, etc.*

2.1.1.3. The same object carries out multiple functions.

<u>Example</u>*: Modern mobile phones provide many additional functions beside their basic function of being a telephone (telephone directory, call-back features, clock, timer, alarm clock, video games, ring tones, voice recognition technology, e-mail, digital camera, Internet browser, and many other things).*

2.1.1.4. The use of all of the systems properties.

Expansion of functions is carried out with the help of a special technique [9].

<u>Example</u>*: The basic function of a tire is to protect the camera from damage. It has the shape of a torus ring (bagel), it is elastic in radial and cross-sectional directions, and consists of a rubber and metal cord. Tires are used also as shock-absorbers on boats, highway protectors, slope coverings in hydraulic engineering construction, in shoreline conservation construction, in drainage systems, as building blocks for garages, warehouses, workshops, for closing reservoirs, as additives in asphalt manufacturing, etc.*

2.1.1.5. Revealing the hidden and new needs; development of methods to satisfy these.

The search for needs is carried out with a special technique, based on the laws of needs development [10]. Using this technique, it is possible to quickly and economically reveal new market segments.

2.1.2. Increase in the quality of system functions.

Increases in the quality of systems functions can be carried out via:

- Increases in specific parameters;
- Application of more progressive equipment, materials, processes, etc., using modern achievements in science and technology.

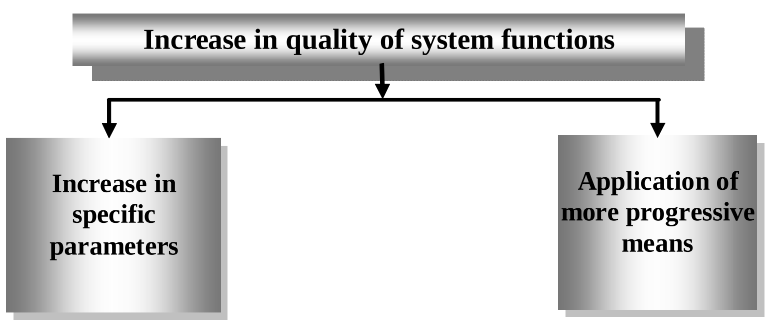

Figure 2. Increase in the quality of system functions

Let us summarize some examples.

2.1.2.1. Increases in specific parameters.

<u>Example</u>*: Modern engines have the tendency to increase a specific power (a ratio of power and weight).*

A similar tendency is present in other areas. Modern accumulators weigh much less than older versions, but have the same capacity. This also relates to electric condensers and many other devices.

The greatest parameters can be seen in modern electronics, especially in microprocessors. The quantities of elements in one processor are consistently increasing.

In vehicles, this tendency can be seen in the steady increase in the use of useful weight. This explains the increase in the displacement of ships, especially tankers.

<u>Example</u>: A tanker that displaces 3,000 tons, uses 57 % of its tonnage for displacement, and a tanker that displaces more than 200,000 tons uses 86 %; therefore, coming closer to ideality (Figure 3).

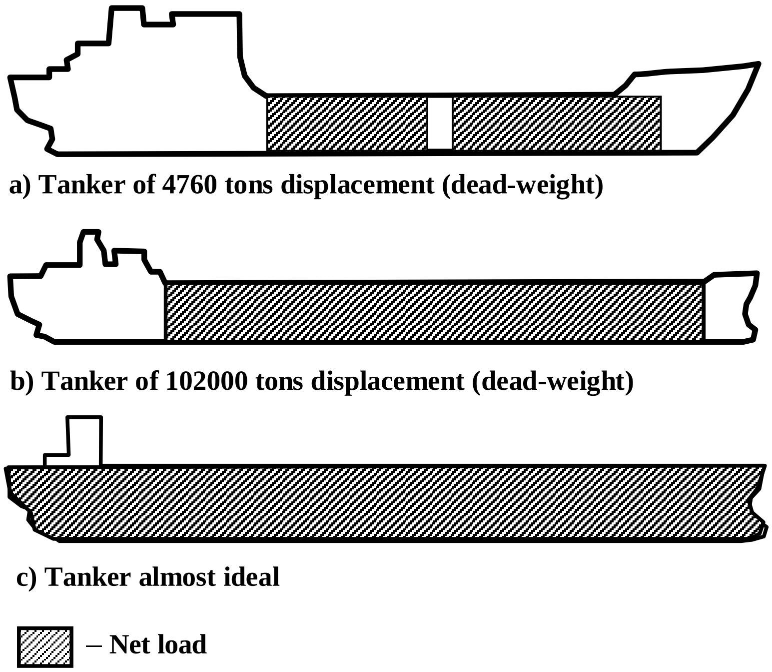

Figure 3. Tanker's evolution

2.1.2.2. Application of more progressive means.

<u>Example</u>: Laser technics are applied in various areas today. It is used in computers for recording and reading the information on a CD. It is also used in a computer mouse, where the mechanical movement of a ball has been replaced by a laser that tracks movement.

2.2. Ways to reduce the denominator

2.2.1. Ways to reduce costs.

The classical way to reduce costs is called functional-cost analysis (Value Engineering, Value Management, and Value Analysis). When one reduces the rejection rate, or brings it to zero, then costs are also reduced. Other ways to reduce costs are shown in Figure 4.

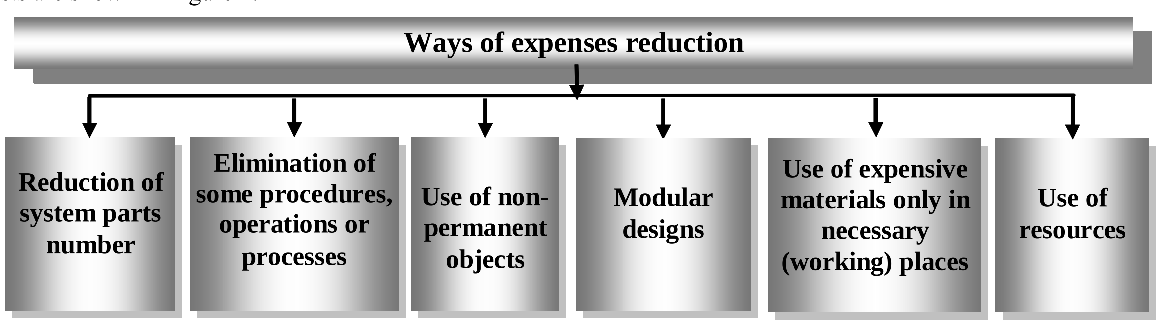

Figure 4. Ways of expenses reduction

Let us show some ways.

2.2.1.1. Reduction of the number of system parts

This can be carried out, for example, by combining associated functions of several elements into one element.

<u>Example</u>: Each computer has to retain its operating program in a ROM chip. For years, the power source for storage of this very important information was a small battery. Today, flash-memory is used. These microcircuits can keep

information in the absence of a power supply. Thus, two elements (a battery and a microcircuit) have been incorporated into one element, which carries out two functions simultaneously.

Example: *In bolted connections, to prevent the nut from unscrewing while in operation, a second nut is added onto the bolt, or a special toothed washer is inserted under the nut.*

The ideal in this case would be "the nut fixes itself." Presently, there are many different designs of connections which automatically fix themselves. Here is an example of one of them:

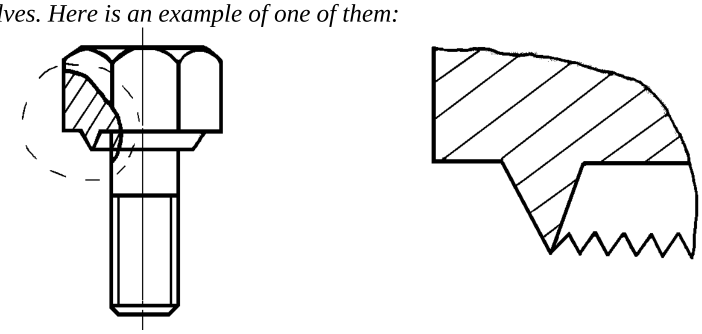

Figure 5. Bolt head

A nut is kept in place by the teeth located on its butt-end. The teeth have sharp edges, fixed at an angle of 7-10°. This allows one to utilize the self-fixing nuts repeatedly. Such nuts are necessary for connections that operate under various loads. This solution presents an example of the association between a nut and a washer.

In bolted connections without a nut, the bolt must fix itself. The concentric pointed lugs are arranged on the front surface of the head, facing towards the connected parts (Figure 5).

2.2.1.2. Elimination of separate procedures, operations, or processes.

Example: It is necessary to change automobile seat belts periodically. Weakened belt material is the cause of this necessity. A tape covering the material has been invented that will show when the belt needs to be changed.

A similar principle is used for the control and replacement of automobile tires. A protector, covered by a layer of colored paint, measures the number of kilometers traveled by the automobile. When the colored paint starts to appear, then the wear on the tire is visible. This method to estimate the wear on tires is simple and is suitable for research on the durability of new types and designs.

2.2.1.3. Use of disposable objects

Example: The quantity of disposable goods increases constantly — utensils, clothes, different tools and devices (i.e., cameras), etc. Soon, disposable motors for automobiles will be available. They will work until the first repair; the cost of these engines are approximately equal to the cost of a major overhaul, and a replacement takes no more than 15 minutes to install.

2.2.1.4. Modular designs

Block designs allow:

- **To simplify and accelerate the processes of assembly and repairs of the equipment**.

Originally, equipment was assembled from separate parts. A highly qualified expert was required for this. The same applied to repair. With a block design, the repair consists only in putting a block in place or switching out the block. Most of modern technics are created using blocks.

Example: Nowadays, the assembly and repair of computers is considerably simplified. A highly qualified expert is no longer needed, unlike what was previously required for radio and television equipment repair.

- **To use disposable parts (blocks).**

Some kinds of block designs use disposable parts.

Example: Safety razors use one handle and replaceable blades.

Example: Modern cutters and mills don't need sharpening — they have a long-lasting holder and replaceable knives.

- **To increase the quantity of functions** carried out by an object due to replacement or addition of separate blocks.

Examples are illustrated in item 2.1.1.

- **Use of expensive materials, but only in necessary (working) places**.

The whole object is made from cheap material, only its working zone is made from a necessary (often expensive) material. For example, using diamonds in cutting tools.

Example: Previously, the whole drill bit was made from fast-cutting steel. Now, only the top part is made from it, and the bottom is produced from regular steel.

Example: In various electrical and electronic devices, the connection ports were made completely of silver or gold. Now, silver or gold only cover the connection ports.

2.2.1.6. Use of resources

Example: It is necessary to wash windowpanes, but in shops with large window areas, it is difficult and labor-consuming. Lavsan film can replace the glaze that currently covers windows. The film resists dust and will be cleaned by the motion of the air outside. Lavsan film is transparent and can be installed on the current frames.

2.2.2. Elimination of undesirable effects

Example: The sanding of a surface by grinding wheels is accompanied by a rise in temperature where the wheel touches the surface. This increase in temperature speeds the degradation of the wheel at the contact point.

The new grinding wheels are composed of the same components, but an endothermic additive has been incorporated into their design. When high temperatures are reached during grinding, the wheel absorbs the heat and distributes the heat evenly throughout for uniform degradation.

2.3. Simultaneous change of the numerator and denominator

Frequently, both the numerator and the denominator change simultaneously. If these changes agree with paragraphs 2.1 and 2.2, then they correspond to a faster growth of ideality, as shown in cell #7 of table 1.

However, we have only examined the opposite changes. Next, we will consider the changes in the same direction at which ideality also grows, that corresponds to cells #1 and #9 of the tables (Figure 6).

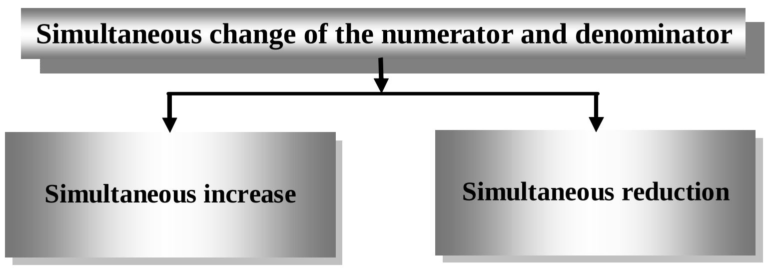

Figure 6. Simultaneous change of the numerator and denominator

2.3.1. Simultaneous decrease of a numerator and a denominator

Situations when a technical system (object) intended for one segment of the market finds its application in other segments are frequent. For this purpose, it should undergo some transformation. For example, the numerous “serious” objects created for the performance of “serious” functions can undergo this transformation. If it is better to accustom children to using these objects in early years, then simplified copies are created.

Example: It is impossible to imagine what life would be like today without personal computers. By combining computers with games, language training, mathematics programs, natural and other science programs, etc., it is possible to teach children at an early age. Certainly, children's computers should not possess all functions, which are inherent in “real” personal computers, so that these computers have a much lower cost.

The same concept is applicable to vehicles. Children's automobiles and motorcycles with small motors can illustrate this.

A similar approach can be applied to various disposable objects, whose examples were shown previously.

Figure 7. Simultaneous decrease of the numerator and denominator

2.3.2. Simultaneous increase in the numerator and denominator

There are many examples around us. Already mentioned were mobile phones, which carry out a set of additional functions — down to the repelling of mosquitoes. Other examples are combined devices — including printers, scanners, and copying devices. Costs to produce these hybrids are higher than what is required to create each device separately, but lower than their sum. It also testifies to the growth of ideality.

In [8] an example was given regarding the development of a car in two opposite directions — decrease (such as a “Smart”) and increase (such as a “Limousine”). The relation of the numerator and the denominator illustrates growth of ideality, each in its own sector.

Finally, the tendency to receive a maximum, spending a minimum — is a tendency to ideality.

Figure 8. Simultaneous increase of the numerator and denominator

3. Ideal objects

It is interesting to note that the tendency to an ideal is inherent not only in technical systems as a whole, but to its individual parts and the processes occurring in them.

It is possible to speak about **ideal substance, ideal form, and ideal process**.

3.1. Ideal substance

The ideal substance is a substance which does not exist, but its functions are carried out as functions (properties) of the substance. For example, it is possible to name these functions — solidity, density, impenetrability, elasticity, corrosion and chemical resistance, electroconductivity, etc.

There are also substances with changeable properties, for example — liquid crystals, polarizing plates, substances with variable transparency, materials with shape memory, fluorescent substances, magnets, electrets, etc.

For different kinds of technical systems, their own "ideal" substances are selected.

G. Altshuller wrote, “Material of the ‘ideal machine’ works so that its properties are used in the best way. For example, metal parts work only on a stretching, wooden parts - only on compression, etc.” [6].

Example: The ideal hull of a submarine should have minimal weight that coincides with the quality of material — in its small density and solidity. Also, the submarine should not be magnetic, so it is harder to detect.

Therefore the hulls of modern submarines are produced from titanium. It possesses high mechanical properties, corrosion resistance in seawater, and it isn’t magnetic.

Example: Many parts of automobiles are made from magnesium, and the body from fiberglass.

3.2. The ideal form

Sometimes it is possible to consider an ideal form that provides a maximum of useful effect. This can be understood as:

- Durability, with a minimum of material used
- Minimal aero- and hydrodynamic resistance
- Tightness
- Etc.

Example: For underwater devices, the ideal form is a sphere. "It possesses high stability and small density. Spherical objects have minimal relations between surface area and volume..." [9].

Conclusion

The concepts of progress and idealization are linked. The progressive development of technical systems inevitably increases ideality, which serves as a measure for progress.

We have shown ways for increasing idealization by increasing the quantity and quality of functions, and eliminating unwanted effects.

There are other ways to approach the technological process of idealization, but it will be the subject of our next work.

Taking into account that ideality can grow in all situations when technical systems can evolve in two opposite directions, we can ask the question: "What ideality has a higher degree of ideality?"

We believe that to answer this question, it is necessary to climb the hierarchical stair (by using Altshuller's nine-screen System Operator) to its highest level – to the level of nature. From the viewpoint of nature, a system which consumes less material and energy resources and at the same time does not disturb nature's existence and evolution (does not destroy, pollute, etc.) has a higher degree of ideality.

If at present time FASHION and PRESTIGE are the driving motivations, it is reasonable to expect that in future they will be replaced by EXPEDIENCY and COMMON SENSE.

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