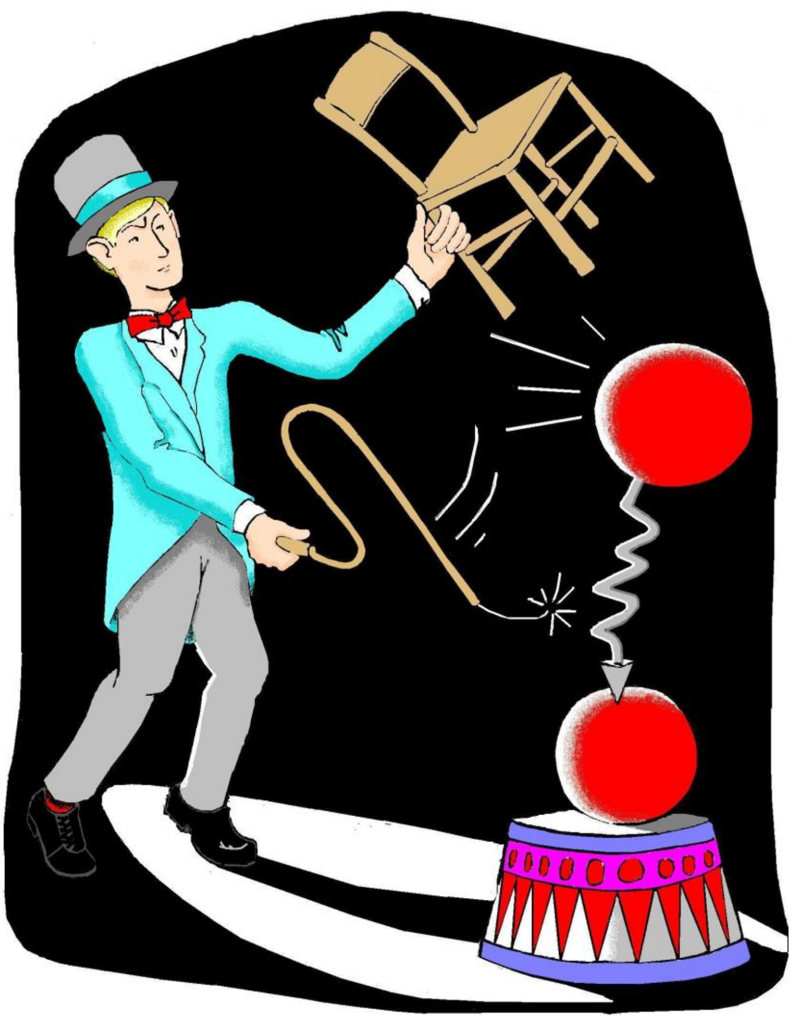
TRIZ POWER TOOLS

Skill #9 Neutralizing Harmful Functions

May 2013 Edition



Adding Functions to Neutralize Harm

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The Algorithm

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Introduction

If you are reading the PDF format—navigate the algorithms with the "Bookmarks" to the left. L1, L2, L3 correspond to levels of the algorithm. The levels are hierarchical; you can go as deeply as required for the situation at hand. Lower levels (L1, L2) have consolidated methods. If you are using the book then use the Table of Contents for the Algorithm.

Each of the books in the TRIZ Power Tools book series are designed to be used as an algorithm. The use of each algorithm can be as detailed or simple as required. This is done by going up or down in the hierarchy of the process steps. The top level (L1) of the bookmarks is the highest level. If more detail is required, the user can go to deeper levels (L2 and L3). A "Cheat Sheet" may be separately provided at www.opensourcetriz.com which can be used to help the problem solver remember the details of the algorithm that are difficult to commit to memory.

Where the Book Materials Come From

Much of the material for this book was inspired by the thought leaders referenced. The original intent was to codify the insights of these thought leaders, but the exercise of codification ultimately led to the synthesis of other experimental processes. This is because codification required recognizing patterns of similarity of tools. Once this was achieved, the various tools were grouped with key decisions. Decisions require and create information which flows to the next decisions. Patterns and gaps became visible during this formative process. Experimental methods were inserted into the gaps. The proof of these experimental methods is whether they actually help the reader to solve real-life problems or identify product or process characteristics that will delight the market.

Neutralizing Harmful Functions

Neutralizing harmful functions is about adding useful functions to the system to neutralize other harmful functions. Generally, we do not want to add functions to a system. This can increase the complexity and cost of the system. By the time that we consider neutralizing functions, we have already tried to idealize the harmful function by making it useful or avoiding the harmful function altogether. If that did not work, we tried to mobilize existing resources to decrease the negative effects of the harmful function. If a contradiction arose, we would resolve it. As a last resort, we consider adding functions to the system to reduce the harmful functions.

We should note that some situations are readily justified in increasing the complexity of a system if the super-system can be decreased in complexity. We should also note that resolving contradictions can require the addition of functions, especially of Separation in Time is used.

It is notable that many of the Solution Standards and other TRIZ tools are stated in functional language. Suggestions for how we might neutralize functions come from a restructuring and reinterpretation of the parts of the Solution Standards.

L1-Neutralize Harmful Functions

So far we have emphasized that all efforts should result in simplification. Our strongest efforts should be towards removing system elements to resolve the problem. There is, however an exception to this rule. We will allow ourselves to add elements or complexity to the system if there is a greater offset elsewhere in the system or super-system.

We will also allow ourselves to add functions and their attending elements as a means of last resort. But we will do everything that we can to "add but not add". In other words, we will look for ways that the functions can be performed without the addition of elements.

We will try each approach in its turn. The order of the approaches are presenting those that drive to the most ideal systems first. For instance, it is better to consider stopping harm before we consider how it might be detected, healed or how we might provide redundancy.

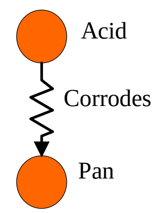
The reader will note that there are many examples of the use of function diagrams. This is not just decoration. The act of creating a function diagram causes the user to see the problem in a different light.

L1-Method

Step 1: Neutralize the harmful function by weakening the harmful tool; neutralizing the harmful field; channeling the harm away; strengthening the product to take the harm; placing a mediator between the tool and the product; redirecting harm to a pre-weakened expendable component; detecting the harm; healing the harm or providing a previously placed cushion in the event of failure.

Example—Acid Container

The assumption here is that the addition of an element to our system allows the supersystem to become simpler. The corrosion of the pan does add a further element of complexity to the super system as it requires someone to replace the container. This requires transactional functions. What ever is added must be simpler and less expensive than the transactional function that it replaces.



Step 1: Neutralize the harmful function by weakening the harmful tool; neutralizing the harmful field; channeling the harm away; strengthening the product to take the harm; placing a mediator between the tool and the product; redirecting harm to a pre-weakened expendable component; detecting the harm; healing the harm or providing a previously placed cushion in the event of failure.

First, we try to weaken the acid. This is not good because we need a strong acid to corrode the coupons. One way around this is next attack the contradiction. The acid needs to be weak in order to not corrode the pan and it must be strong on order to corrode the coupons. We can look at this possible contradiction later.

The next approach is to neutralize the harmful field. The fields in this case are the chemical fields which cause the corrosion. As we have before hinted, it may be possible to introduce fields sufficiently strong to neutralize the chemical fields.

The next approach is to strengthen the pan so that it is not corroded by the acid. Potentially, an oxide layer is used to strengthen the pan. Introducing sufficient oxygen into the acid may make this possible if the material of the pan is correct. Tantalum is an excellent material for corrosion, precisely because of the oxide layer that is formed and protects the pan.

The use of a mediator is next suggested. Most people would think of this as one of the initial suggestions. What is missing is the hidden idea that the mediator should be made of one of the materials of the interaction. Either it should be made from some form of the tool or the product. In our case, it may be best to form the mediator out of the solid form of the acid since it is unharmed by the liquid acid. We might find a way to form the solid acid to make this happen.

The next approach is to redirect the harm to a pre-weakened expendable component. This brings us back to an idea that we have considered before. We really want the acid to attack the cubes. That is its primary function. Perhaps we can make the cubes into a prep-weakened structure that will take all of the harm. Making the container form the material of the cubes is one way. Creating a voltage differential between the two may be another way. In boilers, the method of adding a sacrificial material is used to keep the important components from corroding.

Detecting the harm will not help us much here as we are well aware of the harm that is happening all of the time.

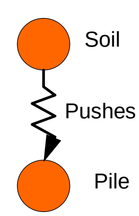
Healing the harm would mean that we are to replenish the dissolved material as it happens. We note that the dissolved material is readily available if we can just get it to plate back onto the material.

Finally, a previously placed cushion makes it possible to keep the acid from flowing elsewhere. If this were very important, then we would like the breach of the container to be known before the next batch of coupons. In this case, a previously placed container outside of the existing container does not simplify the system very much.

Example—Pile Driving

We are adding an element to the system to neutralize the effects of the soil pushing against the pile.

Step 1: Neutralize the harmful function by weakening the harmful tool; neutralizing the harmful field; channeling the harm away; strengthening the product to take the harm; placing a mediator between the tool and the product; redirecting harm to a pre-weakened expendable component; detecting the harm; healing the harm or providing a previously placed cushion in the event of failure.



Weakening the harmful tool means that the soil cannot sustain a large amount of stress without moving out of the way. We must do something to modify the soil. One thing that comes to mind is to separate the soil particles or lubricate them.

Channeling the harm away means that the pushing force goes somewhere other than the pile. Where can it go? If the forces to push the soil remain high, then there is an equal and opposite force on the pile. A possibility is not seen for this approach.

Strengthening the product to take the harm does not seem to apply here.

Placing a mediator between the pile and the soil does not diminish the reaction forces on the pile.

Redirecting the pushing to an expendable component does not seem to apply.

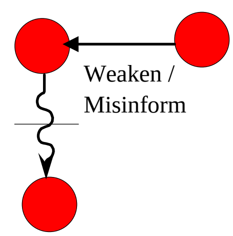
Detecting the pushing does not help to reduce the harm that might follow.

There is no way to "heal pushing".

A previously placed cushion is not necessary because the harm of pushing does not decrease the ability of the pile to perform its function.

L2-Weaken or Misinform the Harmful Tool

If existence of the tool is unpreventable, identify preventative modifications on the harming tool which will have the effect of weakening the harmful effect on the product while the product is being harmed.



Sometimes, the harming object exhibits intelligent action. We can prevent the harm by misinforming the tools so that the harmful function does not occur in the first place, or it can be fooled while the harmful modification should be happening. The ideal tool is misinformed.

Method

Step 1: Consider potential modifications to the tool that prevent harm in the first place. If the tool exhibits intelligence, then identify the misinformation that the tool requires.

Step 2: Identify the physical phenomenon that would deliver the modification. If the tool exhibits intelligence, consider hiding or camouflaging the product.

Step 3: Identify the tool which would deliver the physical phenomenon. Try to find ways to get other objects in the system to perform the modification. If possible, the tool should perform it on itself[1]*. If the tool exhibits intelligence and the misinforming must occur during the harmful modification, consider what object will misinform the tool.*

1 Inventive Principle #25—Self-service: An object must service itself and carry-out supplementary and repair operations. Make use of waste material and energy. Genrich Altshuller, The Innovation Algorithm page 288.

Example—Wing Icing

At high altitudes, the air can be very pure and devoid of particulates. Under these conditions, water can exist at temperatures much lower than freezing in liquid form. The water needs a solid surface upon which to nucleate before it will freeze. This is unfortunate for aircraft flying through these super-cooled water droplets because the instant that the water strikes the leading edge of the wing it freezes. The flow of the air over the wing forces the water droplets to travel on an unusual path. The ice begins to build up. Now the water nucleates on the ice and begins to build up two ridges along the leading edge of the wing. A cross-section of the wing looks as though horns are forming on the leading edge. This shape so disrupts the flow of air over the wings that it completely loses lift and the plane will plummet to the earth. If it were only possible to weaken the tool (the ice on the leading edge which nucleates the ice) or the product (in this case, it is the water droplets which are channeled) then the ice will not form on the leading edge of the wing.

Step 1: Consider potential modifications to the tool that prevent harm in the first place. If the tool exhibits intelligence, then identify the misinformation that the tool requires.

The leading edge of the wing is the tool that must be weakened so that it cannot be a surface upon which the ice will form. Another avenue might be to weaken the product, or water droplets. In this case, if they might be turned into ice before striking the leading edge of the wing then they will bounce harmlessly off of the wing instead of sticking.

Step 2: Identify the physical phenomenon that would deliver the modification. If the tool exhibits intelligence, consider hiding or camouflaging the product.

Heating the leading edge of the wing will weaken the ice that forms in ridges. Another possibility may be to use ultrasound to crystallize the water droplets before they strike the wing. It is known that ultrasound can be used to crystallize super-cooled liquids.

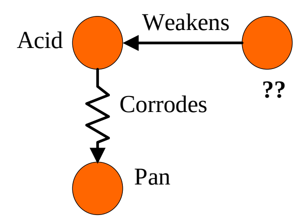
Step 3: Identify the tool which would deliver the physical phenomenon. Try to find ways to get other objects in the system to perform the modification. If possible, the tool should perform it on itself[2]. If the tool exhibits intelligence and the misinforming must occur during the harmful modification, consider what object will misinform the tool.

It may be possible to heat the leading edge of the wing to weaken the ice that forms there. It may be possible to use the air-flow, itself, to produce strong ultrasonic waves to crystallize the droplets of water.

2 Inventive Principle #25—Self-service: An object must service itself and carry-out supplementary and repair operations. Make use of waste material and energy. Genrich Altshuller, The Innovation Algorithm page 288.

Example—Acid Container

We would like to weaken the acid.



Step 1: Consider potential modifications to the tool that prevent harm in the first place. If the tool exhibits intelligence, then identify the misinformation that the tool requires.

Ultimately what we want is for fewer hydrogen ions to attack the pan. This is not good because we need a strong acid to corrode the coupons. One way around this is next attack the contradiction. The acid needs to be weak in order to not corrode the pan and it must be strong on order to corrode the coupons. We can look at this possible contradiction later.

Step 2: Identify the physical phenomenon that would deliver the modification. If the tool exhibits intelligence, consider hiding or camouflaging the product.

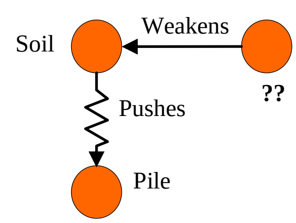
There are different ways to do this such as diluting the acid or causing the hydrogen ions to react with a base to remove them from solution.

Step 3: Identify the tool which would deliver the physical phenomenon. Try to find ways to get other objects in the system to perform the modification. If possible, the tool should perform it on itself[3]. If the tool exhibits intelligence and the misinforming must occur during the harmful modification, consider what object will misinform the tool.

Water can dilute the acid or any base can remove hydrogen ions. If we consider the tool performing it on itself, we realize that the negative ion which is also in solution with the hydrogen ions is capable of tying up the hydrogen ions so long as water is removed from the solution. This brings us to the possibility of using the solid form of the acid which will not react with the pan.

Example—Pile Driving

The intention of this is to weaken the soil so that it does not push back on the pile.



Step 1: Consider potential modifications to the tool that prevent harm in the first place. If the tool exhibits intelligence, then identify the misinformation that the tool requires.

Since there are no intelligent agents here, we will not consider misinforming the soil. Weakening the harmful tool means that the soil cannot sustain a large amount of stress without moving out of the way. We must do something to make the yield stress of the soil as small as possible.

Step 2: Identify the physical phenomenon that would deliver the modification. If the tool exhibits intelligence, consider hiding or camouflaging the product.

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3 Inventive Principle #25—Self-service: An object must service itself and carry-out supplementary and repair operations. Make use of waste material and energy. Genrich Altshuller, The Innovation Algorithm page 288.

One thing that comes to mind is to separate the soil particles.

Other possibilities are to segment the soil further. Large rocks should become sand.

The shape of the soil particles should weaken the interaction between them. For instance, the shape of the soil should be round and small like little balls so that the pile glides easily through it.

A lubricant could be used to decrease the interaction.

Step 3: Identify the tool which would deliver the physical phenomenon. Try to find ways to get other objects in the system to perform the modification. If possible, the tool should perform it on itself[4]*. If the tool exhibits intelligence and the misinforming must occur during the harmful modification, consider what object will misinform the tool.*

The easiest possibility is to have the water separate the soil particles to weaken their interaction. Since we are driving the piles in the water, it is may be possible to also drive water between the particles of soil.

L2-Max and Min Action with Minimum Field

A maximum effect needs to occur in one zone and a minimum action in another zone but the field must be minimized. [5] This usually occurs where a useful function is required but the fields are not sufficient to perform the function. The ideal product is capable of receiving the action, but not without some modification. We still want the minimum action everywhere else.

Method

Step 1: If the effect is amplified over everything and some harm will occur then we may choose to use the minimum field.

Step 2: If the field is minimal and cannot be amplified then we may have to use the minimum field.

Step 3: Given that we are going to use the minimum field then a substance or field is introduced to amplify the affects of the field where it is needed.

4 Inventive Principle #25—Self-service: An object must service itself and carry-out supplementary and repair operations. Make use of waste material and energy. Genrich Altshuller, The Innovation Algorithm page 288.

5 STANDARD 1-1-8-2. If a selective-maximum effect is required (maximum in certain zones, and minimum in other zones), the field should be minimal; then a substance that produces a local effect interacting with a field (e.g. thermite compounds for thermal action or explosive ones for mechanical action) is introduced in places where a maximum effect is required. Example: To weld two metal parts, an exothermic powder producing extra heat is introduced between the parts.

Example—Welding Parts

During welding, adjacent material properties are changed or compromised. (This example comes from the reference below)

Step 1: If the effect is amplified over everything and some harm will occur then we may choose to use the minimum field.

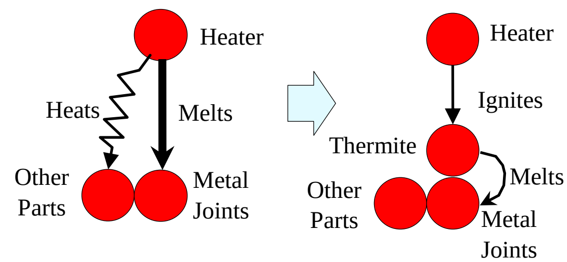
In this case, a high heat field applied everywhere will hurt other elements.

Step 2: If the field is minimal and cannot be amplified then we may have to use the minimum field.

The field is controllable so that this does not apply.

Step 3: Given that we are going to use the minimum field then a substance or field is introduced to amplify the affects of the field where it is needed.

An exothermic powder such as thermite which produces extra heat is introduced between the parts.



Example—Acid Container

We need to weaken the acid everywhere but at the location of corrosion.

Step 1: If the effect is amplified over everything and some harm will occur then we may choose to use the minimum field.

Harm does occur elsewhere, so we want the minimum corrosion field to occur everywhere except the location of the useful corrosion.

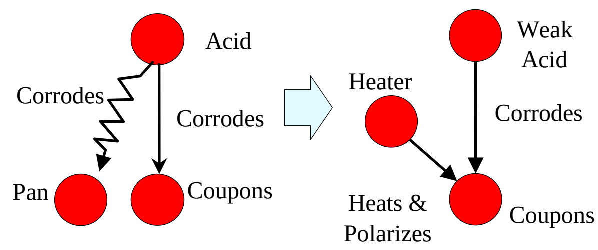
Step 2: If the field is minimal and cannot be amplified then we may have to use the minimum field.

No, the field can be easily amplified so this condition is not evoked. It is sufficient that harm will occur elsewhere if the fields of the corrosion are left as they are.

Step 3: Given that we are going to use the minimum field then a substance or field is introduced to amplify the affects of the field where it is needed.

Perhaps by manipulating the voltage of the coupons, we can use a weak acid and make it highly active at the place where we want it to corrode the most.

It might also be possible to heat the coupons and cool the pan. This is interesting because the large oven might be no longer required. We can heat the coupons in a variety of ways such as attaching small resistance heaters. Directly running current



through the coupons is also possible. This would also have the added benefit of activating the acid more highly where the cubes are and lowering the activity on the pan.

Example—Pile Driving

We have a useful action of the soil pushing on itself.

Step 1: If the effect is amplified over everything and some harm will occur then we may choose to use the minimum field.

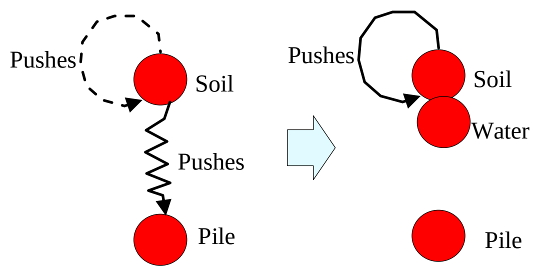
If we amplify the action of pushing on the soil everywhere, is there somewhere it is harmful? Yes, it is harmful on the pile tip. This is sufficient to invoke this approach. However, in order for it to work, the pushing field must be weak at the pile tip and then be strong everywhere else to push the soil.

Step 2: If the field is minimal and cannot be amplified then we may have to use the minimum field.

The field is minimal if we make it minimal. It can then be amplified to move the soil.

Step 3: Given that we are going to use the minimum field then a substance or field is introduced to amplify the affects of the field where it is needed.

The pushing of the soil on the pile must be weak, but where the soil pushes on itself, it should be amplified. This brings to mind the possibility of high forces generated in a thin layer of soil along the length of the pile which has high stresses, but at the pile tip, the forces on the pile are low. This may be possible if water is injected into the tip area where a small cross section is exposed to the water. The high forces on this small area generate high hydraulic pressures which could push up on the thin layer of water around the pile. The diagram illustrates that the combination of the soil and the water amplify the effect of pushing.



L2-Max and Min Action with Maximum Field

A maximum effect needs to occur in one zone and a minimum action in another zone but the field must be maximized. [6] The field may be difficult to control or constant from the native environment such as gravity.

Method

Step 1: Identify whether the fields must be high in order to perform the useful function

Step 2: Identify whether the field location is easily controlled.

Step 3: If the field must be high and difficult to control then a substance is introduced to draw off the field to protect those parts of the system that could be harmed.

Example—Sealing Glass Ampoules

When sealing a glass ampoule with liquid medicine, an overheated glass might destroy the medicine. (This example comes from the reference below).

Step 1: Identify whether the fields must be high in order to perform the useful function.

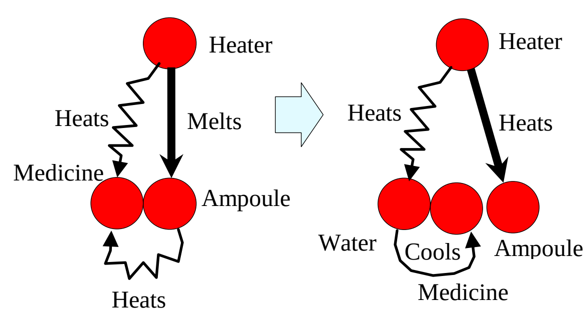
The heater temperature must be high in order to melt the ampoule and close it.

Step 2: Identify whether the field location is easily controlled.

The location of the field is very difficult to control. Hot gases are going everywhere.

Step 3: If the field must be high and difficult to control then a substance is introduced to draw off the field to protect those parts of the system that could be harmed.

The ampoule is put into water leaving the ampoule's tip above the water. Water protects the rest of the ampoule from overheating.



Example—Acid Container

We need to introduce a substance to draw off the corrosive action of the acid on the pan.

Step 1: Identify whether the fields must be high in order to perform the useful function.

We would like the corrosive action of the acid to be as high as possible on the coupons.

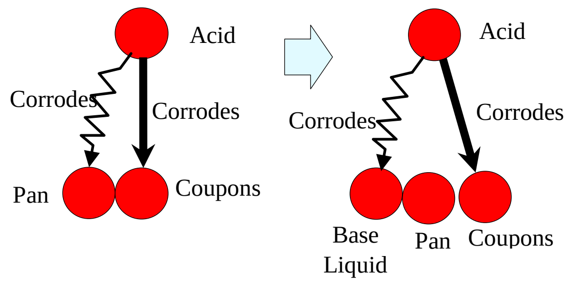
Step 2: Identify whether the field location is easily controlled.

6 STANDARD 1-1-8-1. If a selective effect of action is required (maximum in certain zones, while the minimum is maintained in other zones), the field has to be maximal; then a protective substance is introduced in places where a minimum effect is required. Example: When sealing a glass ampoule with liquid medicine, an overheated glass might destroy the medicine. The ampoule is put into water leaving the ampoule's tip above the water. Water protects the rest of the ampoule from overheating.

The location of the field is difficult to control.

Step 3: If the field must be high and difficult to control then a substance is introduced to draw off the field to protect those parts of the system that could be harmed.

We have discussed this elsewhere, but the idea here is to draw off the harmful fields so that they go somewhere else. This means that the harmful molecular interaction that pull of the metal must pull off something else. If we go to a microscopic level, the molecules are packed tightly together, both in the liquid and in the metal. This means that the tendency to pull apart one molecule is drawn off by one that is very close by and the molecule that is pulled off is rapidly replaced by another. It is like either the molecules push between the metal molecules and present themselves as a sacrifice. Perhaps if the metal were porous, then a sacrificial fluid with high Ph (base) could fill the pores and be replenished. While this is not happening at a molecular level, it might be made to work.



Example—Pile Driving

We need to introduce a substance to draw off the soil forces so that they do not push on the pile.

Step 1: Identify whether the fields must be high in order to perform the useful function.

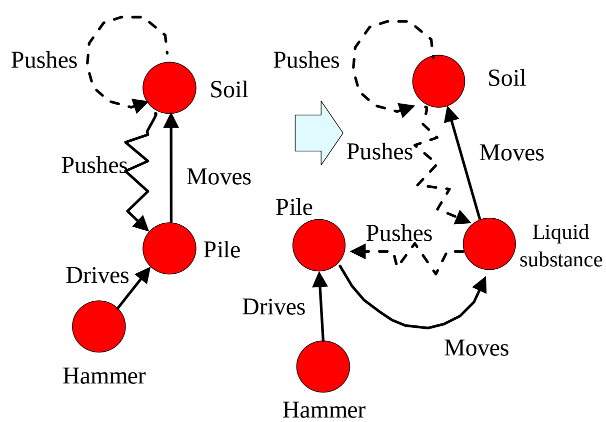
We would like the field to be high in order to push the soil aside.

Step 2: Identify whether the field location is easily controlled.

The field location is distributed throughout the soil and is difficult to control.

Step 3: If the field must be high and difficult to control then a substance is introduced to draw off the field to protect those parts of the system that could be harmed.

Channeling the harm away means that the pushing force of the soil on the tip of the pile goes somewhere other than the pile. Where can it go? The forces on the tip of the pile that move the soil have an equal and opposite force on the pile. This is probably not a good approach for counteracting this harmful function since a lot of soil needs to be moved.



One way to approximate this approach is to pre-insert a liquid substance into the soil.

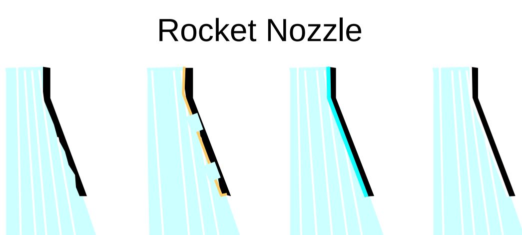
The new substance provides very little resisting force to the pile as shown in the diagram to the right. This is effectively a mediator, as will be shown in the mediator section, which must do the heavy moving of the soil itself. While the driving of the pile is faster, there is no guarantee at this point that the insertion of the liquid into the soil will speed the overall insertion time of the pile. Somehow you have to get the liquid into the soil. While we could take this further, we will not at this point.

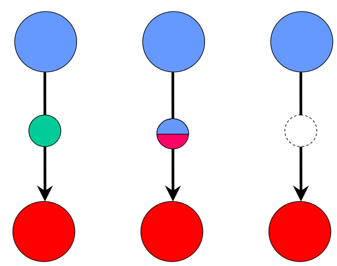
L2-Mediator

The ideal tool is one that does not harm the product. The ideal product is one that we don't mind harming. A mediator becomes both. Most of the harm is being directed to the mediator. This diminishes the harm to the product during the harmful function. Unfortunately, the mediating object is a new object in the system, but it can often be decreased to a coating or minor object. [7] Ideally the mediating object should be made from some derivative of the product or tool.[8] (That is indicated by the two tone mediator). This usually reduces the complexities that often occur with mediators that are composed of substances that are foreign to the system.

Line of Evolution

Following is the line of evolution of mediators.





7 STANDARD 1-2-1. If useful and harmful effects appear between two substances in a SFM and there is no need to maintain a direct contact between the substances, the problem is solved by introducing a third substance between them. Notes: The third substance can also be obtained from the present substances by exposure to the existing fields. In particular, the substance to be introduced can be bubbles, foam, etc. Example: To compact walls of a borehole, gases produced during explosion are used. However, the gases also may cause cracks in the borehole's walls. It is proposed to cover the walls by plasticine that transmits pressure but prevents the walls from crack formation.

8 STANDARD 1-2-2. If there are a useful and a harmful effects between two substances, and there is no need to maintain direct contact between the substances, and it is forbidden or inconvenient to use foreign substances, the problem can be solved by introducing a third substance between the two, which is a modification of the first or the second substances. Note: The third substance can be obtained from the existing substances by exposure to the present fields. In particular, the substance to be introduced can be bubbles, foam, etc. Besides, a modification of the substance may bring about a change in the law of its movement: movable-fixed parts, etc. Example: A hydrodynamic foil's surface might be destroyed by a cavitation produced by the friction between the foil and the water when moving at a high speed. It is proposed to refrigerate the surface of the foil. Surrounding water will freeze and form an ice layer on the foil.

Possible Modifications to Substances

The table to the right shows several ways that one of the existing substances could be modified to become a more ideal mediator.

• Internal additives	• State of Matter
• Ionized	• Chemically altered
• Recombined	• Heat treatment
• Dilution of constituents	• Electrification
• Concentration of constituents	• Heated
• Change of Bulk Properties	• Foam
• Form structures at micro level	• Decomposed
	• Mobilized

Method

Step 1: Place a substance between the tool and the product. This object stops the harm.

--Use a foreign substance

--Enclose both the tool and the product in the mediator

Step 2: Consider ways that this could be performed without the addition of any new substance. Ideally this should use objects or substances that are modifications or derivatives of existing substances (either the tool or the product).

--Place a void or rarified gas between the tool and product

--Use a modification of the tool substance

--Use a modification of the product substance

--Use a mixture of the tool and product

--Use multiplied versions of the tool or product

Example—Distribution of Uneven Loads

A clamping device is used to hold uneven objects. Because of the shape of the object, some parts of the object are more highly stressed than others and yield under the load.

Step 1: Place a substance between the tool and the product. This object stops the harm.

--Use a foreign substance

--Enclose both the tool and the product in the mediator

A substance with a much lower yield point is placed between the clamp and the objects such as a hard rubber. The rubber more evenly distributes the load over the clamped object.

Step 2: Consider ways that this could be performed without the addition of any new substance. Ideally this should use objects or substances that are modifications or derivatives of existing substances (either the tool or the product).

--Place a void or rarified gas between the tool and product

--Use a modification of the tool substance

--Use a modification of the product substance

--Use a mixture of the tool and product

--Use multiplied versions of the tool or product

If the clamping were performed in a hot environment where pliable members were more difficult to use, the clamp could employ powders made from the same materials that were being clamped so as to avoid problems with the mediator reacting poorly with the clamped objects. The powders would yield around the clamped surface and distribute the load evenly.

Example—Acid Container

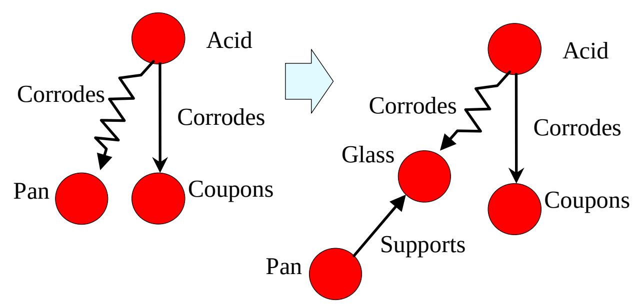
Something must go between the acid and the pan.

Step 1: Place a substance between the tool and the product. This object stops the harm.

--Use a foreign substance

--Enclose both the tool and the product in the mediator

It is assumed that the pan material is the best possible to contain the corrosion in the first place. So, any substance used would have to be a sacrificial material. If we are going to use a mediator then it must be one that is expendable but lasts long enough to do some good. Example of this would be inexpensive solid liners such as plastics or glass. It must still corrode slowly enough that it does not destroy the effectiveness of the acid.



Step 2: Consider ways that this could be performed without the addition of any new substance. Ideally this should use objects or substances that are modifications or derivatives of existing substances (either the tool or the product).

--Place a void or rarified gas between the tool and product

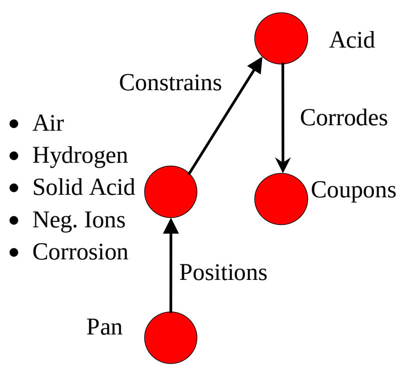
--Use a modification of the tool substance

--Use a modification of the product substance

--Use a mixture of the tool and product

--Use multiplied versions of the tool or product

Acceptable mediators would be liquids or gases that can be replenished. They should be as inexpensive or free as possible. One good candidate is air that could be pumped in or made to fasten itself to the surface of the pan. Another interesting possibility is to use the hydrogen that is formed by the corrosion of the pan to protect the pan. In order for this to work, the hydrogen would need to coat the surface and then stay in place in such a way that the acid could no longer touch the wall.



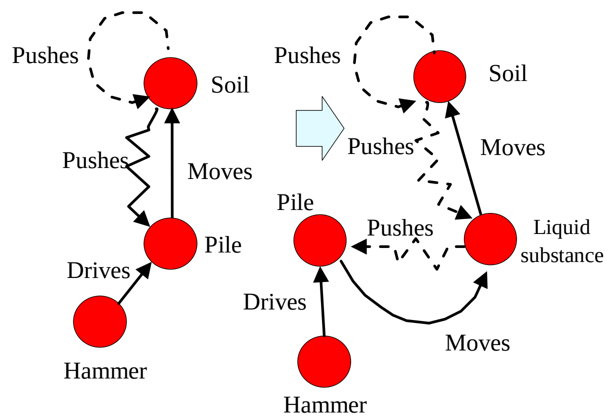
The most acceptable mediator is one that is made of one of the materials of the interaction. Either it should be made from some form of the tool or the product. In our case, it may be best to form the mediator out of the solid form of the acid since it is unharmed by the liquid acid. We might find a way to form the solid acid to make this happen.

Another possibility is to use the negative ions in the fluid to protect the pan. The fields would need to be sufficiently strong to attract these negative ions.

One last possibility is to consider other types of corrosion. One in particular is quite interesting. It turns out that one reason that Tantalum is such a good material for corrosion is that a tantalum oxide (corrosion products not related to acid corrosion) is a very stable and protective material.

Example—Pile Driving

A mediator is sought to put between the pile and the soil such that the pushing on the pile is diminished.



Step 1: Place a substance between the tool and the product. This object stops the harm.

--Use a foreign substance

--Enclose both the tool and the product in the mediator

Many materials could be used to enclose the pile. Unfortunately, anything that pushes on the mediator will also push on the pile.

Step 2: Consider ways that this could be performed without the addition of any new substance. Ideally this should use objects or substances that are modifications or derivatives of existing substances (either the tool or the product).

--Place a void or rarified gas between the tool and product

--Use a modification of the tool substance

--Use a modification of the product substance

--Use a mixture of the tool and product

--Use multiplied versions of the tool or product

Placing a mediator between the pile and the soil does not diminish the reaction forces on the pile.

L2-Redirect Harm to a Pre-weakened Expendable Product

Introduce a weak link or a path of least resistance[9]. Something should be harmed that is expendable rather than the important element.

Method

Step 1: Pre-weaken part of the system so that the harm damages it. If possible, use voids or an absence of material to create the effect.

Example—Electrical Fuse

Electrical fires are often caused in dwellings when wires touch and short circuit. The resulting heat that is generated can cause dwelling fires.

Step 1: Pre-weaken part of the system so that the harm damages it. If possible, use voids or an absence of material to create the effect.

A conductor with higher resistance than the contact resistance and a low melting point is placed in the circuit. When the contact is made between conductors, most of the resistance is in this object and so the electrical power load dissipates its energy melting the substance and opening the circuit.. This is typically called an electrical fuse.

Example—Lizard's Tail

A lizard's tail can often be used by a predator to capture a lizard because it is long and easily trapped between the predator's feet and a surface. Also, it is a large target in general.

Step 1: Pre-weaken part of the system so that the harm damages it. If possible, use voids or an absence of material to create the effect.

The lizard's tail should be pre-weakened to break off close to the torso in such a way that vital organs are not affected. If possible, the tail should grow back over a short period of time to restore balance.

Example—Acid Container

The harm from the acid must go to something else and bypass the pan.

Step 1: Pre-weaken part of the system so that the harm damages it. If possible, use voids or an absence of material to create the effect.

An interesting thought occurred at this point and a search was performed. It turns out that it is possible to control the potential fields by introducing a sacrificial anode material that may be less expensive. This is similar to reversing the field on the pan to stop corrosion. Consult the following link:

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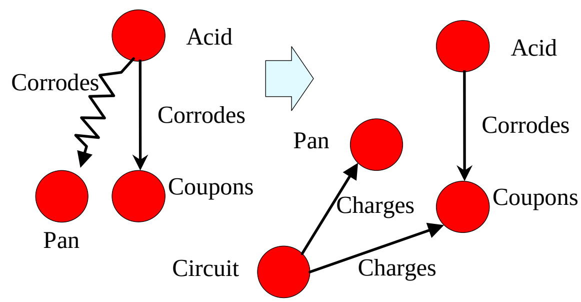
9 STANDARD 1-2-3. If it is required to eliminate the harmful effect of a field upon a substance, the problem can be solved by introducing a second substance that draws off upon itself the harmful effect of the field. Example: To protect underground cables from stresses of ground occurring during frost, cavities are formed in the ground beforehand.

http://www.efunda.com/materials/corrosion/stopping_corrosion.cfm

In order for this to work, the pre-weakened material would need to be right next to the pan material. The molecules would want to attack it first and because it goes away, it would need to be replenished very rapidly. One of the problems with this method is that the acid is rapidly degraded so that it is not as strong as necessary to attack the coupons. Therefore, the material must rapidly go back to its former condition. This suggests a chemical reaction that is equilibrium at all times, but is much more active at a molecular level than the reaction between the acid and the container.

Better yet, what if we could get the acid to preferentially attack the cubes? That is its primary function of the acid in the testing system. Perhaps we can make the coupons, themselves, into a prep-weakened structure that will take all of the harm. This is similar to using a sacrificial material in boilers to keep critical components from corroding. If the coupon, itself, becomes the sacrificial material, then the primary function of the system can only be improved. Corroding the coupons and sacrificing the coupons are essentially the same function. In boilers, the sacrificial material is chosen to create the correct electrochemical potential to keep the critical components from corroding. Since we may not know the sacrificial materials in advance, we can ensure that the coupon becomes the sacrificial material by creating a voltage differential between the pan and the coupons.



Example—Pile Driving

We would like the pushing of the soil to push on something other than the pile that is expendable.

Step 1: Pre-weaken part of the system so that the harm damages it. If possible, use voids or an absence of material to create the effect.

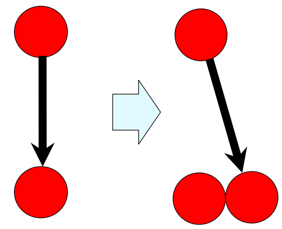
Redirecting the pushing to an expendable component does not seem to apply.

L2-Redirect Extreme Action

An extreme level of action is required but is not allowed for some reason. The extreme level of action is directed toward a second attached object. [10] The reason that it is not allowed can be varied. Perhaps another harmful action occurs or possibly, a useful action occurs in a wrong location on the product. The reason that the action is not allowed must be related to product of the useful action.

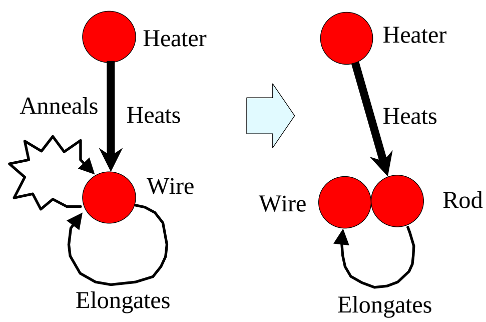
10 STANDARD 1-1-7. If a maximum effect of action on a substance is required and this is not allowed, the maximum action has to be preserved but directed to another substance attached to the first one.

Method



If the situation is such that an extreme level of action is required but is not allowed for some reason, the extreme level of action is directed towards a second object attached to the first product. The attached product performs the required action on the first product.

Example Stretching Wire



"When manufacturing reinforced concrete, it is possible to use metal wire instead of rods. But the wire has to be stretched. To do this it has to be heated up to 700C which is not allowed. The wire is connected to the rod that is heated while the wire remains cold."[11]

If the situation is such that an extreme level of action is required but is not allowed for some reason, the extreme level of action is directed towards a second object attached to the first product. The attached product performs the required action on the first product.

Long lengths of wire are elongated under the action of heat. Unfortunately, the wire loses its temper and cannot maintain the heavy stresses after it is cooled. This is the reason that the extreme temperature is not allowed. By redirecting the heat to the rods, the rods are elongated and when cooled, stretch the wires to the required stress levels. The rods may be sacrificial or they may be such that heat does not harm them. Thus, they can be used over and over.

This is also an example of Separation in Space. The wire must be heated and not heated. A second "wire" attached to the first wire is heated.

Example—Acid Container

We are looking to see if this is a case where the acid performs a useful function on the pan which initiates or causes a harmful action.

If the situation is such that an extreme level of action is required but is not allowed for some reason, the extreme level of action is directed towards a second object attached to the first product. The attached product performs the required action on the first product.

This is not a case where the acid performs a useful action on the pan but a harmful action also occurs. This does not apply.

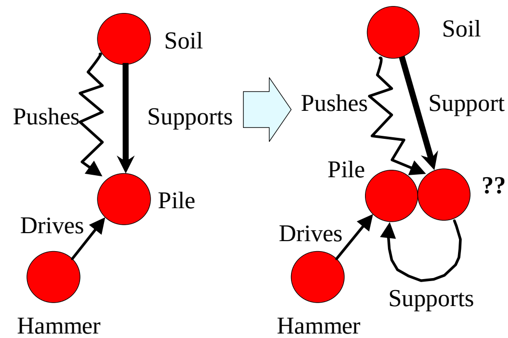
11 Yuri Salamatov—TRIZ: The Right Solution at the Right Time page 231 Standard 1-1-7

Example—Pile Driving

We are looking to see if this is a case where the soil performs a useful action on the pile and a harmful action is initiated or caused.

If the situation is such that an extreme level of action is required but is not allowed for any reason, the extreme level of action is directed towards a second object attached to the first product. The attached product performs the required action on the first product.

The soil performs a useful action on the pile. It supports or pushes on the pile in order to support it. Unfortunately the action is not allowed for the driving. This means that we need to look for a way that the soil's useful AND harmful action of pushing should be directed toward a second object which is attached to the pile. The second object will then perform the function of supporting the pile. Notionally, the figure at the right shows us what we are attempting to do. The problem now becomes one of finding an object that does not push back on the pile while it is being driven, yet is capable of supporting the pile after the driving. It appears that this involves a contradiction. The laws of action and reaction would require that the supporting forces on this mystery object be transferred to the pile during driving. This implies that the pushing forces on the soil are very low during driving and the supporting forces are very high during supporting. For instance, this would be possible if the pile were driven into a liquid substance like concrete during driving and then later, the concrete would set to perform the supporting of the pile. Now a new problem is presented, how the concrete is present in the soil, or how the soil is turned into concrete.



L2-Counter Field

When the field of a useful function also causes a harmful function, a second field is introduced and operates on the harmed product to counter the effect of the first field[12]. Since this often requires the addition of elements to a system, it would only be used if it were able to simplify the super-system or if it can be performed very inexpensively.

Elastic Stress Gravity Friction Adhesion

Buoyant Force Hydrostatic Pressure Jet Pressure Surface Tension

Centrifugal Force Inertial Force Coriolis Force

Oder & Taste Diffusion Osmosis Chemical Fields

Sound Vibrations & Oscillations Ultrasound Waves

Thermal Heating or Cooling Thermal Shocks

Information

Corona Discharge Current Eddie Currents Particle Beams

Nuclear Forces

Electrostatic Fields Magnetic Fields Electromagnetic Fields

Radio Waves Micro Waves Infrared Visible Light Ultraviolet X-Ray Cosmic

Method

Step 1: Identify the field being employed by the harmful function.

Step 2: Identify a second field which is capable of countering the effect of the first field on the harmed product.

Step 3: Are there existing elements in the system that could take on this additional function.

Example—Flower Pollination

In order to pollinate flowers, airflow is used to move the pollen about. Unfortunately, the airflow also has the tendency to close the flower petals making the distribution of pollen inefficient.

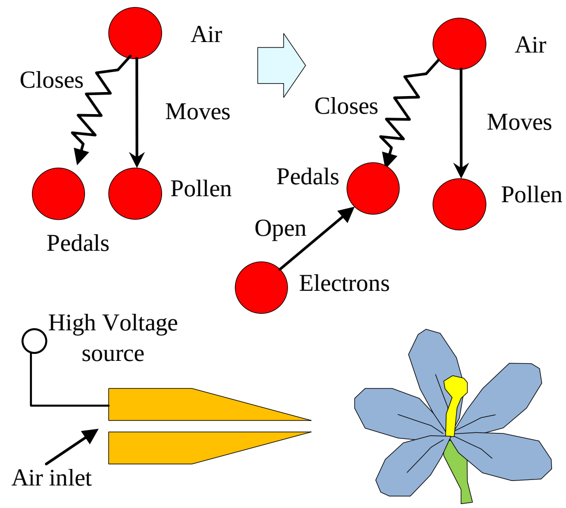
12 STANDARD 1-2-4. If useful and harmful effects appear between two substances in a SFM, and a direct contact between the substances must be maintained, the problem can be solved by transition to a dual SFM, in which the useful effect is provided by the existing field while a new field neutralizes the harmful effect (or transforms the harmful effect into a useful effect). Example: To help with pollination of a flower, airflow is used. However, it also closes the flower. It is proposed to open the flower with electrostatic discharge.

Step 1: Identify the field being employed by the harmful function.

The harmful field is jet pressure.

Step 2: Identify a second field which is capable of countering the effect of the first field on the harmed product.

Electrostatic fields can counter the air force on the pedals causing them to push away from each other against the airflow[13]..



Step 3: Are there existing elements in the system that could take on this additional function.

There are existing electrons in the system, but they need to be collected by a device in the system. Potentially, the nozzle which directs the air could also introduce a corona field into the air to charge the pedals. This would be especially true if the edges of the nozzle could be made very sharp.

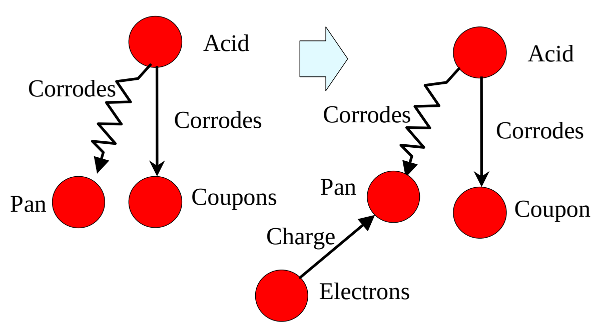
Example—Acid Container

We would like to introduce a field into the pan to counter the fields that are dismanteling the pan, molecule by molecule.

Step 1: Identify the field being employed by the harmful function.

The molecules of pan are pulled from the surface by electrostatic forces

Step 2: Identify a second field which is capable of countering the effect of the first field on the harmed product.



The next approach is to neutralize the harmful field. The fields in this case are the chemical fields which cause the corrosion. As we have before hinted, it may be possible to introduce fields sufficiently strong to neutralize the chemical fields.

13 STANDARD 1-2-4. If useful and harmful effects appear between two substances in a SFM, and a direct contact between the substances must be maintained, the problem can be solved by transition to a dual SFM, in which the useful effect is provided by the existing field while a new field neutralizes the harmful effect (or transforms the harmful effect into a useful effect). Example: To help with pollination of a flower, airflow is used. However, it also closes the flower. It is proposed to open the flower with electrostatic discharge.

Step 3: Are there existing elements in the system that could take on this additional function.

It may be possible to make the pan from an appropriate material with a high enough potential to perform the action itself.

Example—Pile Driving

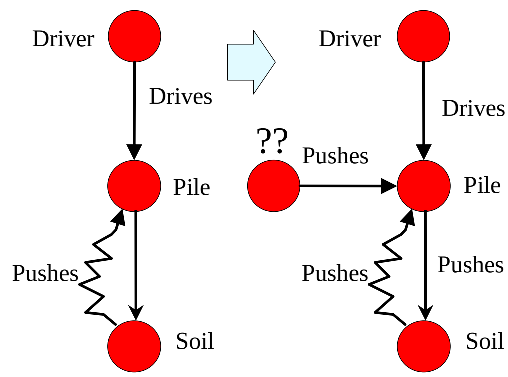
Applying a counter field to the pile driver means that we need to look for a way to push back on the soil in a way that counters the force of the soil pushing back on the pile

Step 1: Identify the field being employed by the harmful function.

The harmful field is a stress field. The soil pushes directly back on the pile.

Step 2: Identify a second field which is capable of countering the effect of the first field on the harmed product.

The second filed should also be a stress field that pushes back with equal or greater field on the soil.



Step 3: Are there existing elements in the system that could take on this additional function.

The driver is the natural element to take on the additional function. This means that the driver drives harder. Note that the soil pushes back harder when the pile is driven harder. The pile drives faster, to be sure but the size of the pile driver needs to be increased. Also, there may be more damage to the part of the pile which is struck by the driver mass. These problems might be solved by idealizing harmful functions or by resolving the contradiction: the driver momentum must be high to drive faster and the driver momentum must be low in order to not break the pile.

L2-Channel Harm

Redirecting harm includes adding another element to the system that channels the harmful tool or fields. This is usually accomplished by creating a path of least resistance to the fields being used.

Method

Step 1: Identify the fields that are performing the harmful function.

Step 2: Identify a path of least resistance for the fields. This may require the addition of new objects to the system.

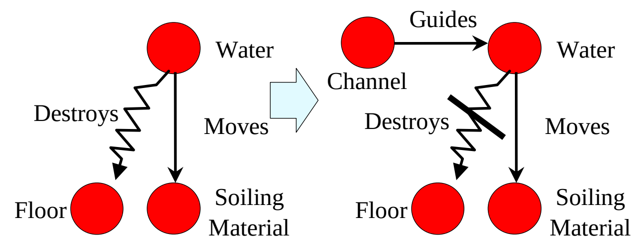
Example—Clothes Washer Overflow

Washers have external water inlets and outlets. If the inlets leak or the outlets are blocked and overflow, the water will often damage other objects around the washer such as a wood floor.

Step 1: Identify the fields that are performing the harmful function.

The field that is moving the water around is mostly gravity.

Step 2: Identify a path of least resistance for the fields. This may require the addition of new objects to the system.



The gravity field must pull the water along a different path. A path of least resistance would be a channel under the washers which would allow the water to flow in another direction away from objects that can be harmed. Preferably the channel is lower than the surrounding area. If this is not possible, a barrier can be built around the washer so that as the height of the water increases, the level of the water is higher than the channel that drains the water away.

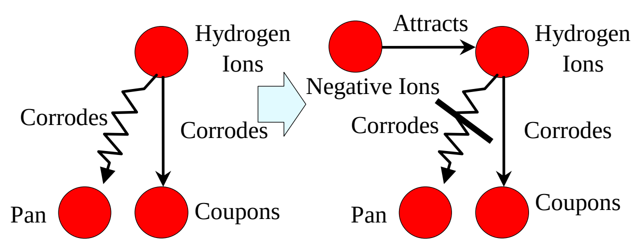
Example—Acid Container

Electrostatic fields are pulling molecules from the surface of the metal. We want to channel these electrostatic fields away from the metal.

Step 1: Identify the fields that are performing the harmful function.

Electrostatic fields caused by the polar nature of the water and the Hydrogen ions.

Step 2: Identify a path of least resistance for the fields. This may require the addition of new objects to the system.



The electrostatic fields of the positively charged ions would need to be channeled away from the metal at the atomic scale. One way to do this would be to force the negative chlorine ions into closer proximity with the H_3O^+ ions. The whole effect would make the positively ions much less mobile. This might be possible if the water molecules were greatly reduced. This brings up a new question. What happens when an acid has less and less water? As the water content decreases there are different species of ions formed with the water molecules. For instance, the crystalline form of form of HCl·H2O (68% HCl), HCl·2H2O (51% HCl), HCl·3H2O (41% HCl), HCl·6H2O (25% HCl). [14]

14 http://en.wikipedia.org/wiki/Hydrochloric_acid

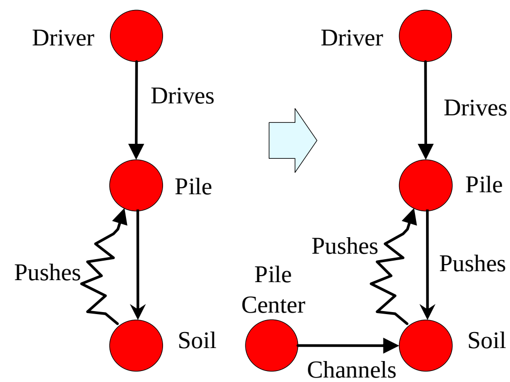
Example—Pile Driving

We need to look for a way to channel the stress fields on the pile which push back when the pile is driven.

Step 1: Identify the fields that are performing the harmful function.

The fields pushing back on the pile are stress fields.

Step 2: Identify a path of least resistance for the fields. This may require the addition of new objects to the system.



Channeling the harm away means that the pushing force of the soil goes somewhere, other than the pile. This can also mean that the soil, itself, moves somewhere other than away from the pile. The soil, itself, has another path. But there is no channel. Now we have a contradiction: a channel must be available in order to not push back on the pile, and a channel must not be available because there is no place to go. Another reason that a channel must not exist is that the final support of the pile is made worse if the soil continues to be channeled away while the pile is supporting a structure. One way to resolve this contradiction is to make the pile hollow. The soil has a place to go. We separate this in time and cap the channel to remove the channel and effectively provide a very blunt pile.

L2-Strengthen the Product

The product is strengthened or made more resistant to the harm. This is a function that happens on the product which makes it less susceptible to the harming action. The properties of the product must change and so we ask what properties of the product make it stronger or weaker and then seek to control these features. Note that we are adding this to the system to strengthen the product while it is being harmed. We could have considered changing the properties before it is harmed. This also requires a function, but we take this up under the heading of mobilizing resources. Doing it before hand is probably more ideal then what we are doing here, because the system does not require the permanent addition of elements. This function may be required in the event that none of the other previous methods work and it is not possible to strengthen the product beforehand.

Method

Step 1: Identify properties of the product that control the harm.

Step 2: Identify functions which would cause the product to have this useful property.

Step 3: If possible, the product should perform the function on itself to avoid adding any new elements to the system.

Example—Acid Container

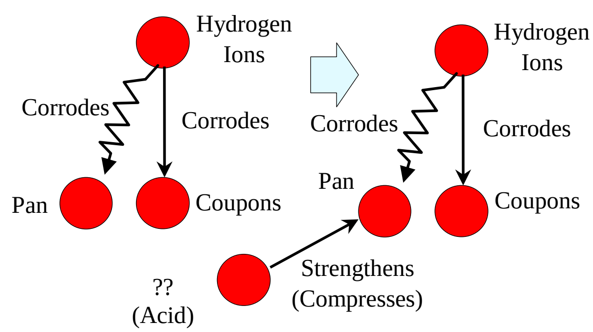
The pan must be strengthened while the hydrogen ions are trying to dismantle it.

Step 1: Identify properties of the product that control the harm.

I believe that the property of the product that controls the harm is the strength of the bonds between the metallic atoms. We want these bonds to be as strong as they can be.

Step 2: Identify functions which would cause the product to have this useful property.

It seems like it would be very difficult to increase the strength of the bonds between the atoms until we realize that corrosion on a surface is rarely uniform. This could mean that some regions have weaker bonds. When we look at metals through a microscope, we discover a grain structure which helps us to understand that the bonds between all atoms of a metal are not equal. This may especially be true of alloys. Stress corrosion, for instance, is the corrosion that occurs along the grain boundaries of certain metals when they are placed under stress. Could it be that the bonds which keep the material intact are weakened by stress and this makes them more susceptible to corrosion? This brings to mind the possibility that very high hydrostatic forces might hold the pan materials together. Is it possible that the acid, itself could force the pan molecules together by the act of a high pressure on the metallic surface? At a molecular level, this looks like molecules striking the surface in rapid succession. It should be noted that when the function diagram was first drawn, the work strengthen was used instead of compresses. Nothing was shown for the tool that accomplished this function.



Step 3: If possible, the product should perform the function on itself to avoid adding any new elements to the system.

This leads to an interesting contradiction. The acid molecules must be at an extremely high pressure to strengthen the pan molecules during corrosion and the acid molecules must be at low pressure to allow corrosion on the coupons that are being tested.

Example—Pile Driving

We want to strengthen the pile against the harmful action of the soil pushing back on the pile.

Step 1: Identify properties of the product that control the harm.

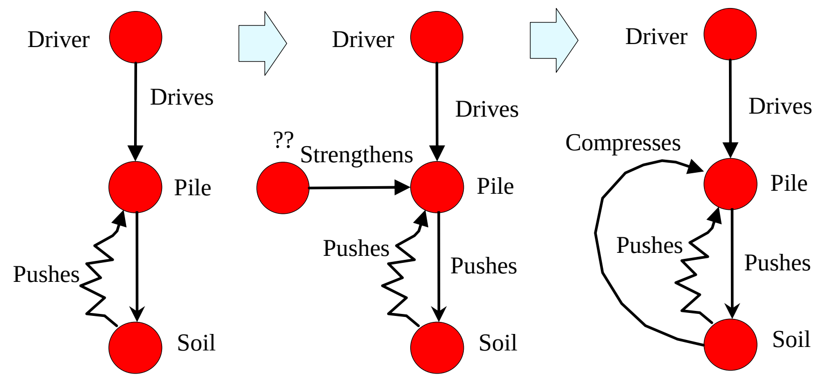
One property of the pile that controls the harm of pushing is the area of the pile that is being pushed on.

Step 2: Identify functions which would cause the product to have this useful property.

The function that would need to operate during driving would be one which reduces the surface area of the pile.

Step 3: If possible, the product should perform the function on itself to avoid adding any new elements to the system.

This creates an interesting problem because we would need to identify a scientific effect or physical phenomenon which can reduce the area over which the pressure acts. One physical phenomenon is pressure acting on the pile which would squeeze it into a smaller shape. Pressure is already provided by the soil, but the pile surface area is not very responsive to this pressure. In other words, it does change shape very much. It seems like the pile needs to have different properties in order to be compressed under the action



of the soil. It would need to be made of an easily compressible material, and it should only be compressible in the radial direction so that it can drive into the soil. This leaves us with the contradiction when the pile gets smaller in diameter. The pile should be small in diameter in order to drive and it should be large in diameter in order to support the structure that will be built on it.

L2-Detection of Harm

The function of detection leads to remedial action so it is less ideal. It usually occurs after or during the time that the harmful function is performed. On the other hand, there are certain types of harm that are very unsafe. Additionally, they may be very unpredictable and difficult to prevent. In this case, it may be necessary to inform someone that the harm is happening or that it has progressed to a critical state. In almost all cases, detection is a function that does not act directly on the main system product, making it an auxiliary function. Detection is usually expensive. Combining these facts together, detection is often a low value function and should be avoided if possible. In the event that it is required, we should look for ways that something else can be employed that already exists in the system to perform the function.

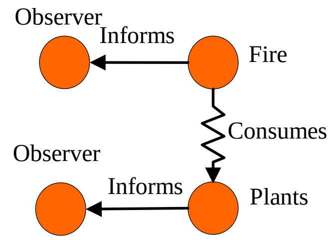
Method

Step 1: Identify that an informing function is required in order to insure that further harm does not occur.

Step 2: Go to the steps for idealizing an informing function and perform the necessary changes to the system.

Example—Forest Fires

Forest Fires are very difficult to stop from occurring. In most cases, the healthy thing to do is to allow the fire to burn. On the other hand, human lives are often at stake. It is necessary to get word to people living in the locale of a fire that one is approaching.



Step 1: Identify that an informing function is required in order to insure that further harm does not occur.

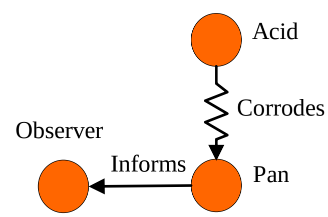
An informing function is required in this case. It is necessary in order that further harm to people and dwellings do not occur.

Step 2: Go to the steps for idealizing an informing function and perform the necessary changes to the system.

The next step is to idealize the informing function so that an observer can detect either the fire or the effect on the plants. Detecting the fire is the first thought that comes to mind, but the consideration of allowing the plants to inform is a novel idea. In some ways, this already happens when the forest service detects the likelihood of fire occurring due to the dryness of the plants. First, we would look at the possibility of not requiring the detection. Then we would try to understand the ideal act of informing the observer and what that entails. Next, we would look for a physical phenomenon or scientific effect that could be used to inform the observer.

Example—Acid Container

If the action of corrosion is difficult to control, then it may be necessary to detect it. However, for many of the methods that we have considered there will probably not be a requirement to detect corrosion. On the other hand, if an acid leak can occur, it may be necessary to detect it.



Step 1: Identify that an informing function is required in order to insure that further harm does not occur.

For several of the approaches that we have considered, detection of harm would be helpful to make sure that further harm does not occur if acid begins leaking.

Step 2: Go to the steps for idealizing an informing function and perform the necessary changes to the system.

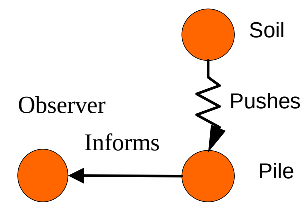
The next step is to idealize the informing function so that an observer can detect the effect of the acid on the pan. First, we would look at the possibility of not requiring the detection. Then we would try to understand the ideal act of informing the observer and what that entails. Next, we would look for a physical phenomenon or scientific effect that could be used to inform the observer.

Example—Pile Driving

In this case, we are considering that it might be important for the pile to inform an observer that it is being pushed on.

Step 1: Identify that an informing function is required in order to insure that further harm does not occur.

It seems a stretch that it would be important for the pile to inform an observer that pushing is taking place. Since there is an equal and opposite reaction of pushing the soil and pushing back on the pile, we know that if the pile is going down, then the soil is pushing back on it. Detection of the harm of pushing does not reduce any harm that might follow. On the other hand, detection of the useful function of driving the pile might have some value which we will not consider here.



Step 2: Go to the steps for idealizing an informing function and perform the necessary changes to the system.

Since detection of pushing is not required, there is no further need to consider this step.

L2-Healing or Regeneration

This modification is added in addition to the harmful function. It is remedial, so it is less ideal. It usually occurs after the harmful function is performed. In order to allow this to happen without adding additional elements, we would like to find a way to make the product regenerate or service itself.[15] [16]

Method

Step 1: Identify what "healing or fixing" means in this case.

Step 2: Identify what "regeneration" means in this case.

Step 3: Consider ways that the modification might be performed during the harm so that it never appears to be harmed. Since this is a useful function, go to TRIZ Power Tools—Idealizing Useful Functions to perform this in the most ideal way.

Example—Healing Fractures in Supports

Aircraft structures are somewhat susceptible to developing cracks which propagate and eventually fail due to the negative safety margins which they are sometimes designed to. While the parts are rigorously tested, it is possible that some parts will fail in the field due to extreme conditions in the environment or the materials from which the structures are made.

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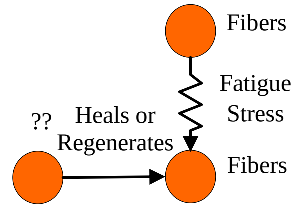
15 Inventive Principle #25—Self-service: An object must service itself and carry-out supplementary and repair operations. Make use of waste material and energy. Genrich Altshuller, The Innovation Algorithm page 288.

16 Inventive Principle #34—Rejecting and Regenerating Parts: After completing its function, or becoming useless, an element of an object is rejected (discarded, dissolved, evaporated, etc.) or modified during its work process. Used-up parts of an object should be restored during its work. Genrich Altshuller, The Innovation Algorithm page 289.

Step 1: Identify what "healing or fixing" means in this case.

Structural composites are formed from fibers (often carbon) which are laid in an epoxy matrix. If cracks in the composites could be healed, particularly at the high stress points, the fracture would be stopped from propagating. More ideally, if a small crack begins to occur in the fiber, it is healed before the crack can propagate through the fiber.



Step 2: Identify what "regeneration" means in this case.

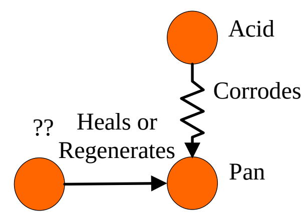
Regeneration means that if a fiber is broken, another will appear in its place and take over the function. Ideally, the old fiber would go away. Also, it could mean that if material pulled apart, new material would be generated to fill the gap.

Step 3: Consider ways that the modification might be performed during the harm so that it never appears to be harmed. Since this is a useful function, go to TRIZ Power Tools—Idealizing Useful Functions to perform this in the most ideal way.

At this point, we would normally go to TRIZ Power Tools—Idealizing Useful Functions to look for ways to either heal or regenerate. For the purpose of showing a potential solution, we will consider the possibility that an uncured matrix could be contained in hollow fibers. The hollow fibers would crack open during the formation of the crack, filling the crack and lowering the stresses.

Example—Acid Container

If we allow the corrosion of the pan to take place and are not able to find ways to avoid or stop the corrosion, then we would need to consider ways to remediate this harm.



Step 1: Identify what "healing or fixing" means in this case.

Healing means that, although the pan suffers corrosion, following a period of therapy, the affected areas go back to a state of not being pitted or weakened.

Step 2: Identify what "regeneration" means in this case.

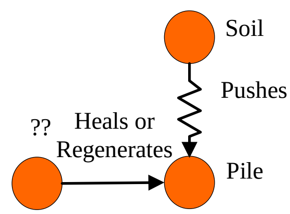
Regeneration means that either new material grows into the spot that was corroded or a whole new pan is generated to take the place of the harmed pan.

Step 3: Consider ways that the modification might be performed during the harm so that it never appears to be harmed. Since this is a useful function, go to TRIZ Power Tools—Idealizing Useful Functions to perform this in the most ideal way.

Healing the harm would mean that we are to replenish the dissolved material during corrosion or after corrosion. We note that the dissolved material is readily available as ions in solution, if we can just get it to go back onto the material. At this point, we would normally go to TRIZ Power Tools—Idealizing Useful Functions to look for ways to put the corroded material back where it belongs. Going back on to the material sounds like plating. It may be possible to make it go back, but it is difficult to get plating to go back into surface pits. The plated material wants to form on sharp edges where the electrical fields are high.

Example—Pile Driving

We would like to undo the effect of the soil pushing back on the pile. Healing or regenerating implies that we do this after the pushing has taken place.



Step 1: Identify what "healing or fixing" means in this case.

In this case, healing or fixing means that although the pile has been pushed back on by the soil, that some sort of action continues to drive the pile into the soil and makes up for the pushing action.

Step 2: Identify what "regeneration" means in this case.

Regeneration does not make sense in this situation.

Step 3: Consider ways that the modification might be performed during the harm so that it never appears to be harmed. Since this is a useful function, go to TRIZ Power Tools—Idealizing Useful Functions to perform this in the most ideal way.

No way is found to "heal pushing" except to find some other means of pushing the pile further into the soil without the need for extra power from the pile driver, itself.

L2-Previously Placed Cushion

For a previously placed cushion[17], a useful tool "fails" in some context. When this happens, another tool, the cushion" must take over the function of the "failed" tool. The harmful function may still continue on the new product, but at least it still is performed. The tool may not need to be permanently failed in order for this to work. That is why we ask "in what context does the product 'fail'?" Sometimes unique solutions can be devised when we allow another tool to take over. This is another way to allow for a second tool to help perform the function.

Method

Step 1: In what context does the product "fail?"

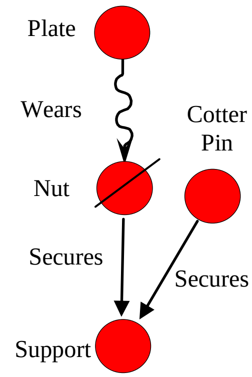
Step 2: Identify another element which can take over for the" failed" product.

Step3: Look for ways to add the minimum possible.

17 Inventive Principle #11—Cushion in Advance: Compensate for the relatively low reliability of an object with emergency measures prepared in advance. Genrich Altshuller, The Innovation Algorithm page 287.

Example—Cotter Pins

A nut which must secure a vital component can become loose during repeated use or during vibration.



Step 1: In what context does the product "fail?"

The nut is no longer able to secure the support.

Step 2: Identify another element which can take over for the" failed" product.

There are several possibilities. A second bolt and nut could take over for the first. A second nut could take over and might be used to lock the first.

Step 3: Look for ways to add the minimum possible.

In some cases, the important thing is that the bolt does not come completely out. In this case, it can be loose. A cotter pit can be used to make sure this does not happen. This is a simple example of a previously placed cushion.

Example—Acid Container

With a previously placed cushion, we are assuming that the harmful action occurs and that something else can take over for the failed product. In this case, we assume that the acid has corroded the pan and the pan is no longer useful

Step 1: In what context does the product "fail?"

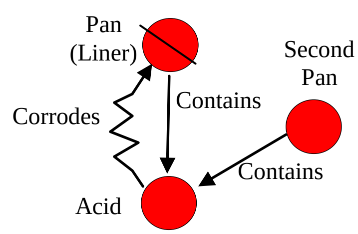
The pan is no longer able to contain the acid.

Step 2: Identify another element which can take over for the" failed" product.

The second pan can take over for the first pan.

Step3: Look for ways to add the minimum possible.

The minimum is a very thin liner that can first be breached. Once breached, a second container which is very thick takes over. After each use, the first container is inspected and disposed of if no longer useful.



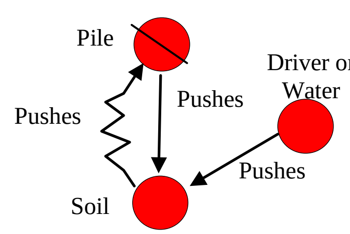
Example—Pile Driving

In the case of the pile driver, something else should take over for the pile if it "fails". The pile fails when it can no longer push the soil. Of course, it is not permanently disabled.

Step 1: In what context does the product "fail?"

Pile is no longer able to push the soil.

Step 2: Identify another element which can take over for the" failed" product.



This means that something else must push on the soil once the pile is incapable of pushing further. Perhaps water or the driver, itself, could be used to further push the soil. In the case of the driver taking over, it would need to be in direct contact with the soil. This creates a funny picture in the mind. We normally think of the driver as striking the pile. In this case, it directly strikes the soil and the driver. Perhaps, the most direct way to move the soil is to have the driver strike it directly and allow the pile to drop into the space that the driver clears. If water is involved, the water can be directly driven by the driver to move the soil.

Step 3: Look for ways to add the minimum possible.

The pile is hollow. The driver extends through the pile and strikes the soil, or water, directly. The driver and water clear a sufficient path for the pile to drop into. Note that the final solution does not directly address the issue of a "failed" pile. Had we gone the normal route, we would likely have concluded that the pile does not actually fail permanently.