Information Strategies for Optimization of the Composite Experiments

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***Abstract**: Effective usage of the results of materials research necessitates new organizational techniques. Besides the traditional data collection and distribution, the organization supports the communication between the provider of the results of materials research and user of them, that is: the designer. Our research aims to interpret the construction requirements and the theory of the material selection which best fulfils them.*

***Keywords**: composite; compromise model; product design; optimization*

1 Introduction

Product designers using composites first interpret the functions of a product to meet the requirements, and then, as part of the design process, select the proper materials that fit these functions. To meet the requirements, designers can only use the results of materials research and development if these results are available in a clear and understandable format. The results of materials research and development today are published in a highly scientific way, and much less attendance is dedicated to the product designers' viewpoint – even though they are the real users of these new developments. We modelled this process in our research work, and designed a new surface for the knowledge transfer, which helps structuring and providing up-to-date information and innovative knowledge in an efficient way.

2 The Characteristics of Knowledge Transfer

Composites have special characteristics designed by or measured in the research process. These characteristics often interact in an opposing way when fulfilling several different functions. Researches define the characteristics according to varied parameters, but do not analyse the sometimes opposing output expectations. This is because material developers do not know the objective targets, that is: the final requirements of a future product, for which compromise characteristics are needed. We assume that "materials research" is separated from "construction". Results of material experiments, however, can well be built into the design process if these results are properly provided. Proper introduction of newly developed materials can also contribute to their marketability. The design method raises the problem: what should be the adequate content and form of archivation, if we wish to provide value for the designers using composites.

Defining the objective function (compromise model) according to the product designers demands, and optimizing the data according to this, gives us the ideal composite variation from the point of view of a product. The aim of our research is to optimize the product-to-be from the point of view of usage by modifying the input variables in practice. For this, we developed a computer model that can be applied to the optimal compromise, and a standard result publishing method.

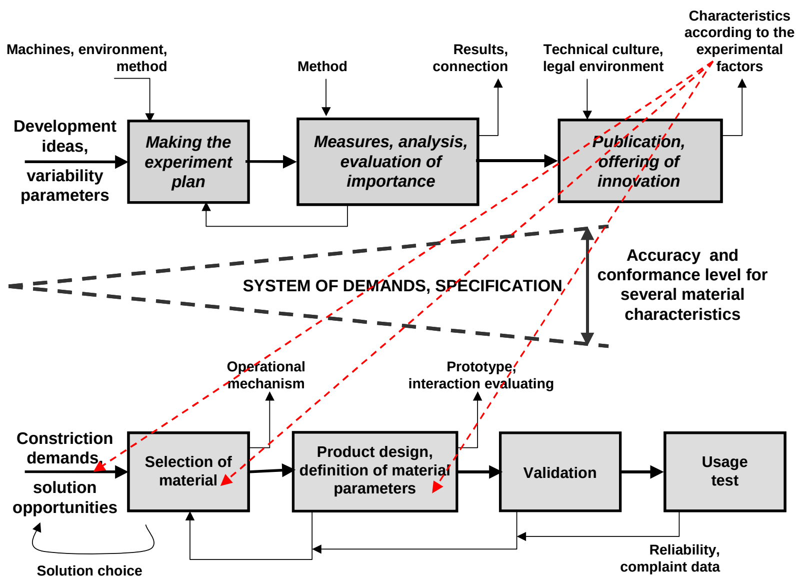

Figure 1

The connection between materials research and the design process

3 The Model of Information Flow between the Two Processes

The designer defines the requirements for the whole life cycle of the product. He/she selects the materials on the basis of that, using the results of materials research. Materials researchers examine the production of the developed material by different settings, and publish the results as materials characteristics for these settings. For using the results, organised information collection is needed.

Functioning often changes in a contradictory way by the variable input characteristics of the construction material. The expectation of the designers is to recieve the most suitable offer to fulfil the different, and sometimes contradictory, demands regarding materials.

Defining the optimal level of input parameters is based on the compromise-optimum (compromise function).

These approaches are useful if inputs are variable and their effects on the outputs are known (usually from research experiments) or can be measured, so that the correlation analysis can give sufficient information.

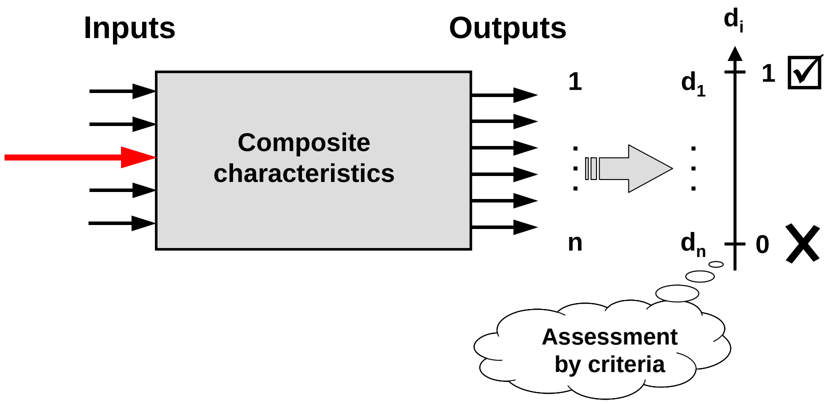

Figure 2

A theoretical model for seeking compromise solutions

The optimization method must take into consideration the weighted format and, at the same time, the functional changes at the inputs. The optimal design parameters can be defined on the basis of these two aspects.

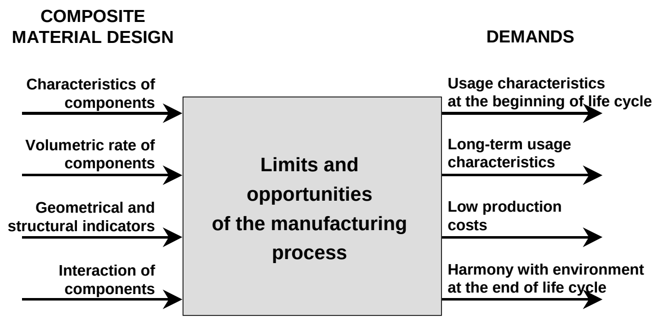

Figure 3

Case study for variable characteristics and the demands of a product

4 Application

From the several purpose functions we chose Harrington's desirability function for our case study.

The optimal level of input can be defined by finding the maximum value of the harmonic average of the desirability function (compromise function).

$$D(x) = \sqrt[n]{d_1(x) \cdot d_2(x) \cdot d_3(x) \cdots d_n(x)},$$

where

D(x) - is the function to be optimized, containing a compromise regarding n number of customer demands,

di(x) - is the function expressing the fulfilment of different customer demands, according to the modified designer parameters.

From the D function calculated this way the optimal value of the design parameter can be defined, which regards contradictory customer demands.

Limit from below / above: Limit from both sides:

$$d_i = e^{-e^{-(b_0 + b_1 \cdot y_i)}}$$

$$d_i = e^{-\left(\left|y_i^*\right|\right)^{n_i}}, \quad y_i^* = \frac{2y_i - \left(y_{max} + y_{min}\right)}{y_{max} - y_{min}}$$

The practical usage of the method is demonstrated by the following example. A, B and C are material characteristics defined by experiments, and their relation with variable parameters (e. g. glass fibre content, linear density of glass fibre) is known.

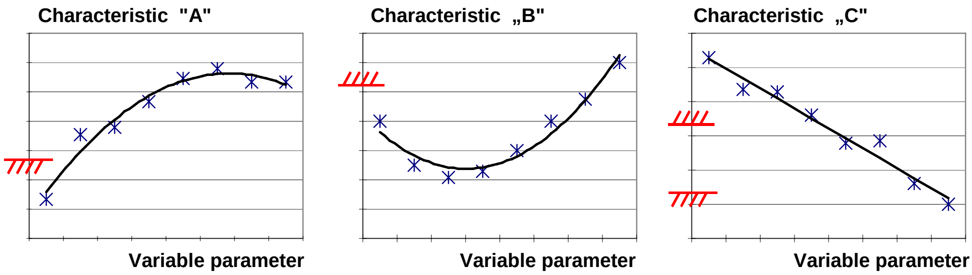

Figure 4

The results of materials research along a variable parameter

We provide the compromise analysis of these relations in accordance with the designer's demands.

From the D function calculated this way the optimal value of the design parameter can be defined, as it is shown in the following figure.

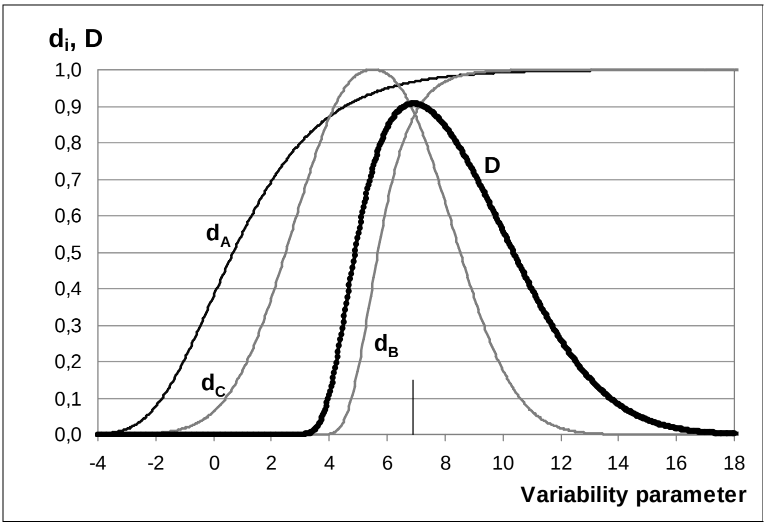

Figure 5

Compromise function calculated from d functions with the optimal value of the design parameter

The result of the optimization is a material parameter setting that fulfils the demands of the designer. The researcher has most probably never tried the material for that purpose system.

The main elements of the information flow between material researchers and product designers are:

– data collection about the material (sufficient structure and depth; database),

– demand interpretation of the product designers,
– finding the ideal material with ideal characteristics based on these data.

Conclusions

The research provides a new method of data dissemination, which makes possible the communication between material researchers and product designers, and the fulfilment of demands based on compromise analysis. We chose an evaluation method that suitable our case from the compromise analyses mentioned in related literature. The different methods can be well automated in a relevant standardized communication framework.

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