Ideal System, Or Why the Question *What?* May Be More Important Than the Question *How?*[*]

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When solving an engineering problem using the trial-and-error method, the starting point of the engineer's thinking is usually the problem at hand. "The trouble lies here because this part does not perform well. How can I improve it?" These are typical reflections of someone attempting a given problem. The engineer's goal is to solve a particular problem – that is, find an answer to the question of **How?** for example, **How to increase efficiency of this part?** or **How to prevent damage to this part?** etc. This implies that an object of modification is known. However, it may turn out that the real problem is quite different, and that creative efforts should be concentrated on changing an entirely different object.

A technological system is not a goal in itself. We only need it to perform a certain **function**, i.e., to serve some **article**, be it another technological system or person. Examples of interactions between technological systems and articles are shown in Fig. 1. In fact, various systems may exist that are capable of performing the same function. A system is essentially a "fee" for attaining the required function. Among several systems performing a similar function, a better system is one that consists of fewer components and requires less resources and maintenance. **An ideal technological system** is one that requires no materials to build, consumes no energy, and does not need space and time to operate. In other words, **an ideal system is an absent system**. The notion of an **ideal system** is one of the cornerstones of TRIZ. **An ideal technological system does not exist as a physical entity but the required function is fully performed.**

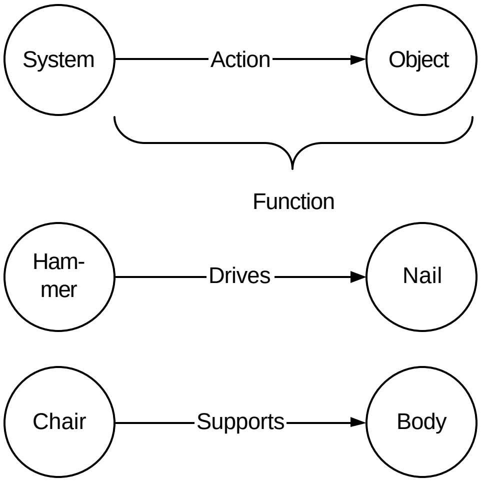

Fig. 1.

The notion of ideality suggests that before looking for a solution to the question of **How?** it is first necessary to pinpoint the object itself that is in need of improvement, i.e., to answer the question of **What?** How then does one attain ideality? Since the function must be performed, some material body ought to be responsible for this performance.

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This can be demonstrated by the following **Ideality Tactics** (see Fig. 2; in this diagram S, O and E represent system, object and environment, respectively):

1. Ideality tactic 1: A system is eliminated when the object of its function is also eliminated .
2. Ideality tactic 2: A system is eliminated when attainment of its function is allocated to its object.
3. Ideality tactic 3: A system is eliminated when another system or the surrounding environment performs its function.

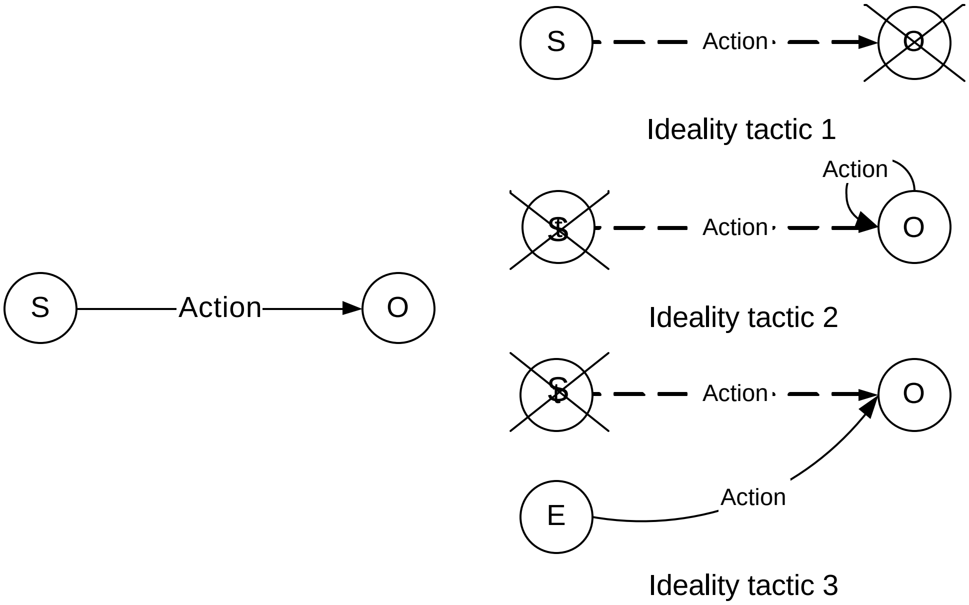

Fig. 2.

The following examples illustrate these approaches.

Case Study 1

Initial Situation

This case study involves a robotic test station for computer components. The robot's gripper (see Fig. 3) performs complex manipulations (clamping, handling, and inserting) of very delicate parts. It is energized by two vacuum lines and four compressed air lines, and has several sensors transmitting signals via electrical cables. The vacuum, compressed air, and electrical communications are all channeled to the distribution/control box at the robot's base by a so-called "umbilical cord" – a corrugated plastic hose encasing all of the tubes and wires. The purpose of this "umbilical cord" is to contain fine particles generated by the rubbing action between the tubes and wires. The cord tends to rupture after prolonged use. The rupture occurs due to the fatigue associated with large amplitude high-speed link motions resulting in excessive twisting of the cord. The rupture allows wear particles to escape into the environment leading to its contamination.

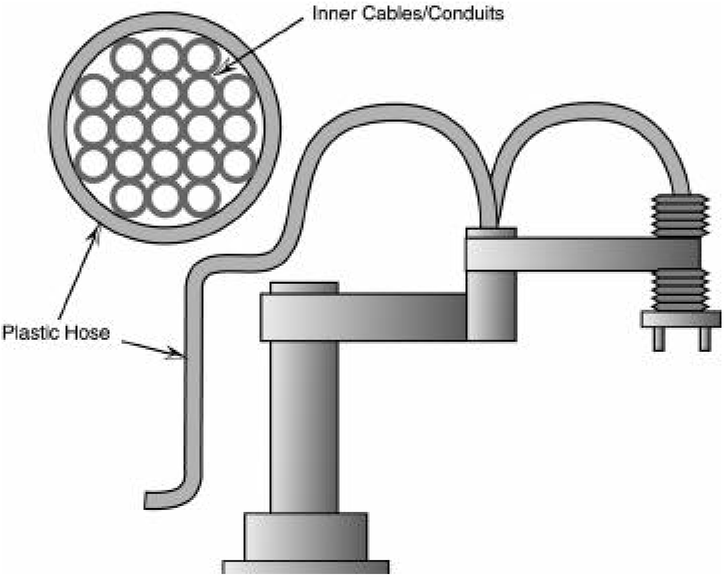

Fig. 3.

In attempting to remedy the situation, engineers focused on solving the following problem: **How to prevent the cord from rupturing?** To this end, more durable plastics for the cord were attempted, but they were more expensive while not significantly extending the cord's useful life. Also suggested was the evacuation of air from the cord, to create negative pressure that would keep the dust particles from escaping. This too, would result in increased costs. A more effective, permanent solution was required.

TRIZ Analysis

There is no need to solve this problem, if we know **what** part of the test station should be changed. The only part that cannot be broken or damaged and does not need any service is an absent part. An ideal "umbilical cord" should not exist. This is possible if the dust particles are not generated in the first place as indicated in ideality tactic 1.

Solution

To prevent dust generation, i.e., rubbing between the inner conduits and wires, they were separated by elastic support braces (see Fig. 4).

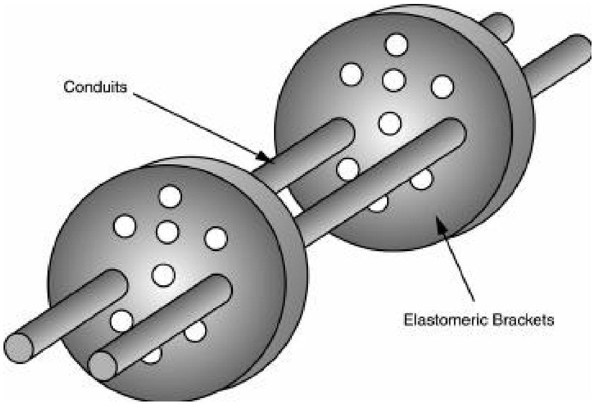

Fig. 4.

Case Study 2

Initial Situation

To control temperature inside a greenhouse, its roof (a light metal frame supporting glass or a thin transparent film) has to be repeatedly lowered and lifted (see Fig. 4). There are hundreds of greenhouses on a farm. It is necessary, therefore, to control the movements of hundreds of frames. A typical commercially available system for moving the frames involves an electromechanical drive, a temperature sensor, and a computerized control unit. Such a system provides automatic handling of the frames, but generates high costs and reduced reliability. Is it possible to improve this scheme? The greenhouse manufacturer addressed the following problem: **How to optimize the design of a typical control system?**

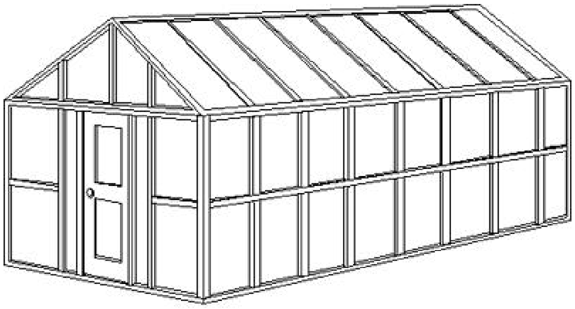

Fig. 4.

There are some options. For example, one could control the movements of several frames by one drive, or, alternatively, use one computer to send instructions to all servo-drives. These solutions, however, are still costly and unreliable.

TRIZ Analysis

Use of the notion of ideality stipulates replacing the formulated problem with a new one. What do we need the drive for? Obviously, for moving the frames. In fact, a drive is not needed, but only the frame movement. An ideal drive does not exist, but the roof is lowered and lifted as needed. If there is no drive, some component of the system ought to take responsibility for moving the frame. The only available component is the roof itself (see ideality tactic 2). Now the problem has changed: The frame has to lift itself when the temperature increases, and it has to lower itself when the temperature drops. This removes all choices but use of the thermal expansion of the roof material.

Solution

The sidebars of the frame are made of bimetallic strips. When the temperature is high, the strips bend and lift the frame; when the temperature drops, the strips straighten and lower the roof (see Fig. 5).

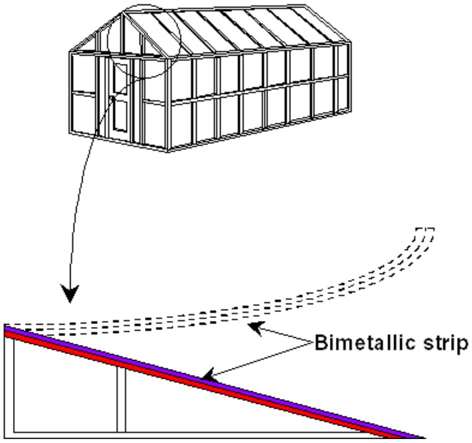

Fig. 5.

Case Study 3

Initial Situation

A space agency was designing an autonomous probe to land on Venus. The probe had to carry various electronic devices to the planet. When the project was close to completion, the agency received a request from a group of scientists, headed by a renowned chemist, to place one more device into the probe. This was impossible to do, as the probe was already so crammed with other devices that one could hardly tuck a matchbox into it, let alone a 6-kg device. The person who signed the request, however, had much clout both in the space industry and in government, so turning him down would have been politically imprudent. A creative solution to the problem, **How to find extra space for the device?** was badly needed.

TRIZ Analysis

As is often the case, a problem that many perceive as a management issue may have an elegant engineering solution. The ideality approach calls for delegating several functions to one object. **What** other device can provide the required function? The only way to "squeeze-in" the extra device without removing another, was to integrate functions of the former with some already existing resource.

Solution

A judicious analysis of the probe design revealed a previously overlooked opportunity. Each planetary probe built earlier had carried to outer space almost 6 kg (what a coincidence!) of "dead weight" made of cast iron. This "dead weight" controlled the position of the probe's center of gravity during landing. The "dead weight" was replaced with the device of interest (see ideality tactic 3), thus performing both functions – its scientific duty and aligning the center of gravity.
Now, try this problem.

Steering Wheel Shake Problem

Compact cars are usually powered by four-cylinder engines that have intense second order vibrations. The second order frequency at idle regimes is not fully attenuated and, for some vehicles, may resonate with the structural modes causing discomfort.

A compact car was equipped with a driver air bag. The steering column without the air bag had its natural frequency well outside the idle RPM, but adding the heavy (~3.5lbs/1.6 kg) air bag substantially reduced its natural frequency. As a result, the steering wheel started shaking with large amplitudes at idle regimes. The shaking was so intense that the car could not be put into production before a dynamic vibration absorber (~0.5 kg of lead) was installed inside of the steering wheel and attached to the steering column by tuned rubber connectors. The lead absorber reduced the shake marginally. To abate the shake effectively, the absorber had to be at least 4-5 times heavier, but there was no space available for so large a chunk of lead. The situation triggered customers' complaints and high warranty costs.

How would you abate the intense shaking using the principle of ideality?