Case Studies in TRIZ: A Novel Jet Engine Nose Cone

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Introduction

Now, more than ever, engineers are faced with the need for rapid development of creative solutions to their problems. But what is creativity? Can we define what we are looking for? Often people are careful not to define creativity, as it is such a complex phenomenon. Furthermore, teaching creativity becomes fostering, nurturing, stimulating or allowing creativity. This article suggests that it is possible to enhance a creative potential and therefore the chances of a creative solution by employing structured approaches, such as TRIZ.

The article focuses on a case study, described in the reference, concerning a novel design for a spinning nose-cone found on the front of a gas-turbine engine (Figure 1). The case offers a comparison between traditional un-structured creativity methods and the systematic process offered by TRIZ.

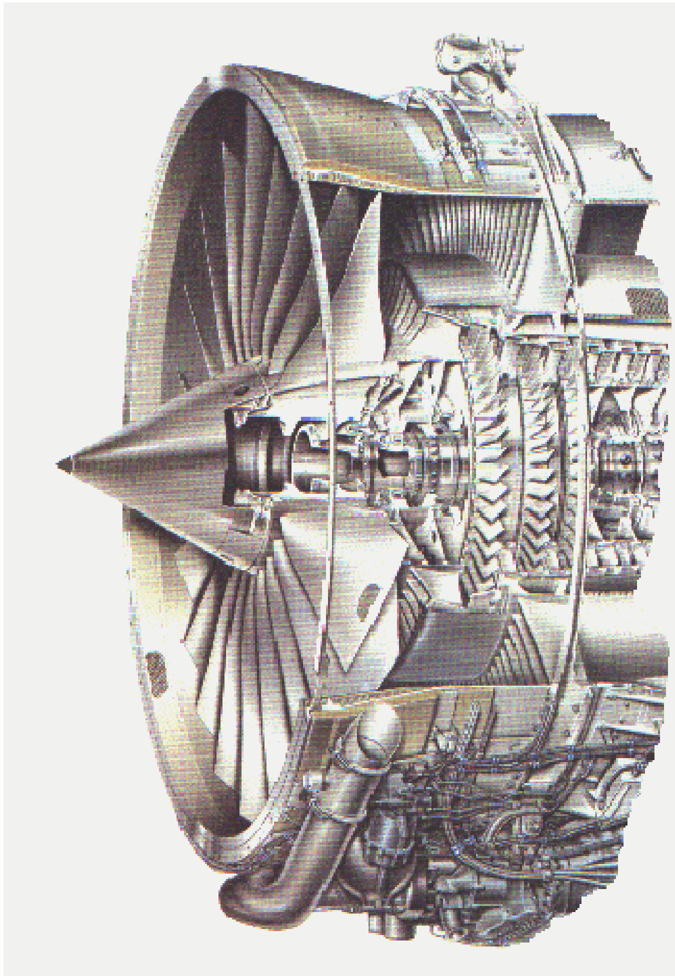

Figure 1: Typical Gas-Turbine Engine Showing Nose Cone

By way of setting the scene, the first section describes some of the definitions and findings from UK Government sponsored Imperial College research:

Creativity - A Working Definition

The necessity for an appropriate definition for the Imperial research project lead to the construction of a working definition as follows: ***Creativity is shared imagination.***

The creativity becomes an innovation when an application becomes apparent and if it is non-domain specific it becomes an invention i.e. a motorcycle is an innovation consisting of inventions like the wheel and the engine.

In order to enhance creativity in engineering, we can focus on aspects which affect the engineers potential to be creative.

Internal / Individual Personality CONFIDENCE	POTENTIAL CREATIVITY	External / Organisational Environment CULTURE
Intrinsic Motivation CURIOSITY	Skills, Knowledge Attitude, Behaviour ASSOCIATION	Extrinsic Motivation RECOGNITION

Figure 2: Potential Creativity Model

The Figure 2 model above expresses a tension zone to be optimised. Developing this creative potential depends entirely upon internal or external perceptual filtering.

Engineering problem solving approach

If we provide the ideal environment for the development of creative potential, an idea may emerge through subconscious association, or incubation, often after a period of relaxed attention or even using a basic trial and error method. However, various procedures have been developed intentionally to move an individual away from habitual pathways of thinking. These procedures enlarge the individual's working memory thereby increasing the source for association. (E.g. analogy with nature)

The figure below draws out a solving procedure. A gas-turbine nose spinner is frozen. One 'obvious' solution route suggests heating of the spinner, as the 'normal' way of removing ice is to melt it. Reformulating the problem to 'removing the ice' however, creates a distinctly different route. The figure illustrates a structure of how the spinner could have been derived using traditional creativity methods.

Note how even if the problem owner had successfully made the paradigm shift away from a typical psychological inertia bound 'remove ice by heating/melting it', to the idea of removing the ice by other means - in this case using a rubber-tip on the end of the spinner - a quite considerable leap of the imagination is required. In fact, Reference 1 uses the example as a demonstration of the unmeasurable, unpredictable nature of creativity, describing the moment of inspiration which produced the solution as something 'dreamt up overnight in a classic case of incubation'.

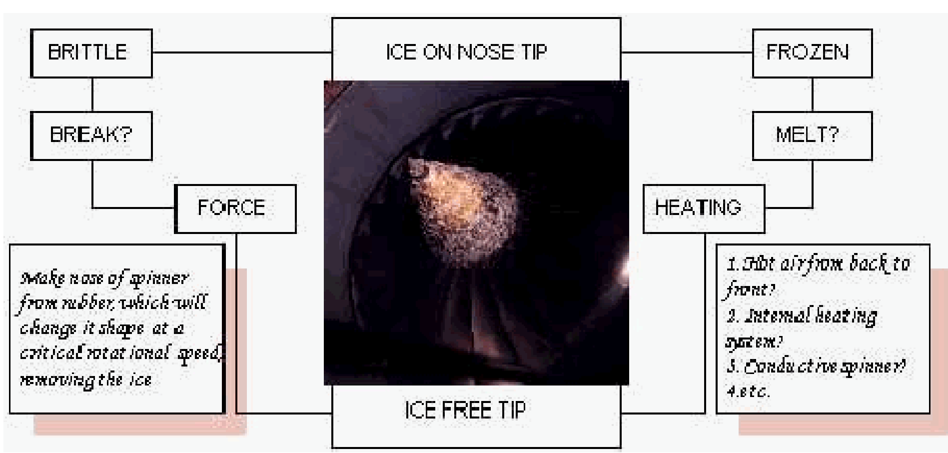

Figure 2: Gas-Turbine Spinner Problem Solution Routes

A TRIZ Approach

Approaching the same problem using TRIZ, we might immediately see the nose-cone icing problem as a contradiction. In common with many gas-turbine related problems, the industry knows how to remove ice from nose-cone spinners. Traditional design solutions to the problem come with a certain weight and power-loss penalty. Thus a designer might be motivated to look for alternative means of removing ice from the nose-cone in order to reduce one or both of these penalties.

In actual fact, we can observe that the two parameters are in contradiction. For example, if we were motivated to reduce weight, switching from a metal to a composite material is a well known solution route. The problem - as far as the nose-cone is concerned - of switching to a composite is that such materials conduct heat less well and thus more energy has to be supplied in order to remove any ice which may accrete on the surface.

In terms of the Contradiction Matrix, we thus have a WEIGHT versus USE OF ENERGY (BY MOVING OBJECT) contradiction. The Matrix recommends Inventive Principles:-

35 - Parameter Changes

12 - Equi-potentiality

34 - Discarding and Recovering, and

31 - Porous Materials

as good solution directions adopted by other inventors facing similar contradictions.

While all of these appear to have some potential relevance to the problem at hand, the first, Parameter Changes, offers some very striking solution directions. As described in Reference 2, the Principle is interpreted in several ways:-

- change an object’s physical state (e.g. to a gas, liquid or solid)

- change the concentration or constituency

- change the degree of flexibility

- change the temperature

Again, the Principle contains several solution triggers which point very specifically in the direction of the previously described rubber-tip - particularly the idea of increasing the flexibility of the system.

Whether or not one believes in 20/20 hindsight and the fact that it is much easier to reverse engineer from an existing solution, the case very specifically highlights the fact that the structure offered by TRIZ does point problem solvers in very fruitful solution directions. That being said, it is also worth noting that the method still leaves the problem solver with a deal of creative thinking to do. In this sense, TRIZ acts as a very good focus for subsequent creative efforts - for example, in an actual situation, a problem solving group might be asked to brainstorm connections between the nose-cone problem and the ‘Parameter Changes’ solution trigger. TRIZ may thus be seen as highly complementary to other creativity tools and techniques.

Inventive Principle 35 - Parameter Changes

Use of Inventive Principle 35 in the nose-cone example above, highlights the value of the Principle. Further comment on the importance of the Principle may be in order:-

'Parameter Changes' is the most commonly cited and applied of the 40 Inventive Principles (Reference 3, plus research at the University of Bath)

Recommendation of Parameter Changes by the Matrix usually implies that a system is approaching the mature end of its evolution S-curve, and is often a strong indicator that shifts from mechanical to fluid to gaseous to fields are necessary if improvements are to be produced.

It is a particularly strong indicator that the need for the major mechanical→hydraulic, hydraulic→pneumatic, and hydraulic/pneumatic→field transitions are emerging.

The 'increase the degree of flexibility' trigger is another powerful message; one which often flies in the direct opposite direction to 'traditional' design instincts to increase the stiffness of systems rather than go the other way. Some designers fight the 'increase flexibility' direction quite vociferously despite powerful evidence that the TRIZ recommendation is actually a much more powerful solution direction.

Conclusions

While it is always simpler to see good ideas in retrospect, it is hoped that the article has shown how TRIZ provides systematic route by which the spinner idea could have been derived.

TRIZ offers very good solution 'triggers'. Beyond these triggers, all the creative energy's of the problem solver are required to produce a specific solution. In such instances, there is much common ground between TRIZ and the many available unstructured creativity methods.

Inventive Principle 35, 'Parameter Changes' is a particularly important member of the family of Inventive Principles.

References

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