Evolving the Corkscrew: A TRIZ-based Hypothesis

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This brief article demonstrates how several key principles of TRIZ—Ideality, Contradictions, Systems Approach Thinking and Patterns of Evolutions (including resource utilization, uneven development of systems, increasing dynamics, increased controllability, increasing complexity followed by simplification, matching and mismatching of system elements, transition to the micro-level, increased use of fields, and decreased human involvement) might have been used to invent the corkscrew.

A question

Which came first, the cork or the corkscrew? Textbooks tell us that the plain truth is: corkscrews were conceived for corks. But on reading this, the TRIZ student should immediately say: wait a minute, didn't the mechanism already exist? And the TRIZ student would of course be right. After all, didn't a guy named Archimedes invent the screw, and wasn't it being used centuries before wine bottles or their corks became common in early 18th century?

The mechanism in question is the Archimedes screw, a device designed for lifting water for irrigation and drainage purposes. In fact, it is one of the oldest machines still in use. Its invention has traditionally been credited to Archimedes (circa 287-212 B.C.). Diodorus Siculus, a Roman historian active in the first century B.C. wrote: "men easily irrigate the whole of it [an island in the delta of the Nile] by means of a certain instrument conceived by Archimedes of Syracuse, and which gets its name [cochlias] because it has the form of a spiral or screw."

Roots of the corkscrew

The evolution of bottles as a storage mechanism for wine led to the need for materials to seal them. That wine, and other bottled fluids such as perfume and medicines, would be consumed defined the need for devices that would help users extract the sealing materials from inside the neck of the bottle.

Although wine, perfumes and pharmaceuticals had existed in ancient times, storing them in glass vessels is a relatively new development. Up until the late 17th century, bottles were hand produced, extremely rare, very fragile and prohibitively expensive. When bottles came into common use, they (those storing wine in particular) were sealed by wood plugs covered with coarse, wax-impregnated linen. The wooden plugs were long enough to extend outside the neck of the bottle, enabling people to extract them with nothing more than their hands as tools.

Before we can understand the requirements that led to the development of the corkscrew, let's see how the same requirements led to the wood/linen/wax plug innovation. The contradictory requirements here are clear: the plug should seal the bottle tightly and be easy to remove.

The poly-system solution—wood, linen, wax—that sealed liquid in and air out, while being easy to remove by a handle (the length of wood extending outside the bottle), seems to meet the requirement. The linen, soaked in wax, was a bi-system made up of two flexible materials, with the linen serving as a mediator (or carrier) for the wax. The wax-soaked linen, together with the wooden plug and the opening of the bottle, form a poly-system that allows the bottle to be sealed. TRIZ students know this solution was an overly complex system, typical of the early stages of a system's evolution. Why? Because the basic function of the system is "filling the hole," which should be done with the least possible number of components and the least amount of complexity.

How was the poly-system created?

Without having access to the inventor or his notes, we can only imagine the actual chain of events that led to the wood/linen/wax innovation. But because TRIZ models how innovative thinkers think, we can posit that the process might have gone something like this: the inventor has a need. He wants to plug the glass opening of the bottle, and wood, a common, low-cost, easy to shape (carve) material, seems like a logical choice to experiment with. The inventor realizes that he faces a contradiction: the wood plug should be large enough to seal the bottle and small enough to be put into the bottle and removed. After trying a number of times to make the perfect wooden plug, and undoubtedly breaking a few bottles along the way, he realizes that maybe the root contradiction is that the plug should be both rigid and flexible, so he tries to solve this new problem. Faced with this contradiction, and not having an ability to invent a new material, he looks for combinations of materials that would resolve the contradiction.

Again, we can only imagine the inventor's thought process, but at that point in history wax had been used to seal documents for thousands of years. We know this because the use of seals can be traced back to the Old Testament, where we read that Jezebel used Ahab's seal to counterfeit important documents. We also know the practice of using tar and beeswax to seal (or caulk) the planking in boats and ships dates back to the Romans. (Ancient Greek and Romans also used resins and wax to seal amphora, but the use of amphora ended with the fall of the Roman Empire.[1]) Although he may have started with a different material altogether, say by stuffing a wadding of rags in the bottle, he would certainly have seen the deficiencies here very quickly. Regardless, we can reasonably assume that wax in some variety was one of his first thoughts. This becomes even more reasonable when we imagine our inventor lived in a port city, somewhere that the resources of imported bottles, nautical sealants, cloth for sails, and beeswax candle exporters surrounded him.

When our inventor applied wax to the wood, one of several new problems emerged—if the wax was added to the outer surface of the wood, it might have been hard to get a thick, uniform layer. To solve this, he may have tried using the candle-making technique of alternately dipping the wood in heated wax and letting it cool before dipping again.

Given that he was successful with whatever technique he might have used to deposit the wax, when the wax-coated plug was inserted into the bottle, some of the wax scraped off, affecting the seal (in TRIZ we think of this as a secondary problem). Noticing this, he may have tried to melt the wax into the gap between the bottle and plug. This would illustrate the principles of transition to the micro-level and the use of a thermal field, but regardless, this solution too held problems: movement would break the hardened wax. Even had he made the wax seal solution work on insertion, it could not satisfy the subsequent requirement of having to remove and reseal the bottle with the same plug.

After some experimentation, he realized that he needed a medium to hold the wax in place. The required material must be solid so it fills the gap, and it must be porous so it holds the wax. A natural thought would be: linen. Thus, the wax-impregnated linen covering the wooden plug comprise, together with the opening of the bottle, a poly-system that appears to solve the problem. Dip the linen in the wax so the wax fills the pores, place the linen over the hole in the bottle, and press the wooden plug into the bottle. The wooden plug provides the solid mass to fill the hole, the wax does the sealing and the linen provides the carrier that controls the flow of the wax. The resulting solution both seals the bottle and is reusable. And an added benefit (super-effect in TRIZ terminology) is that the plug now fits different sized openings because the linen is compressible (more dynamic than the wooden plug, which would have needed to be custom fit to the bottle – after all the standardization of parts and Six Sigma didn't exist in those days).

If our inventor was really savvy, he might have realized that wood and cloth served one function of taking up the gap and fitting tightly, but it didn't prevent leakage. The wood and wax served a different function of stopping the flow of liquids and adapting to the irregular opening, but it did not form a tight fit. If our inventor had been a student of TRIZ, this would have led him to hybridize the linen and wax into one system to solve his problem.

Getting the cork into and out of the bottle

Before 1728, wine was stored in casks. Bottles and pitchers were used to serve wine, but not to store or ship it. The evolution of sturdy, inexpensive glass bottles established a foundation for the change to bottles, and in 1728, a French royal decree allowed the sale of wine in bottles. (Note: before this point regulations prevented the storage of wine in glass bottles. Regulations often limit innovation and are referred to as a type of governing dynamics.) Around the same time that "black glass" bottles, mass-produced from England, were becoming available, it was found that cork could be used to seal them. Three elements of evolution intersected to cause the shift to cork: the evolution of wine containers, the change in regulations, and the availability of a new resource, cork, through trade between England and Portugal.

Cork, which was available from Portugal, had all of the characteristics of the wood, linen, wax plug and more. Cork was a more ideal solution in several ways. It was a single material (therefore less complex); it was also flexible, rigid and resilient. Cork could be inserted into the bottle and seal the opening to contain the liquid, and it had the added benefit of being more hygienic (a super-effect). But as with all new solutions, it did have a weakness: when cork was first used to plug wine bottles, people used the same long design that had worked for removing the wooden plug. (This is a common mistake people make when using new materials, which is well known by students of TRIZ). The weakness: while a long cork could be pulled from the bottle, it would sometimes break off inside the neck of the bottle.

Thus, history brings us to the need for a cork removal device.

Back to which came first, the cork or the corkscrew?

The fact that the word "corkscrew" did not appear in dictionaries before the 18th century and the tool was not patented until 1795, would lead one to think that the cork came before the corkscrew. But we have the invention of Archimedes to contend with. And not only in the abstract. During the period that wood, linen and wax plugs were being used in the thriving wine trade, the manufacture of weapons was another thriving industry. Some writers believe that the corkscrew was inspired by the tool that was used as a gun-wadding or cartridge remover. This wadding remover was an instrument with a helix of contrasting pitch, ending in two pointed hooks. The instrument was screwed into the barrel of a musket to remove the wadding. This tool had existed from the middle of the 17th century. Could it be that our corkscrew inventor drew an analogy between removing wadding and removing corks?

A different and somewhat more enchanting legend suggests that tendrils of the grape vine, which wind like a corkscrew, were the actual inspiration. Either way, wadding or tendrils, legend suggests an invention by analogy.[2]

From a TRIZ perspective, drawing analogies is a good strategy, but can be a slow process if we are waiting for it to happen naturally. Suppose for a moment that our wine bottle plugging and unplugging expert was neither a hunter nor a soldier. He may have never made the wadding remover connection. But had he known about TRIZ's systematic, structured approach to innovation, he could have invented the solution without knowing anything about the gun industry.

So, which came first?

For the person who knows and understands the evolution of systems, answering this question is easy. The fact is that the mechanism for removing a cork had been around since Archimedes' time and was visible in other industries at the time it became needed for cork removal. As someone once said, necessity is the mother of invention. The new cork material created a necessity that forced our inventor (or a series of inventors) to find a way to remove the cork when it broke off and was impossible to remove by hand. My guess is this was a long and painful process. It did not have to be.

TRIZ is the great equalizer

Interestingly, even if Archimedes had not invented the screw, people who understand TRIZ could have solved the problem. Having an in-depth understanding of TRIZ provides the innovator with a significant advantage. It makes no difference whether you are working on sealing a bottle or working with a state-of-the-art technological system, the rules are the same, and people who really understand TRIZ understand the rules.

For the initiated, TRIZ changes the way you think about everything around you and accelerates the process of innovation. The uninitiated will wait and wait for the creative flash to occur, perhaps organize and participate in brainstorming sessions—which are good for solving simple problems but not tough technological problems, or surf the net to find the information they need to solve their problem. The people who truly understand TRIZ know it is usually easier to invent a solution than to find one.

Patterns of Evolution

An examination of the corkscrew shows more about TRIZ than how it might have been invented. Consider the simple waiter's key corkscrew, found in restaurants and bars around the world. Over and above the Archimedes-inspired screw shape, the waiter's key integrates a lever to assist the human arm in extracting the cork. This type of corkscrew also features a short, sharp knife. Here we have a more evolved poly-system that is dynamic and more functional than the plain corkscrew.

More recent innovations show the evolutionary pattern of decreased human involvement, evolution toward the increased use of fields and toward the micro-level by replacing the function of manually removing a cork with the muscles of your arm with nitrogen gas. Several models of "cork lifters" (the inverse of cork pullers) use a hollow needle to pierce the cork. Once pierced, the operator releases pressurized gas from a cartridge in the handle of the device, and the expanding gas lifts (or pushes) the cork out of the opening.

A final word

This paper is not meant to present the actual history of the evolution of the corkscrew, but to illustrate the timeless and universal applicability of TRIZ and its associated principles. To ignore TRIZ is to willingly stay stuck in the rut of the trial-and-error, fits-and-starts approach to innovation with which our 18th century (and too many of our 21st century) innovators would have been satisfied.

References:

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2. Crestin-Billet, F., *Collectible Corkscrews*, Flammarion, Paris, 2001

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