Systematic Innovation

e-zine

Issue 29, June 2004

In this month's issue:

The Systematic Innovation e-zine is a monthly, subscription only, publication. Each month will feature articles and features aimed at advancing the state of the art in TRIZ and related problem solving methodologies.

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Readers' comments and inputs are always welcome.
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Using Geometry To Reduce Stresses
or 'Not Letting The Design Tools Degrade The Product'

How often do we let ourselves compromise the design and functionality of a product because of the limitations of the tools available to help us design and manufacture that product. 'Too often' is the hypothesis put forward by this article.

Our specific focus will be on CAD systems and the way that they encourage designers to design artifacts containing as many straight lines, parallel lines, perpendicular lines and symmetries as possible.

CAD systems particularly like straight lines and symmetries. It is in the interests of the CAD system providers to make it easy for designers to use their software. The more convenient it is, the more likely that a designer will choose one piece of software over another. Thus we can see the logic of why a typical CAD suite will, for example, allow a designer to specify a line of symmetry in order that the software can automatically do all the hard work to mirror everything drawn on one side of the symmetry line onto the other side.

Unfortunately, a few seconds saved during the design process can often handicap a product for the rest of eternity since what is best for the designer is rarely best for the artifact.

One of the reasons that the geometric evolution and increasing asymmetry trends are such important ones at this point in time in the evolution of many systems is that all those straight lines and symmetrical features represent untapped potential in terms of allowing a system to deliver more and/or better functions.

A simple example should hopefully serve to illustrate the point. Figure 1 illustrates a cross-section through a typical flange joint as may have been designed using a typical CAD system in its default mode. In the time it takes to draw half a dozen lines, a designer can completely define a perfectly competent, axi-symmetric flange joint. There is nothing wrong with 'perfectly competent' of course – and since only a special few designers will have any great interest in flange joint design, it is commonly the case that a designer will focus their creative efforts in more inspiring areas.

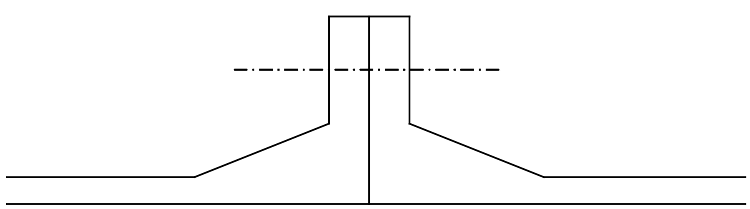


Figure 1: Typical Flange Joint design

'Perfectly competent' on the other hand is some considerable distance away from 'ideal' and means that a whole clutch of improvement opportunities will have been missed. A more ideal solution is the flange design illustrated in Figure 2. Coming up with this design requires the designer to draw one or two more lines on the drawing (and conduct a fairly extensive experimental programme to prove the benefits!), but the net result is that the flange can now be joined with 50% less bolts. Net result – a lifetime of lower material usage and saved maintenance time.

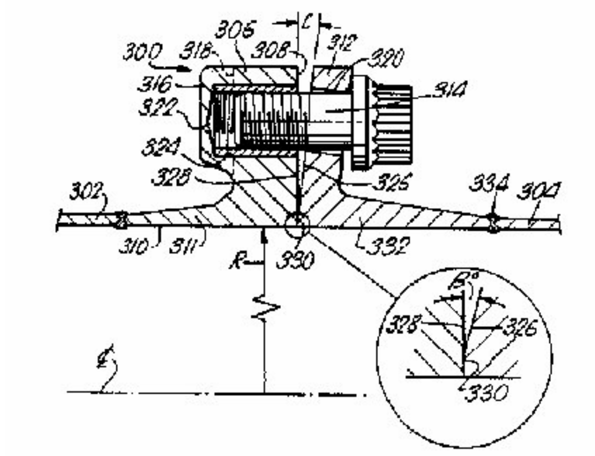


Figure 2: US Patent 5,230,540 Flange Joint Design

In fairness to designers and CAD system providers, it is worth pointing out that what is easy to draw also tends to be easy to manufacture. The same point about short-term versus long-term benefit applies; sure the Figure 1 flange joint has one less manufacturing operation than the Figure 2 design, but is that momentary saving worth the lifetime of extra weight and maintenance effort. Answer: probably unlikely. At the very least, therefore, it is at least worth asking the question.

Some of the benefits of using curvature and asymmetry are a little more subtle and difficult to spot. Taking the flange joint example a stage further by examining the stress profile across the flange face as the bolts are tightened, we might see a stress profile like that shown in Figure 3.

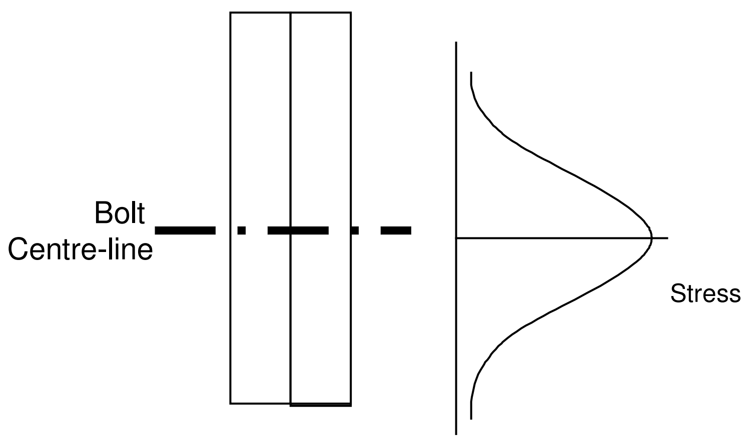


Figure 3: US Typical Stress Profile Across A Typical Flange Face

Again, this profile is perfectly okay provided the designer has sized the components in such a way that the peak stress doesn't exceed a certain limit. Again also, 'perfectly okay' is not the same as ideal. One of the 'problems' with designing this kind of default flange is that, as shown by the stress profile, certain parts of the surface are at a very high stress and are thus 'working very hard' while other parts have a very easy life. This is the result of drawing what's easiest to draw. If we changed our design goal, however, to say, wouldn't it be nice to design the structure so that the peak stress was much lower and that the 'work' that the different parts of the flange faces performed was 'more even', then we would end up with a design that looked more like that shown in Figure 4.

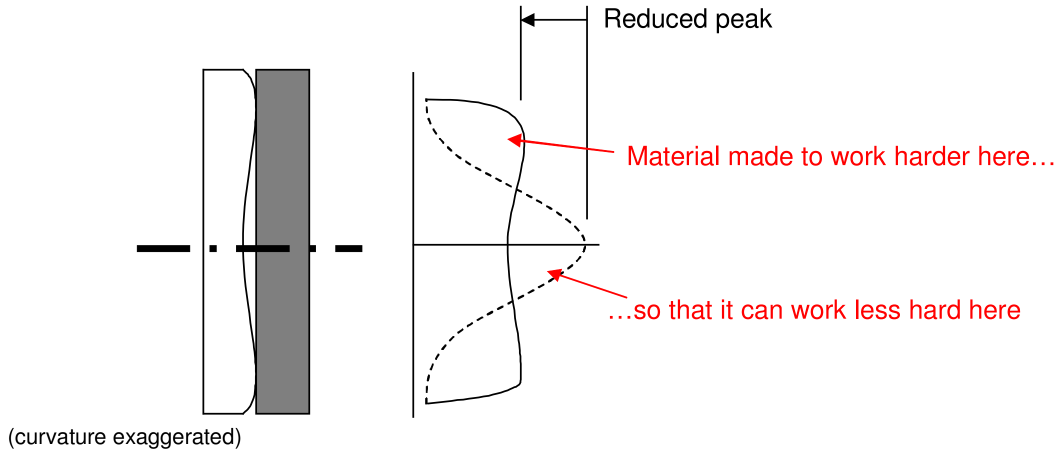


Figure 4: Designing The Surface To Obtain The Desired Stress Profile

The point here is not that we necessarily want to design for an 'even stress distribution' (in the flange, in fact, we would like a well focused stress peak that is not where the bolt is placed – hence the Figure 2 shape flange face), but that by allowing the shape of the surface change, we are suddenly able to design to achieve whatever stress or performance profile that we like.

This simple 'turning around' of the design strategy from 'design using straight lines and live with the consequences' to 'design for the consequences and let the line shape become the variable' is the main learning point from this discussion. The switch, we think, is an important one since, if you think about it, designing for the function is what TRIZ is trying to get us to do. Function is king. Designer (or manufacture) convenience is the servant of that function.

Business Principle 22 – 'Blessing In Disguise'

Following on from last month's discussion about a novel interpretation of Inventive Principle 22 in its technical context (Reference 1), our focus shifts this month to a discussion of the Principle in action in the world of business.

One of the basic ideas behind the 'Blessing-In –Disguise' Principle is that it forces problem solvers to explore the possibilities that things that are thought of as 'bad' in and around a system may be transformed into resources that can deliver a useful function. The new Hands-On Systematic Innovation for Business & Management book contains several examples of the Principle in action. We present a few more below; firstly a few short examples, and then go on to present a more detailed analysis of the phenomenon of 'constructed crisis'.

First a couple of recently read examples of companies deploying Principle 22 to good effect:

Novartis

Health-care giant Novartis Pharmaceutical developed a more creative approach to the commonly experienced psychological inertia problems associated with knowing when a piece of research has reached a dead-end. Most of our brains when they find themselves in this kind of situation will say to us 'look how much effort you just expended to get this far; are you really going to throw all of that away?'. According to the Novartis spokesperson, 'it's a common problem for the team of scientists to get obsessed with a compound and come up with reasons why research should continue. So they guard against that by putting a few thousand dollars for each scientist on the team on the table that they can take if, at any time, they decide to kill the project. Basically, they're paid to stop a failing course of action.' A fine example of Principle 22B 'Add a second harmful object or action to neutralize or eliminate the effects of an existing harmful object or action'. Offering a few thousand dollars to kill a project represents the addition of a minor negative (minor in relation to the amount of money invested in the piece of research), to provide a much bigger positive.

Ideo

Related to the Novartis story, at Ideo, the Palo Alto, Calif.-based design firm that helped create products like the Palm Pilot and the Polaroid I-Zone, the possibility of failure is inculcated into the company's culture. Ideo's very mantra, 'Enlightened trial and error outperforms the planning of flawless intellects', reflects the expectation of failure - and CEO David Kelley loses no opportunity to reinforce that. When the company grew to a point where its team of 200-plus designers needed to be broken up into more manageable units, Kelley wasn't about to take the conventional route of announcing a restructuring and reassigning his people. Instead, he called staffers together and asked a handful of top designers to give a pitch about why employees should join his or her studio. 'Almost every employee got his or her first choice - and the two who didn't were paid a few thousand to change their minds,' Kelley quoted, 'so they had perceived choice.'

Then, rather than stand up and give the boilerplate post-reorganization speech about a rosy future ahead, Kelley's message was, 'the only thing I'm sure of is, just like the products we've built, this is the first iteration and what we've done is wrong. But this is the best we can do right now. It's like one of our product prototypes, so what we will have to do is keep tweaking it until it gets better and better - or possibly abandon it if it doesn't work at all.' In many ways, the success of Ideo is built on this whole 'fail fast' philosophy. In many companies, 'failure' is viewed as a severely career limiting activity. What Ideo have learned is that often we learn much more from a failure than we do from a success; so doing it quickly allows us to get to the strongest solutions in, hopefully, the shortest possible span of time.

Constructed Crisis

The main inspiration behind this article has been Jim Collins' book 'Good To Great' (Reference 2), which we finished re-reading during a recent long distance flight. For those of you unfamiliar with the book, it records the outcome of a significant piece of (privately funded) research into a number of companies that have successfully made the transition from being 'good' (in business for 15 years or more, 'average' performance in terms of their industry) to 'great' (10 years or more of sustained, industry leading growth, return on investment, cumulative stock returns, etc). The book is a highly recommended (albeit often uncomfortable) read for anyone working in one of the world's non-great organizations.

Without wishing to dwell too long on the basis of Collins' findings, what struck us vividly as we went through the descriptions of all of the eleven companies that the Collins research team deemed to have made the good-to-great transition was that all eleven of them had made use of Principle 22. As shown in Table 1, all eleven of the studied companies were in the midst of some kind of crisis when the transition point from good to great occurred.

Company	Crisis
Gillette	Threat of takeover
Wells-Fargo	Deregulation of banking industry
Pitney Bowes	Loss of protected monopoly
Nucor	Combination of cheap imports and looming bankruptcy
Abbott Labs	Product recall
Walgreen	Decision to get out of the restaurant business
Circuit City	Looming bankruptcy
Kimberley-Clark	Decision to sell all paper mills
Kroger	Threat of 'supermarkets' to grocery business
Fannie Mae	Massive financial losses
Philip Morris	Emerging public awareness that 'cigarettes cause cancer'

Table 1: Transition-Inspiring Crisis At 11 Good-To-Great Companies

Collins' doesn't pay too much attention to this crisis effect, but the fact that 100% of the companies that passed the good-to-great test criteria, should perhaps be taken to be indicative of something. Perhaps something that should cause us to think carefully about our own organizations.

Figure 1 illustrates what we think is the most significant effect influencing what happened in these eleven companies, and what needs to be recognized in our own organization. The figure plots the level of stress up the y-axis. We might think of this 'stress' parameter as the stress experienced by an individual in an organization, or the total organization stress resulting from a summation of all of the individual stresses. The x-axis variable is more vague, and is presented here as any parameter that managers inside the organization might chose to vary in order to change something about the business. It could be remuneration or working hours or ay kind of improvement activity.

The red-line in the figure illustrates the effect of any of those actions on the level of stress. Although this line is in all likelihood unplottable in any realistic sense, and contains a number of gross over-simplifications, it nevertheless indicates the important key effect that, over time, the level of stress will tend towards a minimum level. Organisations, in other words, tend, in the same way that humans do, to a state of minimum tension. In the figure, we might think of this 'optimum' (from the point of view of the individuals) minimum stress as the 'accepted' level.

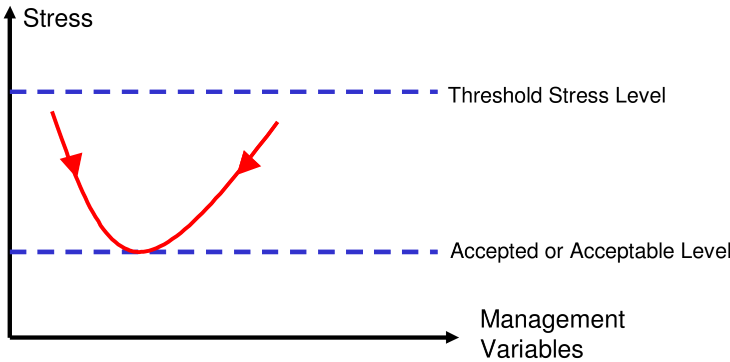


Figure 1: Organisational Stress Levels

At the top of the figure is another gross over-simplification, but again hopefully another useful one. Here we have the idea of a 'threshold' of stress. Again this can be interpreted for individuals or for the organization as a whole. This threshold level will of course vary from one individual to another, but the point is that any attempt to raise stress above a certain level will fail. This phenomenon is fundamental to the wiring of the human brain. It is a concept discussed in more detail in Reference 3. For the purpose of the discussion here, the threshold stress level is that level that, once reached, will provoke the individual or the organization into action.

The red-line stress characteristic shown in the figure suggests to us that over time, the system will naturally tend to a level of minimum stress. Once a system has reached that state, any perturbation or change can only result in an increase in the level of stress. Giving someone the choice of staying at their current level of stress (or perhaps more appropriately, 'level of comfort') or going to a higher state, the large majority will prefer to stay at the lower level. This phenomenon probably helps to explain why such a large proportion of change initiatives in organizations fail. People like to stay in their comfort zone, and since the word 'change' is traditionally linked with 'stress', then in most people's minds they don't like change.

Suppose now that something in or around the system shown in Figure 1 shifts, and that as a result we end up with the stress characteristic illustrated in Figure 2.

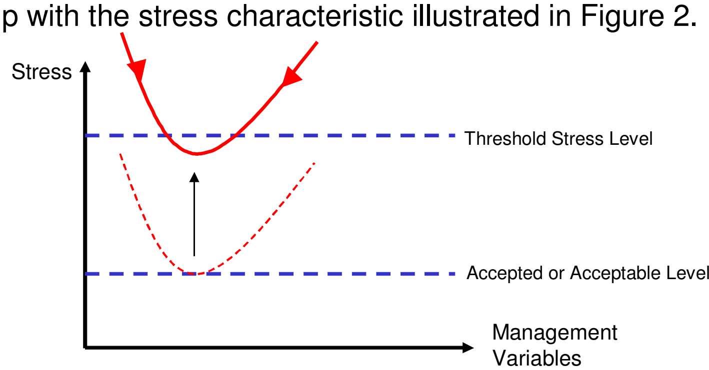


Figure 2: Organisational Stress Shifted To A Higher Level

Now we are in trouble. If enough people are at or close to their threshold level of stress, and we are, by definition at a level higher than that which we find to be acceptable. We have now achieved a situation where the difference between actual and desired stress begins to work in our favour. Now we have no choice but to do something to reduce the level of stress. If this means changing something within the system, then people are much likely to be willing to work with us to achieve the change since they are presently in a position of discomfort where the prospect of change is perceived as a potential means to reduce the current level of stress.

There is, in other words, a positive desire for change. As illustrated in Figure 3, what we are hoping for when we work for this change is that when we are finished, our level of stress will be back at an acceptable level.

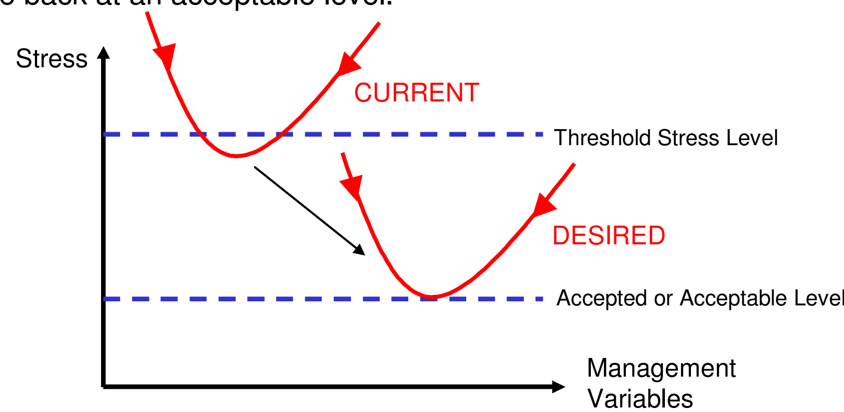


Figure 3: Stress As A Means Of Encouraging Change

The shift described in the Figure is, of course, the result of a change from one system to a new one. It is about the discontinuous jump from one s-curve to another. It is precisely this kind of system-shift that provoked the transition from good to great in each of the companies studied by Collins and his team. In each case, the Principle (or at least one of the Principles – several of the companies combined multiple Principles if we analyse in detail how they transformed their business), used to inspire the shift was number 22.

In the case of all eleven of the good-to-great companies, the use of Principle 22 was forced upon the management teams – since they all found themselves in a do-something-or-die crisis. The implication from the discussion here, is that because of the tend-to-minimum-stress tendency of any system, successful change is much more likely to occur from a position of high stress than from a position of low stress. Several business thinkers and organizational leaders are beginning to talk about 'constructed crisis' as a means of solving this problem. The basic idea behind 'constructed crisis' is that it is an explicit deployment of Principle 22. If an organization is much more likely to successfully change when there is a crisis, but there is no real crisis, then construct one to make people behave as if there is.

If we can imagine a term called 'change success potential', which we might define as

change success potential = (current stress state) – (change stress state)

then we can begin to see some of the important dynamics governing whether a change initiative will be successful or not. In the Figure 1 system, when the current stress state is at its minimum, the change success potential is inevitably a negative quantity. (Note here that even if the change stress state might turn out to *actually* be lower than the current state, because people tend to associate change as a bad thing, the *perceived* stress state will always tend to be higher.) Conversely, if the current stress state is at or close to the threshold level, then the change stress state is inevitably lower, and consequently the change success potential is positive.

Thus the change success potential parameter gives us an indication of whether a change will be successful or not. If it is positive, the change is likely to succeed (at least in getting everyone to buy into it), while if it is negative, then, based on Collins research and elsewhere, our chances of success will be greatly diminished.

References

1) Systematic Innovation E-zine, 'Gracefully Degrading Products: Principle 22 And Design For Emotion', May 2004.
2) Collins, J., 'Good To Great: Why Some Companies Make The Leap… And Others Don't', Random House Business Books, London, 2001
3) Mann, D.L., 'Ideality And 'Self-X: Part 3: Business Context and Case Studies', TRIZ Journal, April 2003.

Somewhere There Is An Advantage…..

A bit of a mystery object, guess-what? competition in this month's 'humour' (in the broadest sense of the word!) section. The following photograph was taken in a Dublin hotel room recently.

Three jobs: firstly, can you identify the object?

Second, once you have identified what it is, you will see that the surface segmentation features visible in the picture have done something useful (as the TRIZ trend would have predicted it would) to the design, can you work out what advantage the surface features achieve.

Thirdly, if you think about the design in a bit more detail (perhaps zooming out and looking at the immediate super-system), you may see that the surface segmentation effect brings around a number of potential problems. Can you identify what these problems are, and then, more importantly, how another trend can help to retain the advantages offered by the protrusions without having any of the down-sides.

Answers next month.

Patent of the Month

Directly from this month's patent of the month:
A central goal of nanotechnology research is to design and fabricate novel materials with sizes or length scales in the nanometer range. These materials fall into a variety of architectural classes, such as compact clusters, hollow shells, tubes, two-dimensional layers, and three-dimensional molecular networks. In recent years, a wide combination of chemical building blocks and synthetic strategies have been investigated. Numerous specific methods have produced interesting new materials, but a single general strategy for fabricating materials having many different architectures and symmetries has not been developed. Furthermore, most of the recent work has focused on inorganic and organic synthetic materials as building blocks, while biological molecules such as proteins offer some special advantages that have not yet been exploited. As such, there is continued interest in the development of new materials and systematic methods for producing nanostructures, especially using biological macromolecules

US6,756,039 granted to inventors at the University of California on June 29 describes some of the output of the research programme into self-assembling proteins. The word 'self' was the thing that attracted us to the patent, but the thing that makes it our patent of the month is the way that the inventors – even though they are dealing with things at the molecular scale – are still thinking about the geometry of the proteins.

The idea that the TRIZ trends can be applied at all geometry scales is often difficult for newcomers to the method to comprehend. Perhaps the problem exists because we typically draw and communicate examples at the human scale. It is very easy, for example, to see the geometric evolution trend in action in pizza boxes, but far less easily to connect the idea of point-to-line-to-curve-to-3D-curve to the 'design of molecules. A brief glance through the US6,756,039 invention disclosure will, however, reveal that the exact same concepts are highly applicable to the 'design' of molecules. Random pieces of text from the disclosure:

The subject fusion proteins find use in the preparation of a variety of nanostructures, where such structures include: cages, shells, double-layer rings, two-dimensional layers, three-dimensional crystals, filaments, and tubes.

The fusion protein according to claim 3, wherein said geometry of symmetry has an angle of intersection chosen from an angle that is:
(a) 54.7.degree.;
(b) 35.3.degree.; and
(c) 20.9.degree..

Typically, the naturally occurring protein components that make up the subject fusion proteins are ones that naturally associate with identical proteins to produce dimeric or trimeric structures. Other proteins that self-assemble into larger complexes such as tetramers and hexamers by way of dimeric and trimeric building blocks are also useful.

the subject fusion proteins may self-assemble into effectively infinitely repeating regular structures, such as two-dimensional layers, three-dimensional crystals; and filaments and tubes of indefinite length.

the geometry of the symmetry elements may be intersecting or non-intersecting

structures can be assembled that resemble either an open cage, a closed shell or a relatively compact ball

A patent well worth a look from this geometric perspective. Also worth a look from the perspective of those wishing to test their evolution potential skills – the invention has masses of untapped potential relative to other trends – but also because of some of the functional benefits offered by the self-assembly capabilities realized by the inventors:

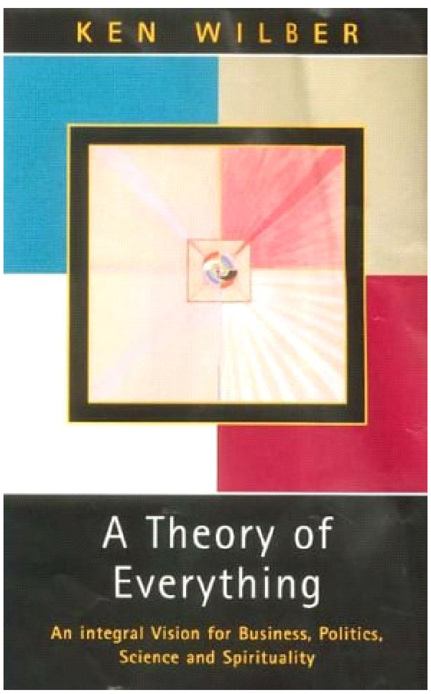
Hollow structures find use in drug or gene delivery; for stabilizing, shielding or sequestering other molecules in their interior volumes; and the like. More compact structures find use in the presentation of multiple antigens, or other optically or electronically active chemical groups. The subject fusion proteins can also be employed to assemble two-dimensional layers, where such ordered protein layers find use as biological coatings, sensors, detectors, molecular sieves, and the like. Where the fusion proteins are employed to produce three-dimensional layers, the resultant structures find use as molecular sieves, biological matrices, carriers for crystallizing small molecules, and the like.

Best of the Month

Anyone writing a book with the title ‘A Theory Of Everything’ is inevitably going to do two things. Firstly they are going to set themselves up for a lot of me-versus-you criticism – the inclination of most readers likely to be ‘how dare you presume to…’ variety. Secondly, they are likely to produce something of interest to TRIZ aficionados, since in many ways the big underlying idea of TRIZ is almost exactly the same – wouldn’t it be great if we could put all the good stuff in one place and create a big global problem-solving framework.

When the author of such a book is renowned philosopher and thinker Ken Wilbur, however, it is difficult not to be intrigued by what he has to say. As it happens, the book is a compilation (and extension) of many of Wilber’s earlier ideas, but it has to be said, there is an awful lot of sense being spoken.

Expect to hear more about how Wilber’s Theory of Everything might come to influence TRIZ (or the other way around) as we take what we learned and begin the process of sorting out the complementarities and contradictions. In the meantime, the book is eminently readable, and well worth your time.



Investments

The problem of getting medications from outside to inside the body of a patient is an area of massive research and development around the world. Delivery of drugs directly into the bloodstream is generally viewed as the most effective and efficient way of getting them to the places where they are needed. Getting the drug into the bloodstream, however, continues to be a significant challenge. The dominant means of delivery for a very long time now is the syringe. Since the first syringes appeared, there has been very little evolution of the basic idea of a hollow metal tube. While adequate in many ways, the syringe presents a number of significant trade-offs and compromises:-

- we want the syringe to be big (easy transport of medication) and small (big syringes are difficult to insert into the patient)
- we want the syringe wall to be thin (the thinner it is, the lower the distress to the skin of the patient, due to the lower force required to pierce the skin) and we would like it to be thick (since thicker equals stronger – i.e. if the wall thickness is too small then the syringe may buckle and deform)
- we want the material to be bio-compatible (i.e. expensive) and yet cheap
- we want the syringe to be sharp (for easy insertion) and blunt (so that it doesn't hurt anyone after it has been used)

Researchers from the Georgia Institute of Technology, lead by biomedical engineer Mark Prausnitz, have developed solutions to several of these contradictions by finding ways to manufacture solid and hollow metal, silicon, plastic and glass microneedles that range in size from one millimeter to one thousandth of a millimeter. The researchers demonstrated that an array of 400 microneedles can be used to pierce human skin, and successfully used a similar micro array to deliver insulin to diabetic rats.

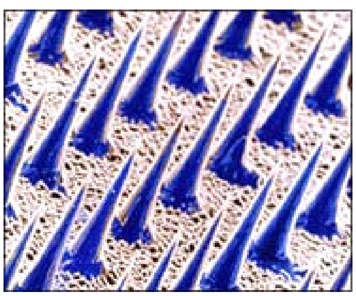


Figure showing possible arrangement of micro-needles on some kind of flexible substrate. It may be possible to 'give injections' by using a stick-on patch using the technology developed at Georgia Tech.

The lab has licensed the technology to a Massachusetts company, Biovalve, while other companies owned by 3M and Johnson and Johnson are tapping other labs to develop their own lines of microneedles.

Biology – Symbiosis

As discussed in earlier work (Reference 1), biology is a great deployer of the 'Merging' Inventive Principle. The permanent merging of two different life-forms (e.g. lichens) is a key driver of evolution. On a sometimes more transitory, less permanent level is the idea of symbiosis. In its most common usage, symbiosis is used to describe the intimate association between two distantly, related species that are mutually benefiting from their association. Reference 2 is an excellent on-line resource identifying the various types and forms of symbiosis found in nature.

Our interest here is in two examples found in recent issues of BBC Wildlife magazine.

The first relates to the seeds of certain orchids. The whole subject of reproduction in biology is concerned with the trade-off between produce-lots-of simple-bits-most-of-which-will-be-lost versus produce-small-numbers-of-highly-sophisticated-objects strategies. In the case of many plants, the trade-off is honed to one involving the desire for seeds to be as small and light as possible to ease dispersion, and yet wanting them to contain enough food materials to support the plant following germination. The trade-off is illustrated in Figure 1.

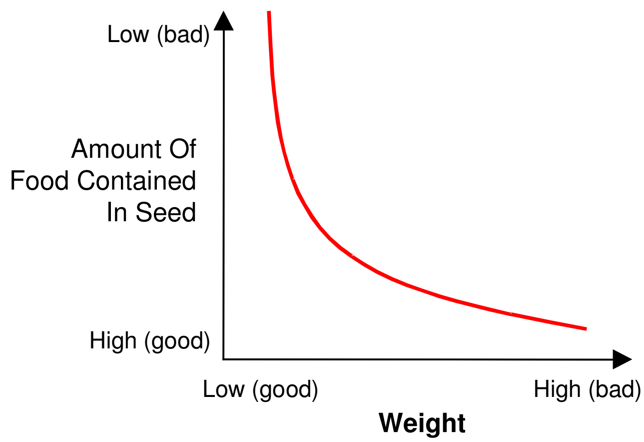


Figure 1: Amount Of Substance Versus Weight Conflict In Seeds

At one end of the spectrum we can find the coco-de-mer from the Sychelles. The seeds of the coco-de-mer are encased in a nutrition-providing fruit weighing 18kg. As you can probably imagine, the coco-de-mer tends not to use the wind as a seed dispersal method.

The orchid, on the other hand, does use wind. Essentially, the smaller and lighter a seed is, the more likely that it will travel large distances, boldly seeking out new places to grow. But then, according to our Figure 1 trade-off, these small seeds are highly unlikely to be able to carry enough food to allow them to survive beyond germination. In steps Inventive Principles 5, Merging, in the form of a symbiotic relationship that certain orchids have formed with soil fungi. Interestingly from the TRIZ perspective, as can be seen in Figure 2, Principle 5 is one of the recommended strategies for solving the seed conflict as predicted by the 2003 Contradiction Matrix.

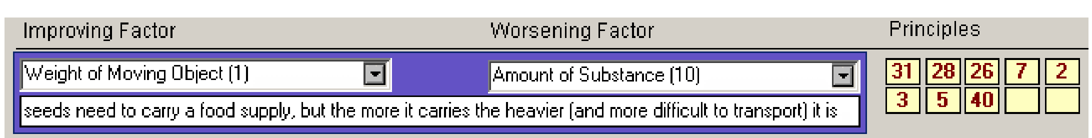


Figure 2: Matrix 2003 Recommendations For Weight/Amount-Of-Substance Conflict Pair
(actually, the orchid is also using Principle 2 – since the food carrying part of its role is 'Taken Out')

According to the BBC Wildlife article (Reference 3), the orchid-soil-fungus relationship is a truly win-win symbiotic one since, once the new orchid plant has become self-sustaining, the fungi shares the food produced by the orchid.

A different conflict, but the same use of a symbiotic win-win occurs with certain woodpeckers. According to a North American survey of woodpeckers, when they drill into trees they pick up dozens of different wood-rot fungi in their beaks. This is especially so for woodpeckers nesting in tree cavities. The woodpeckers rely on these wood-rotting fungi to help them excavate those cavities, and as an added extension to their win in the relationship, the fungi they carry attract more beetles, which in turn become a food source for the woodpecker. The win for the fungi is that the woodpecker helps them to spread to new trees.

References

1) Mann, D.L., 'Complexity Increases And Then…(Thoughts From Natural System Evolution)', TRIZ Journal, January 2003.
2) http://www.botany.hawaii.edu/faculty/wong/Bot201/Symbiosis/Symbiosis.htm
3) Gates, P., 'Invasion Of The Seed Snatchers', BBC Wildlife Magazine, Vol 22, No.5, May 2004.