Integrating trend impact analysis methods with trend evolution of technological systems in order to improve innovation development strategies.
A theoretical and application study.

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1. Abstract

The following paper proposes the integration of Trend Impact Analysis with selected TRIZ methodologies and patent based CHE/CPE measures (Cited Harmful and Positive Effects) in order to improve the evolution of technical systems and the selection of innovative development directions. The article discusses the dynamics of impact analysis methodologies, introduces the concept of Cited Harmful/Positive Effects, and proposes a model for the integration of TRIZ, CHE/CPE and Trend Impact Analysis. A Triz trend impact analysis case study is then presented, focusing on the application of the method in the development of an improved microwave susceptor food package.

2. Introduction

When utilising TRIZ methods in both the solution of process and product problems, and in the development of new concepts, it is often difficult to decide what the best solution or development path is. Measurement of the impact of the solution can be partly achieved through judicious use of functional analysis tools or through the application of Ideality measures. However these methods only convey some aspects of the impact of, for example, a 'Geometric Volumetric' evolutionary jump. A powerful tool that needs to be integrated within the TRIZ methodology, in order to improve this situation, is trend impact analysis. This technique has already found numerous applications in fields as diverse as economics and environmental analysis.

3. Trend Impact Analysis.

According to Gordon (1994) Trend Impact Analysis is 'a forecasting method that permits extrapolations of historical trends to be modified in view of expectation about future events'. A schema of a trend analysis chart is shown in Figure 1. The probability/effect rows represent the effect or indeed the probability of an event occurring sometime in the future. Event rows represent the description of events relating to the subject area that are likely to occur over a period of time. In TRIZ terms, 'Event' can represent an evolutionary jump with respect to the TRIZ lines and laws of evolution (Figure 2)

Figure 1: Trend Impact Chart schema

Event	Event Description	Probability or Effect	Probability or Effect	Probability or Effect
1				
2				
3				
4				

Figure 2: Trend Impact Chart schema with TRIZ bias

Evolutionary Jump	Evolutionary Description	Probability or Effect	Probability or Effect	Probability or Effect
1	Geometric Evolution (Vol) from 2D to Axi-Symmetric			
2	Dynamization Evolution from immobile to Jointed System			
3	Etc			
4	Etc			

The probability/effect metrics can be represented by key characteristics (**KC**'s) of the product or process. For example key characteristics for a food product may be 1. Mouth-feel. 2. Colour. 3. Texture. For an extrusion nozzle it may be 1. Viscosity. 2. Flow rate. For business problems these characteristics may be 1. ROI. 2. Market share etc. Obviously the key characteristics are product/process specific and may or may not have been identified using the voice of the customer. Figure 3 represents a TRIZ based trend impact chart with respect to 3 characteristics

Figure 3: TRIZ trend impact chart

Evolutionary Jump	Evolutionary Description	Effect 1 Texture	Effect 2 Mouthfeel	Effect 3 Colour
1	Geometric Evolution (Vol) from 2D to Axi-Symmetric			
2	Dynamization Evolution from immobile to Jointed System			
3	Etc			
4	Etc			

The impact of the changes in TRIZ evolution can be represented by an impact metric- commonly used in cross-impact analysis studies:

1. **Very positive effect ++**
2. **Positive effect +**
3. **No Effect 0**
4. **Negative effect -**
5. **Very negative effect --**

Trend impact analysis can also be integrated with the Systems Operator system with each 'Square' being represented by its own trend impact chart. For example, changes on a sub system level may have predominantly positive impacts on the sub system characteristics but on the system level may incur what a developer may see as unacceptable negative impacts. The trend impact chart can also be used as a means to identify the effect that one evolutionary step has on another, at both the sub, system and super system levels, as can be seen below in Figure 4. This method can be used to identify interacting Hierarchical Effects (Mann and DeWulf 2002).

Figure 4: Describing Hierarchical effects with the trend impact chart

Evolutionary Jump	Evolutionary Description	Geometric Ev	Dynamization	Surf Segmentation
1	Geometric Evolution (Vol) from 2D to Axi-Symmetric			
2	Dynamization Evolution from immobile to Jointed System			
3	Surf Seg: Planar to Roughened			

4. Patent Information and CHE

Obviously in order to use the trend impact chart optimally it is important that the developer (s) has either intimate knowledge of the problem space or at least access to an information source that can aid the development of a realistic trend impact chart. This information can come from a number of sources, most notably technical papers, the developers own experience, journals, the internet, and the Patent databases of the world. Of these, the most important information resource available to any developer is the Patent database. No other information resource offers full disclosure of technical inventions. Another key aspect of the patent information resource is the fact that all patents require a 'Background to the invention' section which describes the prior art with respect to other inventions. In many instances this information can quickly illustrate impacts (both positive and negative) that previous inventions have had on different product characteristics.

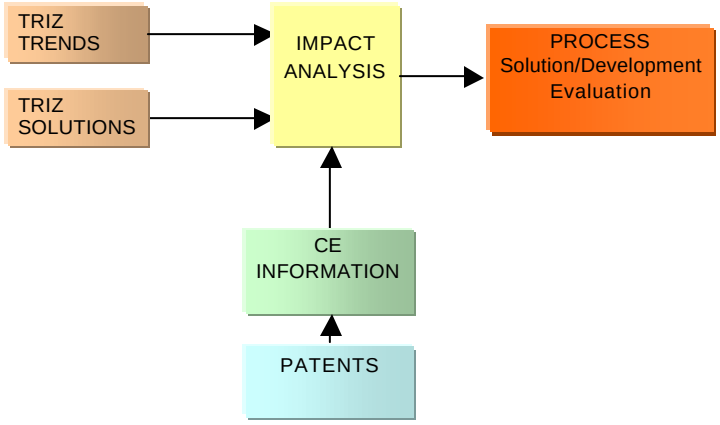
These effects will be known as CHE's and CPE's- Cited Harmful Effects and Cited Positive Effects. These effects can be recorded, on a Cited Effect Table (Figure 4)

Figure 5: Cited Effect Table

Patent No	CHE (s) Key Characteristic 1	CPE (s) Key Characteristic 1

This Cited Effects knowledge, coupled with developer experience, will enable the creation of a realistic trend impact chart that gives a good overview of the development/solution space. The key advantage in using this methodology is that fact that the development and solution spaces are well charted even before the development of process/product prototypes.

Figure 6: Process/Product Solution and Development Model



5. Process/Product Solution and Development Model

A process/product solution and development model is shown in Figure 5 that can serve as a useful framework in the utilisation of TRIZ trends/solutions, trends impact analysis and CE's in the appraisal and development of new products and processes.

6. CASE STUDY- Application of Triz trend impact analysis in Microwave Susceptor development

6.1 Background

This case study represents a small part of a larger innovation study that focused on the development of an improved microwave **susceptor** for food products. Although various contradictions were highlighted throughout the duration of the project the focus of this paper is the application of Triz trend impact analysis in the selection of optimal innovation development directions.

6.2 Microwave Susceptors

The basic premise of microwave susceptors is that it is possible to generate thermal energy from a thin metallic film (microwave susceptor) upon exposure to microwave radiation. This effect has been used in a variety of packaging structures to achieve cooking of foodstuffs with microwave energy, including crisping and browning, of various food products. Numerous attempts have been made to improve the overall uniformity of heating in susceptor-based packages. Generally results to date in the development of a cheap, easy to manufacture, and effective susceptor have been unsuccessful. All currently available food products utilising susceptors technology are characterised by poor resulting mouthfeel characteristics. As a result there is still a potential market gap for a susceptor that improves key sensory characteristics.

6.3 Analysis

75 Microwave susceptor patents were analysed as part of a larger project in the development of an innovative food susceptor package. In order to fully analyse the impact of each potential trend development a Triz trend impact chart was developed focusing on 3 Key Characteristics- previously identified through market, technology and consumer analysis.

1. **Crispiness (of food product)**
2. **Cost**
3. **Complexity (of package)**

Once the KC's had been identified, a CE table was developed, through the systematic analysis of the 75 selected susceptor patents. The 75 susceptor patents represent a FULL life cycle analysis of susceptor technology. It is important when carrying out CE analysis that the patents analysed represent at least a 90% sample of all inventions in the selected technology category.

The CE table is shown below, and represents a summary of the CHE's and CPE's identified through the patent analysis. It is also important to note that this

analysis should, in some cases, be carried out in conjunction with some form of experimental analysis (where possible).

Figure 7: CE's table summary for microwave susceptors

KC	CHE (s)	CPE (s)
KC 1: Crispiness	- Lying in moisture- prevents crispiness - Many susceptors crisp only one side. - Excessive charring and burning on food stuff surfaces - Higher loads, less crispiness - Large area less load improves crispiness	-Metallized Susceptor aids crispiness (*better than nothing*) -Susceptor closer to most sides of the food product improve crispiness - Better control of microwave propagation improves crispiness
KC 2: Cost	- Costs increase with more parts - Susceptor costs relatively expensive	- Less susceptor area cheaper costs - Simple package is better for costs
KC 3: Complexity	- Increased complexity, increased costs - Increased complexity- increased manufacturing time - Increased complexity increased user difficulty	- More complex susceptor packages have better results - More complex patents have increased application

For the purposes of this paper the CE table has been simplified, but it does illustrate the utility of the method in quickly developing a knowledge base for further development.

After the CE table had been developed, a trend impact analysis was created. Specifc trends were selected after a TRIZ trend analysis was carried out on the 75 selected patents and trend gaps were ascertained. A TRIZ trend gap analysis

should always be the first stage in any trend impact analysis study. The trend impact analysis chart for susceptor development in shown below, in Figure 8.

Figure 8: Trend impact chart for microwave development

Evolutionary Jump	Evolutionary Description	KC1: Crisp	KC2: Cost	KC3: Complexity
1	**DYNAMIZATION** (Immobile to Jointed) (Introduce a moving susceptor)	++	--	-
2	**SURFACE SEGMENTATION** (Smooth to Rib) (Introduce ribs into susceptor surface)	+	0	-
3	**INCREASING ASYMMETRY** (Sym to Asym) (Introduce Asy ribs onto susceptor surface)	++	0	-

As can be clearly seen the development of an asymmetrical susceptor offers net benefit without many of the development difficulties encountered with the development of a moving susceptor. As a result an Asymmetrical susceptor profile was selected as the best development path for an improved microwave susceptor product. Development then focused on the optimisation of asymmetrical features using Design of Experiments.

It should be noted that Triz trend impact analysis can be taken from the view of the Consumer or the Manufacturer. For example KC's of a consumer orientated Triz trend impact analysis chart for a microwave susceptor product may be 1. Purchase costs, 2. Ease of use and 3. Flavour.

6.4 Conclusion

This article has introduced the concept of utilising Trend Impact Analysis and Cited Effects as a useful means to improve solution and trend evolution selection. A model, the Product/Process Solution and Development model has been proposed as a framework to best utilise Trend Impact Analysis and Cited Effects in Triz development and solution projects. A case study utilising Triz trend impact analysis in the analysis and selection of innovative development

directions has also been presented in order to illustrate the usefulness of the method in product development projects.

References

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Author:

Barry Winkless, BSc, Dip, MSc, is a consultant with Altran Technologies- the largest Innovation and Technology consultancy in the world. He is a frequent contributor to the TRIZ journal and has worked on a number of innovation projects using TRIZ and other cutting edge methodologies. He is interested in new product development, TRIZ methods in innovation, TRIZ integration with other methods and the use of Quantitative indicators in invention analysis. He is currently in the process of completing a PhD in the development of an integrated TRIZ and patent valuation methodology in innovation analysis and development.