

System conflicts

Or What Makes Some Problems So Difficult To Solve*

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Solving engineering design problems usually begins with attempts at finding solutions using conventional means. This approach, however, does not always yield the desired results. Imagine, for example, that we want to enhance the comfort of a car. One of the simplest known ways to achieve this goal is by enlarging the vehicle's passenger compartment. With this enhancement, however, we also obtain increased drag resistance, increased fuel consumption, and a reduction of the car's effective speed. Thus, gaining an advantage as a result of improving one part of a car, is negated by the development of disadvantages in other parts.

An engineering problem "graduates" to the rank of a difficult one when attempts to improve some system attributes by using conventional means lead to the deterioration of other system attributes. Clashes such as weight versus strength or power versus fuel consumption or productivity versus space, lead to a situation called a **system conflict**.

A system conflict is present when:

- *the useful action causes simultaneously a harmful effect or*
- *the introduction (intensification) of the useful action, or elimination or reduction of the harmful action causes deterioration or unacceptable complication of one of the system's parts or of the whole system.*

A problem associated with a system conflict can be resolved either by finding a trade-off between opposing demands, or by satisfying them. Trade-offs or compromise solutions do not eliminate system conflicts, but rather soften them, thus retaining harmful (undesirable) actions/shortcomings in the system. Conflicting requirements keep "stretching" the system and, over time, grow increasingly incompatible. Eventually further advancement of the system's performance becomes impossible without eliminating the system conflict.

From a TRIZ standpoint, creating an invention means overcoming a system conflict.

Presence of a system conflict is the most important characteristic that differentiates a difficult problem from a simple one. Thus, TRIZ is primarily concerned with the development of tools for eliminating system conflicts.

In spite of the infinite variety of engineering problems and their apparent uniqueness, the system conflicts which shape these problems are not necessarily unique. System conflicts can be classified by the type of conflicting interactions between the system's components. Each type of system conflict can be associated with a specific conceptual approach (i.e., a rule) to its resolution. Let us consider one such approach.

Any system is designed and built to perform at least one *primary function*. Various parts of the system can be ranked as *main components* and as *auxiliary components*, according to their contribution to the performance of the primary function. Main components are those whose removal from the system makes the primary function impossible to perform. Auxiliary components support performance of the main components. For example, in the milling operation, the part being machined, the cutting tool, and the spindle are the main components, while the cooling solution is an auxiliary component (its removal from the system may not always lead to a ceasing of the operation).

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Let us introduce a rule: *If there is a system conflict between the main component and an auxiliary component, it may be resolved by eliminating the latter and delegating its useful action to some main component or to the system's environment.*

One of the most frequently encountered situations associated with this rule is shown graphically in Fig. 1 (whereas, MC 1 and MC 2 represent main component 1 and main component 2, respectively, and AC represents an auxiliary component).

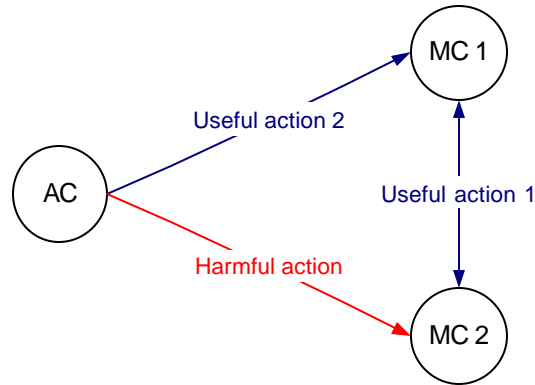


Fig. 1.

The rule is based on the notion of an *ideal technological system*, discussed in the article “Ideal System”. As one can see, elimination of a conflicting auxiliary component allows for achieving two goals:

- Automatic elimination of a harmful action and retainment of a useful action (see Fig. 2)
- Advancing the system towards increasing ideality

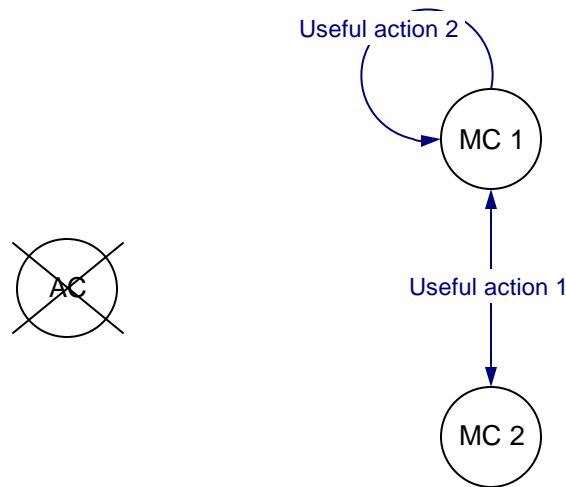


Fig. 2.

Let us consider some case studies illustrating this rule.

Case Study 1

Initial Situation

To study the aerodynamic properties of a car, a scaled model was placed inside a transparent pipe through which water was pumped (Fig. 3). Interaction between the model and the water

caused the formation of vortices. The vortices, however, were not easily discernable in the clear water, so the model was covered with a layer of liquid paint. When the paint was thinly layered, observation time was rather short. On the other hand, when the paint was thickly layered, the overall dimensions of the model became distorted, rendering the entire experiment meaningless. What could be done?

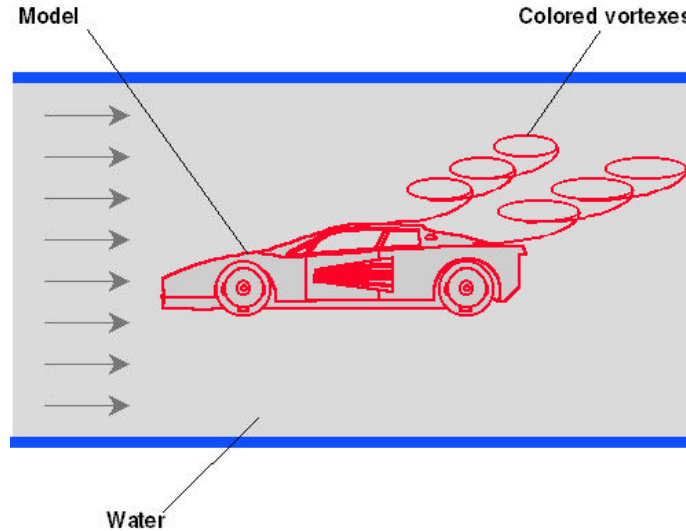


Fig. 3.

TRIZ Analysis

The primary function of the system is visualization of vortices. The system conflict is obvious (see Fig. 4): *To allow sufficient time for observation, the paint layer should be thick, but a thick layer distorts the model.*

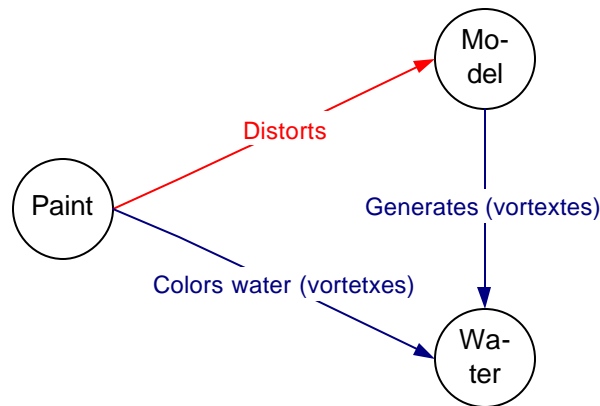


Fig. 4.

Here, conflicting interactions develop among three components of the system: the water (vortexes), the model, and the paint. Removal of the paint from the system makes it much less effective, but does not completely ruin its performance (one can still see, albeit poorly, vortexes of clear water). This takes the paint into the category of auxiliary components, and, in keeping with our rule, out of the system.

Thus, a new system conflict develops: *Absent paint does not distort the model, but does not color the water (vortexes) either.* To resolve this system conflict, one can use ideality approach 2 (see "Ideal System"). Ideally, the water itself should color the vortexes (see Fig. 5). To accomplish this, the water, of course, should be somehow "modified."

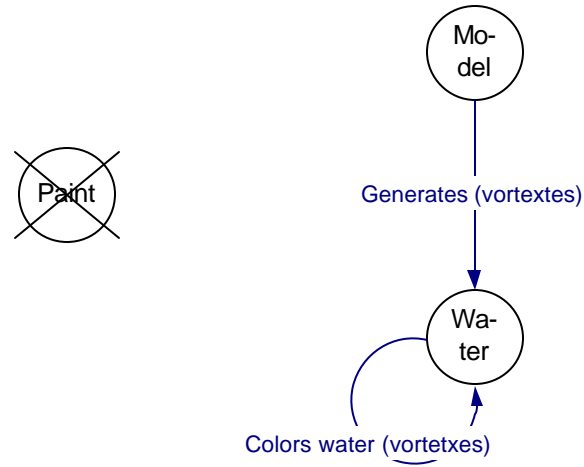


Fig. 5.

Solution

Gas bubbles are used to “color” the vortexes (Fig. 6). To form the bubbles, a physical effect of electrolysis is used. Running electric current through the water while using the model as an electrode, results in decomposition of the water into hydrogen and oxygen. Bubbles consisting of these gases enter the vortexes and make them visible.

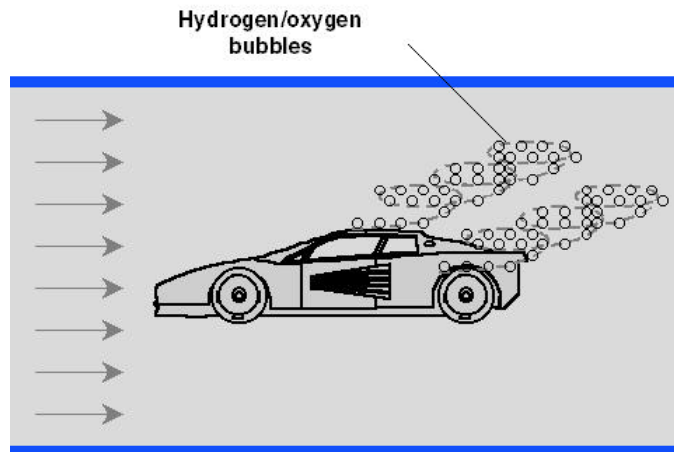


Fig. 6.

Case Study 2

Initial Situation

Some vacuum processing systems contain pipe lines made of glass pipes welded together. After the pipes are welded, the welds have to be hole-checked (see Fig. 7). To accomplish this, an electrode is inserted inside the pipe and positioned against the weld. Another electrode is positioned outside the weld. When high electric voltage is applied to the electrode a corona discharge develops across the glass (this is seen as a glowing zone between the electrodes). If there is even the tiniest hole in the weld, the discharge concentrates in it, and the air in the hole starts to shine brightly. The outside electrode is then removed and the hole is brazed with a gas welding torch. Yet, as soon as the outside electrode is removed, the hole can no longer be seen, and one is forced to braze a wider weld area than is necessary. This is an undesirable effect because it causes harmful thermal stresses.

An attempt was made to combine the hole detection and welding processes into one operation by performing the welding while maintaining the corona discharge. However, this led to the rapid burn out of the outside electrode, as it could not withstand the high-temperature torch long enough.

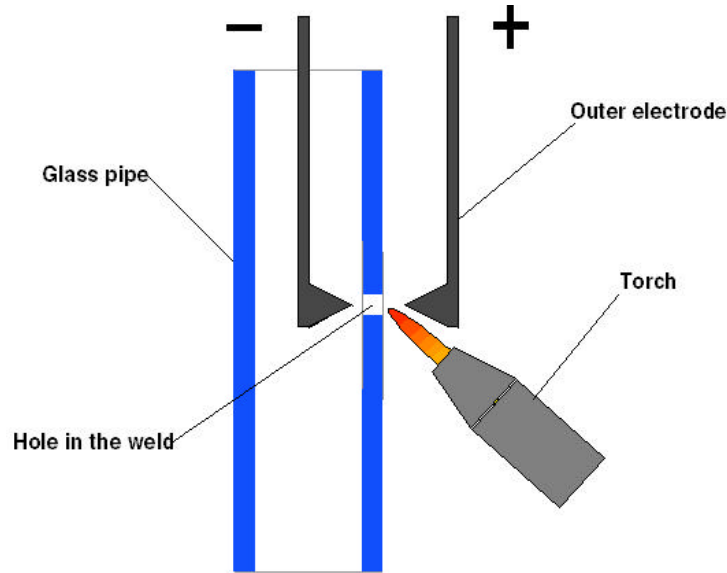


Fig. 7.

TRIZ Analysis

The primary function of this system is pipe repair. The system conflict is easily formulated (see Fig. 8): *The outer electrode allows for detection of the hole, but is damaged by the torch.*

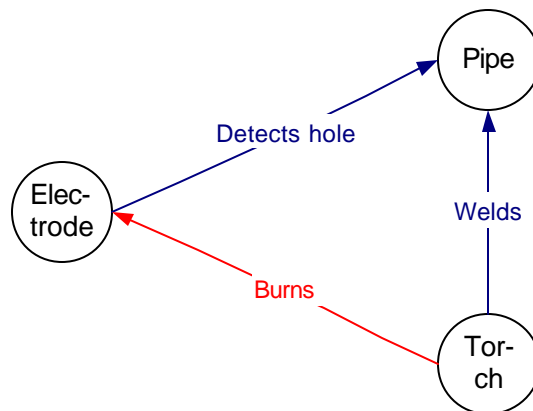


Fig. 8.

As in the previous case, conflicting interactions develop among three components of the system: the outer electrode, the pipe, and the torch. Since the primary function is pipe repair, the outer electrode is relegated to auxiliary component status. According to the rule, this calls for its elimination.

A new system conflict develops: *An outer electrode that is absent cannot be damaged, but without it the hole is not detected.* This conflict can be resolved by the already familiar approach: the electrode's function is delegated to a remaining main component (see Fig. 9).

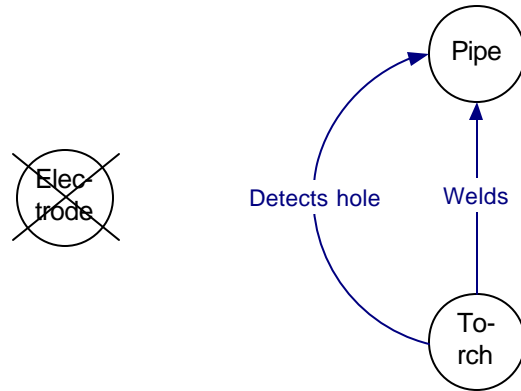


Fig. 9.

Solution

Use the gas torch as an outer electrode (Fig. 10). Here, ions present in the flame conduct electrical current of the corona discharge.

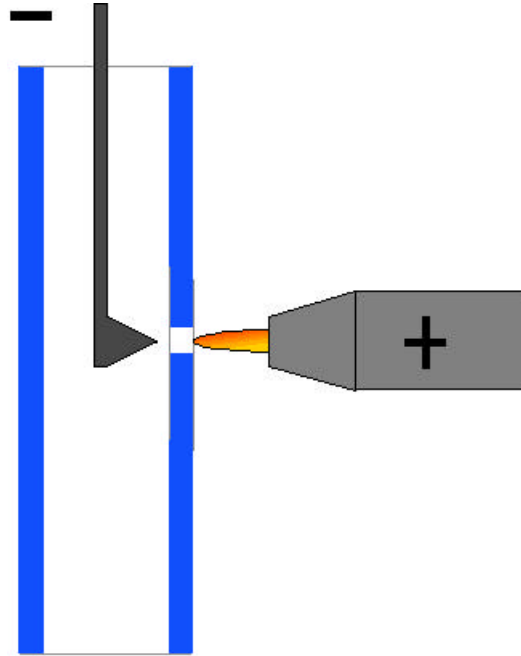


Fig. 10.

Now, let's try to find and overcome a system conflict in the following problem:

Hot Extrusion Problem

Extrusion of hot metals is an effective method for fabrication of net-shaped parts. (see Fig. 11). In this process, a hot billet is first inserted inside a container. Then the hydraulically-powered ram squeezes the billet out of the die, so the finished part assumes the shape of the die's opening. About 70 percent of the ram force is spent on overcoming friction between the billet and the walls of the container. To reduce friction, various lubricants are used (usually liquid glass and graphite). The lubricants, however, may adversely affect the mechanical properties of the extruded part's surface. What can be done?

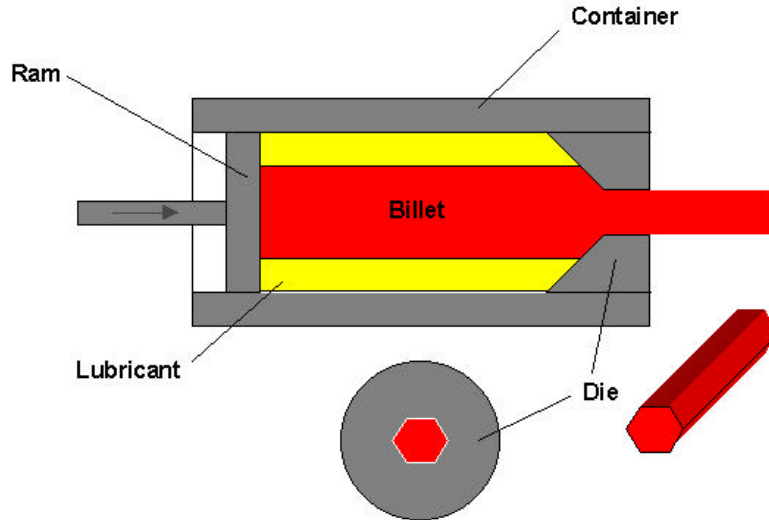


Fig. 11.

*Solution to the Steering Wheel Shake Problem**

An ideal vibration absorber is one that is absent, yet its function is fully performed. The suggested solution entailed the use of the air bag as the vibration absorber (see Fig. 12). Use of the air bag as the vibration absorber mass required its attachment to the steering wheel via tuned resilient elements. Air bag performance was not affected, as demonstrated in numerous deployment tests, and a reduction of the steering wheel vibrations by 6 to 7 times was achieved. The lead-based absorber was eliminated altogether, reducing both cost and environmental hazards.

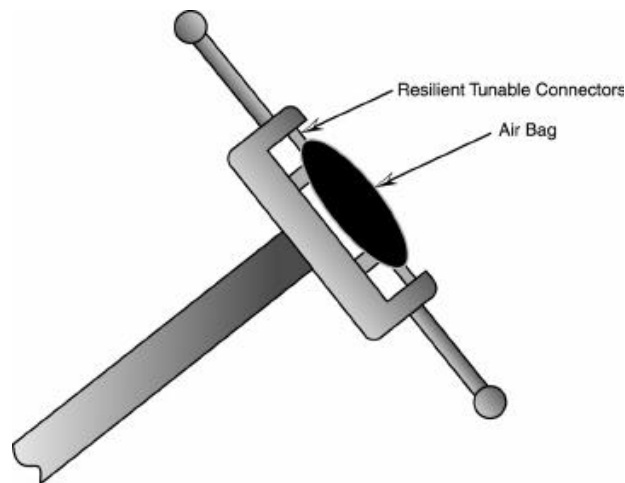


Fig. 12.

* See the article "Ideal System."