Utilizing Axiomatic Design
to
Render Objective Ideality Calculations

Dr. Michael S. Slocum
Vice President of Innovation and Design
Breakthrough Management Group
MichaelS@BMGi.com

The concept of the ideal final result (IFR) is an important foundational element in the Theory of Inventive Problem Solving. As an abstraction, the IFR is used to envision the *perfect* system. The designer then designs his/her system by adding elements until a minimum set of customer requirements is satisfied. It is my understanding that the Ideality equation was developed by Altshuller in order to demonstrate the concept that the harmful effects and costs should approach zero.[1] Additionally, this formula is being utilized in order to evaluate the state of "idealness" that a particular system is at in some discrete moment of time. Under this consideration, it would seem that the use of the formula has overreached inherent capabilities. I make this observation due to the difficulties presented when a given system and the corresponding Ideality (I) are considered. There is no current method within the TRIZ body of knowledge for capturing *all* of the useful and harmful functions—consequently, Ideality calculations will be incomplete. Axiomatic Design forces a structured approach to the identification and correlation of system elements.[2] The complementary natures of Axiomatic Design and TRIZ has been written about in the TRIZ Journal and elsewhere; therefore, I will simply focus on the use of the design matrix and it's impact on ideality calculations.[3] The design equation below describes a system with three functional requirements (FR) and three corresponding design parameters (DP). The intervening matrix indicates the FR-DP interactions. The non-diagonal interactions may be used to characterize the data used in the denominator of the ideality equation.

[1] Private conversation with Dr. Mark Barkan in Longmont, CO, on the 24th and 25th of July, 2003.
[2] Suh N., The Principles of Design, Oxford Series on Advanced Manufacturing, Oxford University Press, New York, NY, 1990, ISBN 0-19-504345-6.
[3] http://www.triz-journal.com/archives/2000/09/c/index.htm, http://www.triz-journal.com/archives/1999/06/a/index.htm, http://www.triz-journal.com/archives/2000/11/d/index.htm, http://www.triz-journal.com/archives/2003/06/a/01.pdf

$$\begin{Bmatrix} FR_1 \\ FR_2 \\ FR_3 \end{Bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \begin{Bmatrix} DP_1 \\ DP_2 \\ DP_3 \end{Bmatrix}$$

$$Ideality = \frac{\sum F_u}{\sum (F_h + \text{cost})} = \frac{(A_{11} + A_{22} + A_{33})}{(A_{12} + A_{13} + A_{21} + A_{23} + A_{31} + A_{32}) + \text{cost}(\text{DP}_1 + DP_2 + DP_3)}$$

$$Ideality = \frac{\sum F_u}{\sum (F_h + \text{cost})} = \frac{(A_{11} + A_{22} + A_{33})}{\left(\frac{1}{R_{12}} + \frac{1}{R_{13}} + \frac{1}{R_{21}} + \frac{1}{R_{23}} + \frac{1}{R_{31}} + \frac{1}{R_{32}}\right) + \text{cost}(\text{DP}_1 + DP_2 + DP_3)}$$

Two approaches are identified for using the design equation to calculate ideality:

1. use the non-diagonal elements of the matrix
2. use the inverse of the reangularity of the non-diagonal elements of the matrix[4]

After selecting an above approach to capture a representation of the harmful effects[5] then use the diagonal elements of the design equation to identify useful functions in the numerator and the costs of the associated DP's in the denominator. This approach constrains the system so that all of the design elements are captured and considered as to whether their use impacts the numerator and/or the denominator of the ideality equation. It is important to note that the units associated with the design elements and the associated DP costs must be converted to a dimensionless format in order to be meaningfully used. This approach yields a structured and objective calculation of ideality.

[4] see http://www.triz-journal.com/archives/2003/06/a/01.pdf

[5] some Axiomatic Design / TRIZ users doubt the validity in using elements of interaction from the design equation as harmful effects