SYSTEMATIC INNOVATION: AN INTRODUCTION

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Abstract

Imagine the biggest study of human creativity ever conducted. Picture the systematic study of over two million of the world's most successful patents, and the construction of a problem solving method which then combines those solutions into a whole that strips away all boundaries between different industries. Now imagine that it exists. What you're seeing is Systematic Innovation. The reason you may not have heard of it before, is that it was initially devised and developed as 'TRIZ' in the former Soviet Union, and practically no-one outside the Eastern Bloc had heard of it before the fall of the Berlin Wall. In this chapter, we examine what that Soviet research achieved and how that platform has now been transformed into a comprehensive Systematic Innovation methodology, suitable for all types of innovation and innovation management issues. In the chapter we show how today's version of the method is helping users to systematically and reliably create breakthrough solutions to problems of all descriptions.

Introduction

TRIZ stands for *Teoriya Resheniya Izobreatatelskikh Zadatch,* which, translated into English approximates to the Theory of Inventive Problem Solving. TRIZ research began in 1946 when engineer Genrich Altshuller was tasked with studying patents (Reference 1). TRIZ and its 'Systematic Innovation' updates today represent the output of over 2000 person years worth of research into not just patents, but successful problem solutions from all areas of human endeavour (Reference 2). The main findings of Systematic Innovation are:-

1. That the same problems and solutions appear again and again across different industries, but that most organisations tend to re-invent the wheel rather than look outside their own experiences or the experiences of their direct competitors.
2. That the most powerful solutions are the ones that successfully eliminate the compromises and trade-offs conventionally viewed as inherent in systems.
3. That there are only a small number of possible strategies for overcoming such contradictions.

4. That the most powerful solutions also make maximum use of resources. Most organisations are highly inclined to solve problems by adding things rather than making the current things work more effectively, or transforming the things viewed as harmful into something useful.
5. That technology evolution trends follow highly predictable paths.

TRIZ was barely visible outside the Soviet Union until the fall of the Iron Curtain. Since then, the spread of the method has been relatively slow, thanks to a combination of language and cultural mismatches and the reluctance of organisations using TRIZ to describe their successes (and failures) to others.

This short chapter is intended to give newcomers enough information to determine whether TRIZ/systematic Innovation has got something to offer them. Systematic Innovation works on several levels – Figure 1 – firstly a collection of tools, secondly a complete process that links different tools together for any given innovation situation, and thirdly a series of philosophical ideas. In the first section, the chapter focuses on these ideas and the impact they have on the way problems and opportunities are defined. The second section then outlines a simplified case study in which one of the basic tools is used to solve a typical manufacture quality problem. A third, final, section then outlines strategies for finding out more about and deploying the method.

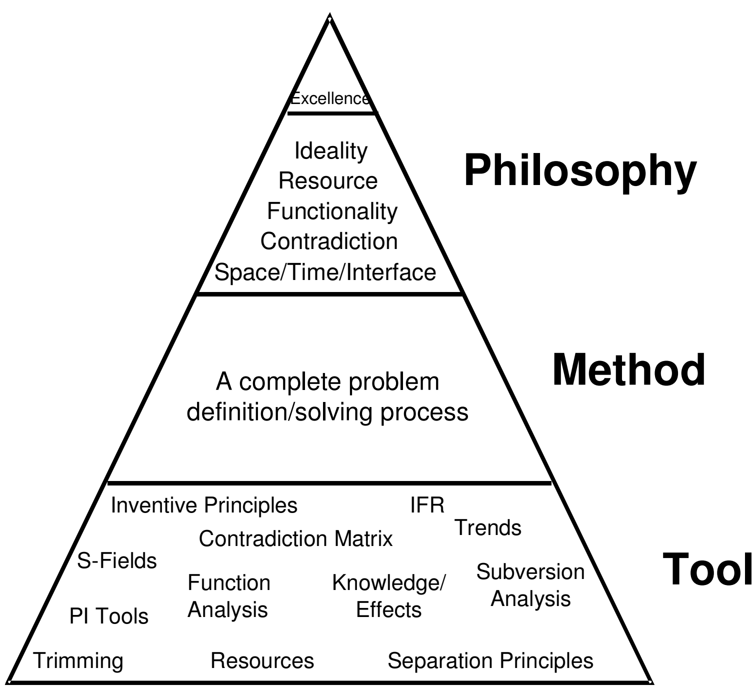

Figure 1: Tool, Method & Philosophical Levels of Systematic Innovation

Philosophy of Systematic Innovation – Five Pillars

At its highest level, Systematic Innovation may be thought of as the distillation of excellence into a single, unified entity. Excellence in this case means best practice from every area of endeavour. One of the early discoveries of Genrich Altshuller and now one of the big ideas encompassed in Systematic Innovation is that amongst this excellence, someone, somewhere has already solved your problem.

To some people this statement might sound quite threatening. This is particularly so if, for example, we are a leader in our particular discipline and have been working on a problem for a long period of time. Systematic Innovation recognises that a world expert in their field is exactly that. It also recognises that being an expert in a field is a full-time job. Few if any experts in one field have the time to become familiar with other fields. This, then, is where the method becomes an opportunity rather than a threat. TRIZ research uncovered the fact that very different industries are all solving very similar problems, and that by constructing an appropriate framework for knowledge it makes it possible to systematically bridge the gaps that traditionally exist between different the industries and sciences. The expert, therefore, is offered the opportunity to see how experts in other fields have solved similar problems. Even if, at first sight, those problems do not appear to be the same.

There are, of course, two sides to this story. The first is that we have a problem. In this case, Systematic Innovation will allow us to identify who and how that problem has been solved in other sectors. The second possibility is that we already have a solution. In this situation the method can be used to systematically connect us to industries that have not yet solved their own problems, and hence provide an opportunity to more fully exploit what we already possess.

In both directions, Systematic Innovation provides means for problem solvers to access the good solutions obtained by the world's finest inventive minds. The basic process by which this occurs is illustrated in Figure 2. Essentially, researchers have encapsulated the principles of good inventive practice and set them into a globally generic problem-solving framework. The task of problem definers and problem solvers using the large majority of the Systematic Innovation tools thus becomes one in which they have to map their specific problems and solutions to and from this generic framework.

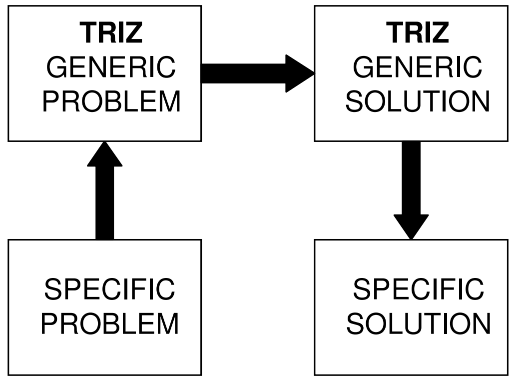

Figure 2: The Basic TRIZ Problem Solving Process

Beyond this big idea of distilling all knowledge into a common framework, there are then five central philosophies underpinning the method. Systematic Innovation can be used without knowledge of these pillars, and indeed many users are happy to simply take one or two tools from the toolkit. Nevertheless, appreciation of these big ideas undoubtedly increases the likelihood that the method will deliver significant tangible benefit. The pillars are described in no particular order below:

Ideality

Ideality is in many ways similar to the concept of 'value'. Ideality is defined as the sum of the benefits that a system delivers to its user divided by the sum of the cost of delivering those benefits and the any other negative side-effects that may occur (waste, waiting time, environmental damage, etc). The original TRIZ researchers identified a very simple phenomenon common to all successful innovations – that they all delivered a higher level of ideality than the products and processes that preceded them. Hopefully the idea that we should give customers more good things and less bad if we are going to be successful is not a great surprise. It does mean, however, that there is a definable direction of success. More interesting than this idea of direction is the concept of a final destination. In Systematic Innovation this final destination is known as the Ideal Final Result (IFR). The IFR is defined as that point when the customer gets all the benefits they want, without any of the costs or harms. While this concept might sound very theoretical, at the very least it offers a long term evolution goal.

Related to this evolution towards the IFR (recognising that every customer will potentially have a different definition of the IFR of course) is the knowledge that systems evolve through a series of discontinuous jumps or s-curves. Figure 3 illustrates a fundamental dynamic governing the evolution of all systems – any individual system will improve up to a point where it is incapable of improving further, then, provided the customer is demanding further improvements, the only way forward is to make a discontinuous jump to another system. The evolution of systems towards the IFR destination may thus be seen as a series of discontinuous jumps.

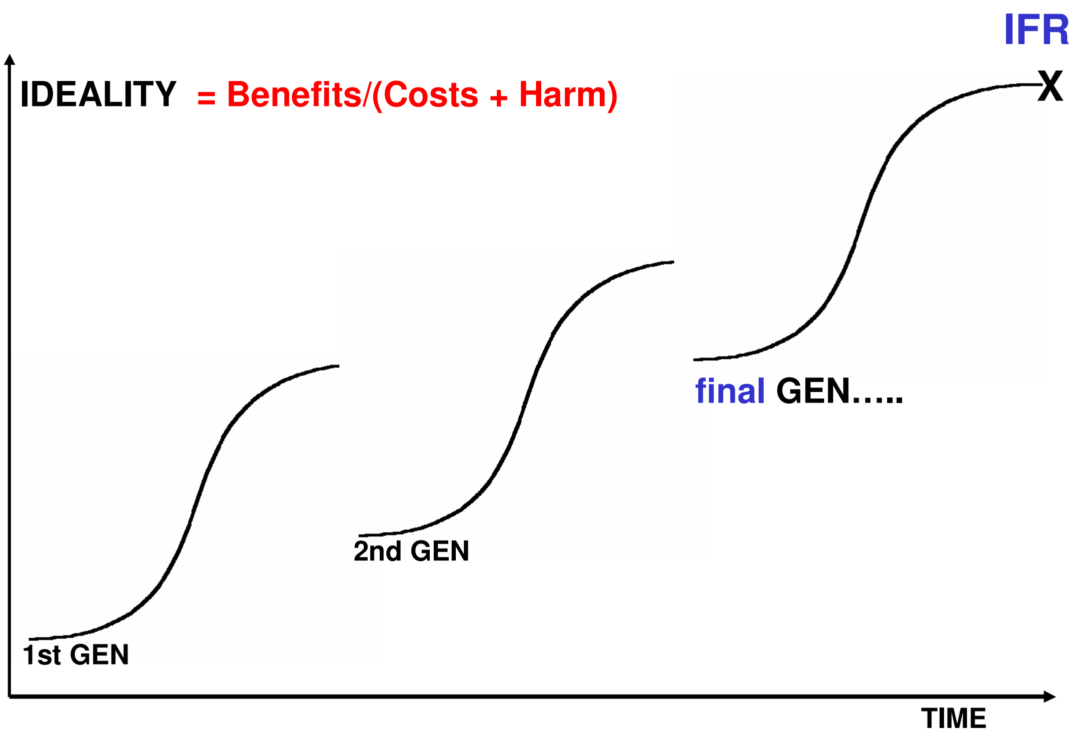

Figure 3: The Fundamental Dynamics Of System Evolution

The next key finding of Systematic Innovation is that the steps denoting a shift from one S-curve to the next are highly predictable. This may sound difficult to believe, but the overwhelming evidence from the analysis of all of the successful solutions is that there are a number of patterns of discontinuous jumps that repeat faithfully across different industries. This chapter does not set out to 'prove' that these trend patterns are correct, but instead merely asks the users to speculate on the impact that predictable evolution would have on their business and the way it thinks about its future relative to competitors.

Contradictions

Although often the first of the tools seen by newcomers to TRIZ or Systematic Innovation, Contradictions is probably the tool which is deployed least well. At least part of the reason for this is that the main underlying principle of the Contradictions philosophy – that of seeking to identify and eliminate contradictions, trade-offs, paradoxes, conflicts or whatever other term we might use – is almost the complete opposite of traditional problem solving strategies. In nearly all problem solving methodologies the emphasis is very firmly placed on the importance of achieving ‘optimum’ compromises between conflicting problem parameters. There is a strong tendency in a traditional design approach, in fact, to think of the design process as an amorphous bag filled with an incompressible fluid made from the different design parameters – Figure 4 – in which, as the designer tries to squash the bag to improve one parameter, it bulges out somewhere else as a different parameter gets worse.

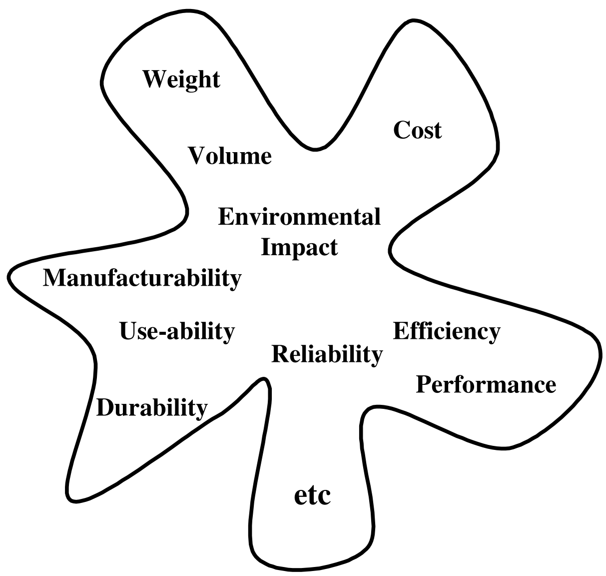

Figure 4: The Design Process As An Incompressible-Fluid Filled Bag

The keen emphasis on ‘trade-off’ solutions in traditional problem solving practice often means that problem owners are rarely explicitly aware that conflicts exist. The first major part of the paradigm shift that takes place in the Contradictions part of TRIZ is the need for problem solvers to actively seek out the conflicts and contradictions inherent in all systems. The second part then involves using the Systematic Innovation methodology to try and ‘eliminate’ (Reference 3) those contradictions rather than to accept them. Or, in terms of the incompressible-fluid filled bag analogy, the aim is to attach a valve of some kind which allows the amount of fluid in the bag to be changed.

Once contradictions have been identified, Systematic Innovation contains a number of ‘contradiction elimination’ tools – primarily the Contradiction Matrix (References 3 and 4) – which encapsulate how others have successfully solved similar problems. At this point in time, the research has identified 40 Inventive Principles which might apply in any given contradiction situation. The Contradiction Matrix allows problem solvers to narrow down that list of 40 to a more manageable five or six Principles which might apply to an individual contradiction type. There may, of course, ultimately be more than 40 Principles. As of today, however, wherever researchers look, we see the same 40.

Contradiction elimination is one of the most powerful of the Systematic Innovation problem solving tools. A common phenomenon when problem contradictions are eliminated instead of traded-off is that the benefits tend to extend beyond those initially targeted during the problem solving process (References 5 and 6).

In terms of evolutionary S-curves, it is the emergence of limiting contradictions (Reference 7) that ultimately restrict the ability of systems to give all of the benefits that customers desire and give the S-curve its characteristic flattened profile at the mature end of the curve. The TRIZ contradiction elimination tools thus have a very important role to play in allowing systems to transition from one S-curve to another.

Functionality

Although the functionality aspects of Systematic Innovation owe a significant debt to the pioneering work on Value Engineering by Miles (Reference 8), the method of defining and using functionality data is markedly different; sufficient at the very least to merit discussion as a distinct paradigm shift in thinking relative to traditional occidental thought processes. Three aspects are worthy of particular note:-

1) The idea that a system possesses a Main Useful Function (MUF) and that any system component which does not contribute towards the achievement of this function is ultimately harmful. In a heat exchanger, for example, the MUF is to

transfer heat to the working medium; everything else in the system is there solely because we don't yet know how to achieve the MUF without the support of the ancillary components. (Systems may of course perform several additional useful functions according to the requirements of the customer.)

2) In traditional function mapping, the emphasis is very much on the establishment of positive functional relationships between components. Systematic Innovation places considerable emphasis on plotting both the positive and the negative relationships contained in a system, and, more importantly, on using the function analysis as a means of identifying the contradictions in a system.

3) Functionality is the common thread by which it becomes possible to share knowledge between widely differing industries. A motor car is a specific solution to the generic function 'move people', just as a washing powder is a specific solution to the generic function 'remove object'. By classifying and arranging knowledge by function, it becomes possible for manufacturers of washing powder to examine how other industries have achieved the same basic 'remove solid object' function. '*Solutions change, functions stay the same*' is a message which forms a central thread in the TRIZ methodology: People want a hole not a drill. Functions, it should additionally be noted can be both tangible ('remove solid object') and intangible ('feel nice to the touch').

A number of functionally classified knowledge databases for at least the tangible functions are now becoming commercially available. A free version is available at Reference 9.

Use Of Resources

The fourth of the five philosophical pillars of TRIZ is the simplest, and relates to the unprecedented emphasis placed on the maximisation of use of everything contained within a system. In TRIZ terms, a resource is *anything in the system which is not being used to its maximum potential*. TRIZ demands an aggressive and seemingly relentless pursuit of things in (and around) a system which are not being used to their maximum potential. Discovery of such resources then reveals opportunities through which the design of a system may be improved.

In addition to this relentless pursuit of resources, TRIZ demands that the search for resources also take due account of negative as well as the traditionally positive resources in a system. In Systematic Innovation terms, even the bad stuff is good stuff – we merely haven't thought hard enough yet about how to make the transformation from lemons to lemonade. By way of an example of this 'turning lemons into lemonade' concept, practitioners often think of resonance as a resource. This is in direct contradiction to most practice, where resonance is commonly viewed as something to be avoided at all costs. Systematic Innovation says that somewhere, somehow, resonance in a system can be used to beneficial effect. In effect, resonance is a potent force lever capable of amplifying small inputs into large outputs. Resonance is currently being used to generate beneficial effects in a number of new product developments from vacuum cleaners (resonating carpet fibres to enhance extraction of dust particles), paint stripping systems on ships (firing a pulsed jet of water – existing resource! – at the local resonant frequency of the hull), and in helping to empty trucks carrying powder-based substances more quickly.

Space, Time, Interface

The fifth pillar of Systematic Innovation is about perspective on problems. Our perspective on a situation plays a very important role in determining the solutions we derive. It is therefore very important to be able to look at things from many different view points – not only physically and temporally, but also the relationships and interfaces between the things can be as important as the things themselves. The human brain has not evolved to be creative. It has evolved to absorb sparse data and make decisions on that data. Sometimes – as in an emergency – this decision making process has to happen very quickly. As a result, the brain very quickly makes assumptions about what a problem is and what to do about it. Unfortunately, the brain very often jumps to what turns out to be the wrong definition of the situation. The space-time-interface pillar of the method is about enabling users to systematically re-frame their thinking in order to avoid the problem of jumping to the wrong problem definition. The space-time-interface pillar of systematic innovation is where the internal workings of the brain meet the outside world – Figure 5. In any creative problem solving session it is helpful to accommodate both domains.

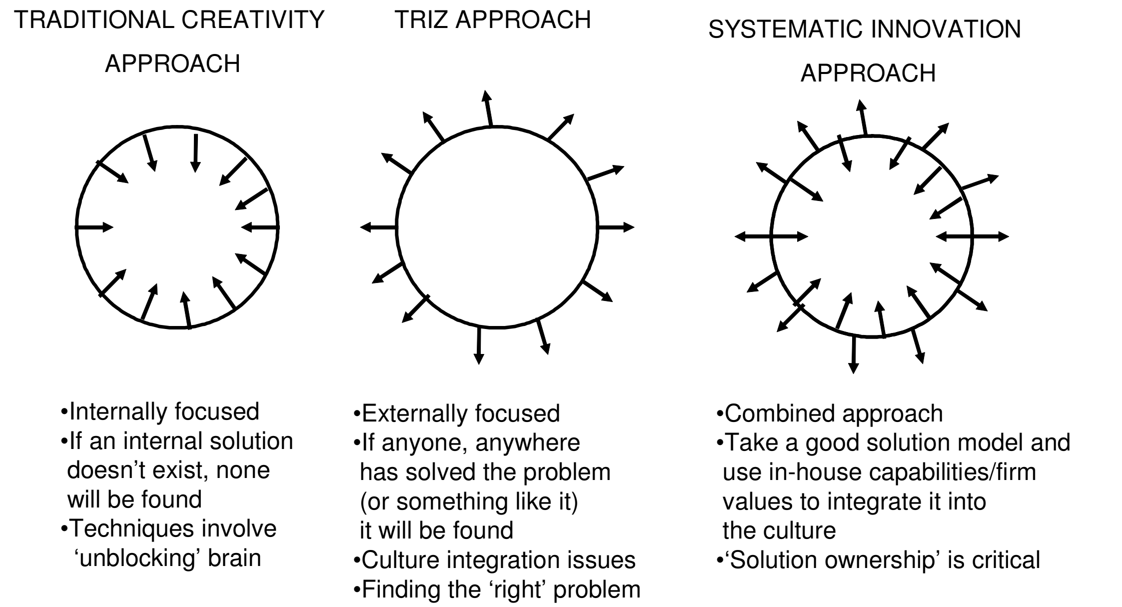

Figure 5: Space-Time-Interface – Utilising Internal And External Worlds

A Simple Case Study

In order to give a flavour of Systematic Innovation in action and to compare its approach with that of traditional problem solving methods, this section of the chapter examines a typical manufacture quality problem. The example relates to the extrusion of man-made textile fibres. In this operation we are trying to produce fibres of as small a diameter as possible in order to produce the highest possible appearance and feel in the finished textile. We are also trying to achieve 6 Sigma levels of quality (i.e. 3.4 failures per million opportunities) during the extrusion process, but unfortunately have not been able to do so despite considerable experimental effort. The main source of defects concerns fibre breakage due to localised 'necking' – lengths of the fibre that are lower than specified diameter. The start point for this situation then is our desire to improve the quality of the extrusion process by reducing the necking problem and hence reducing the number of fibre breakages.

Once we know what we would like to improve, the next question asked in a simplified version of the TRIZ process would be 'what is stopping us from making the improvement?' The answer to this question may be that we don't know. If that is the case then the Systematic Innovation method will tell us that we need to acquire some data in order to understand why in this case necking occurs. For most production processes the desire to optimise processes generally means that we will have a pretty good idea about what causes variation in the process. In the case of a typical extrusion operation quality is likely to be related to changes in temperature of the material, atmospheric temperature, size of the die, pumping pressure, tension on the fibre after extrusion, atmospheric pressure, humidity, etc. Let us then speculate that the reason for the presence of necking in the fibre is fluctuation in the temperature of the molten material before it enters the die. In traditional problem solving analysis, we might chose to explore this situation further by asking why the temperature fluctuations occur. Indeed we might take this a step further by experimenting with all of the other variables in the system to see how they might affect temperature and then necking. If we did this we might well determine that, for example, it was possible to reduce the temperature variation problem by slowing down the process (i.e. allowing more time for the temperature to stabilise throughout the material). With this finding we now have the potential of a solution to the problem; slowing the process down improves temperature distribution which in turn reduces breakages. While this might indeed solve the quality problem, the solution has been achieved at the expense of throughput. We have improved one thing only for another to get worse. If we determine that quality is more important than speed then we may be happy with this decision.

Systematic Innovation on the other hand will tell us that we have now found a contradiction. Something gets better and something else gets worse. In the ideal case, we would find a way of improving the quality without reducing the speed. The contradictions part of the method contains a Contradiction Matrix tool (Reference 3). This tool enables users to see how other problem solvers have solved similar problems without making compromises. In the case of this hypothetical extrusion process, we have identified that there is a contradiction between our desire for even temperature distribution and the lack of time for the heat to spread evenly through the material. According to TRIZ, someone, somewhere has already found ways of solving this problem. Figure 6 illustrates how the Matrix has been used to resolve the problem in other disciplines.

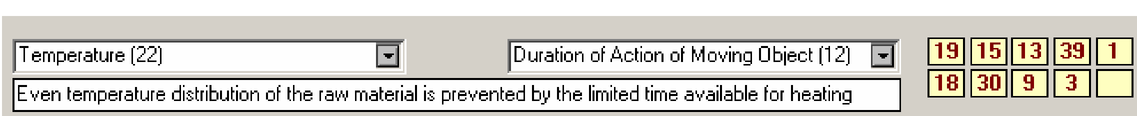

Figure 6: The Temperature versus Time Contradiction And How Other People Have Solved It

In this case we may see that 9 different Inventive Principles have been used to successfully resolve this type of temperature-versus-time conflict pair. Closer examination of the Inventive Principle descriptions (Reference 10) will then reveal several possible solution options:-

Principle 15, Dynamics – introduce some kind of a stirrer into the system to improve mixing of hot and cold materials.
Principle 19, Periodic Action – rather than adding a mechanical mixer, use pressure pulsations to improve mixing of the raw material.
Principle 1, Segmentation – instead of attempting to heat all of the raw material to the same temperature, recognise that the only time when temperature is important is when the material enters the die. Hence rather than seeking to accurately control the temperature of all of the material, segment the problem and only accurately control that material which is about to enter the die.
Principle 18, Vibration – here we might use some form of vibration (the Principle actually suggests the use of ultrasound) to improve mixing of the material and hence the removal of hot spots.

The only limits to the number of solutions that can be found will generally be dependent on the ability of the problem solver to interpret the Inventive Principles. With practice it is possible to still be generating viable no-trade-off solutions for several hours. Compare this with a typical brainstorming session where ideas generally run out after less than 20-30 minutes.

This quality problem study has been solved as a contradiction problem since – as with many manufacture systems – there are highly likely to be contradictions present since we are always trying to get the maximum out of the system that we can. Asking the pair of questions ‘what would I like to improve?’ and ‘what stops me?’ is a simple and effective way of identifying these contradictions. An alternative problem strategy would have involved recognising that the problem has got something to do with the even heating of a liquid. Making this connection, the Systematic Innovation function database would have suggested that, looking across every different industry, there are many ways of delivering this function. We could, for example, seek to deploy acoustic cavitation or the Joule-Lenz Effect or Ranque Effect or microwave, etc as other sectors wishing to perform the ‘heat liquid’ function have already discovered for me. If we have never heard of some of these methods of heating, the database at Reference 9 provides more information on each.

Summary

To try and summarize and give a flavour of the world's biggest study of creativity and innovation in a mere dozen pages is an almost impossible task. For anyone that wishes to explore TRIZ or Systematic Innovation in more detail there is a wealth of available information on the subject. Much of this information is available for free on the Internet. See Reference 9, for example, for a collection of over 200 TRIZ websites. Despite the fact that TRIZ will tell us that the nuclear, aerospace, bio-sciences, micro-electronics, chemical process, automotive, food, education, politics, HR, literature, music, logistics, etc sectors are all solving similar problems it is still very difficult to conceive the possibility that someone has already solved your problem. But that is indeed what the evidence of over two million analyses will tell us. As companies and individuals gradually become more willing to talk about what they are doing with TRIZ, it becomes increasingly likely to find something specifically connected with your situation.

The main success factor with Systematic Innovation is to get some initial tangible benefit. To learn the whole of the method will probably require an investment of three to six months of effort. No-one is going to (or indeed ought to) make this level of commitment without some faith that the benefits will outweigh the costs. A very important final word, then, is that there is absolutely no need to learn the whole of the toolkit before users can start delivering real benefits. Many users will learn one tool only, and will stick with just that one tool. If that enables them to solve a problem or create a patent then a major service will have been provided. Then and only then should the inclination to learn other parts be encouraged. Let the use of Systematic Innovation grow from the tangible benefits that it delivers.

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