THE DATABASE "METHODOS" ASSISTS AN EFFECTIVE APPLICATION OF DESIGN METHODS

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Abstract

The success of a company will be more and more influenced by product innovations. It is a big problem for many enterprises to realise innovations because of complex problem definitions and the multiplicity of new and often badly structured problems. Therefore the use of design methods and tools to support these formal processes within product development is very important. Systematic operation, selection, coordination, networking and evaluation of the appropriate design methods have to be considered project-specifically. Studies have shown that general reasons for an insufficient application of methods are for example time pressure and lack of method competence. Furthermore support is missing for the practical transfer of the abstractly described methods, suitable introduction strategies, methodical flexibility to support the non-standard work style and sufficient linkage of subsidiary methods to overall methods. The assisting system of methods *Methodos* enables the search for user-oriented methods, procedures and instruments. It already contains descriptions and illustrative information about easily understandable design methods that can be applied during an innovation process. Therefore selected innovation methods will be transferred to user-friendly software tools that are applicable as stand-alone solutions as well.

Keywords: Systematic product development, design theory, innovation methods

1.   Introduction

The development of new and saleable products is essential for the assurance of long-ranged success of enterprises [13]. The necessary innovation of product development assumes good ideas as as well an economic and high quality design of the product [9]. Furthermore the well timed market entry is important. In this context it is subserved that the innovation is distinguished as a systematic process flow with a complete methodical support [7]. In small and middle enterprises (SME) often the qualifications and resources for a suitable methodical support do not exist. In many cases methods are considered as too complex and impractical [11]. Also the measurable benefit of methods is to be queried [5]. A possibility to overcome the limits of know how and capacity and to minimise economic risks is a cooperation [14]. For this reason SME are able to transform rapidly new requirements and technologies in innovative products by retaining financial self-reliance.

Based on these facts the Technical University of Braunschweig started the project GINA - Holistic Innovation Processes in Modular Enterprise Networks - (http://www.gina-net.de) with five industrial partners. A sub-ordinate target of this project is to examine development processes within an enterprise and between enterprises. Beyond the project GINA aims at making methods and tools available for the optimisation of processes.

The focus of this project is the design of the internet-based assisting system of methods *Methodos*. With the aid of this dialog system the user is able to select suitable methods by integrating user and task specifications. In addition, implemented methods are integrated in the system and are accessible for the user.

2.   Assisting system of methods

The assisting system of methods *Methodos* is an improvement of the conventional modular systems of methods that are described in literature, e.g. [5], [16]. In this context a modular system is defined as a systematic collection of methods that supports methodical selection for specified design steps [5]. Characteristic for most of the modular systems is the variety of alternatively useable and quite similar methods which confuse the user more than they help him. At present the efficient application by user and task specification is inadequately assisted by the existing systems [12].

Another target of optimisation is the improvement of method preparation, e.g. well structured schedules for the correct use of methods, comprehensible documentations and easily understandable visualisations of method results.

2.1   Program Architecture

For an efficient integration of method results in the process chain of innovation and for processing multiple boundary conditions the computer-assisted use of methods is essential. A system which can be accessed by internet is suitable particularly with regard to the realisation of delocated cooperation projects.

For this reason the internet portal application *Methodos* was created in cooperation with a professional software enterprise by applying the "Microsoft .NET Framework". It offers a cross-browser support for Netscape and Internet Explorer, mobile device support for WAP and Pocket Browser devices. The data source for the application is a SQL Server database containing procedures and configuration settings. The portal's front-end is administrated with an online tool that allows to manage the security, layout and content of the portal.

Methodos is a combination of three modules:

- Structured method collection,
- Dialog system for a systematic selection of methods,
- Method Tools.

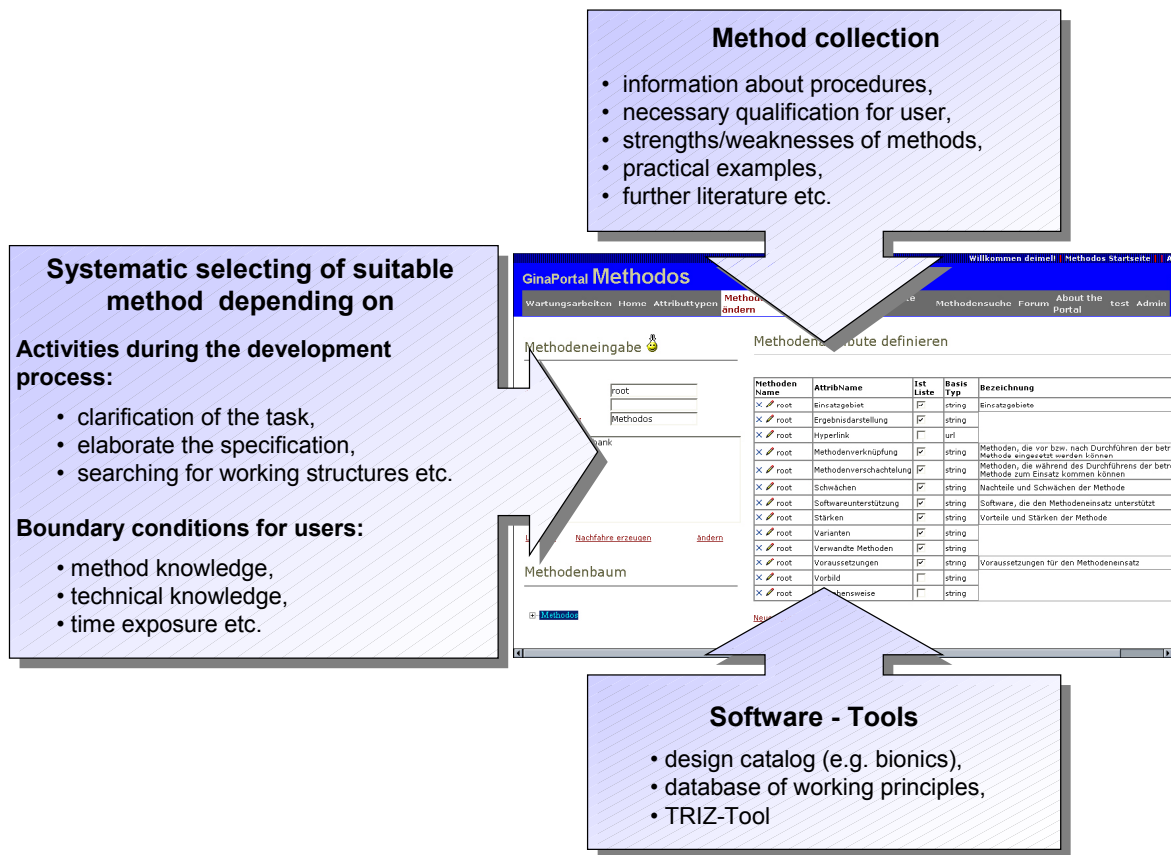Figure 1 shows the principle design of the assisting system of methods *Methodos*.

Method collection

- information about procedures,
- necessary qualification for user,
- strengths/weaknesses of methods,
- practical examples,
- further literature etc.

Systematic selecting of suitable method depending on

Activities during the development process:

- clarification of the task,
- elaborate the specification,
- searching for working structures etc.

Boundary conditions for users:

- method knowledge,
- technical knowledge,
- time exposure etc.

Software - Tools

- design catalog (e.g. bionics),
- database of working principles,
- TRIZ-Tool

Figure 1. Design of the assisting system of methods *Methodos*

2.2   Structured method collection

At present the structured method collection contains a library of approximately 50 methods which support the innovation process. To ensure a consistent data management and a simple maintaining the methods are classified to the field of application in a hierarchic structure.

Each method is characterised by input and output parameters. The input parameters describe the performing task. The output parameters represent the result of the method. Input and output parameters are information as well as material objects [12]. For the transfer of the input parameters to the output parameters the following aspects have to be mentioned [2]:

- discursive or algorithmic procedure steps of the method
- user specific boundary conditions, e.g. skills, experiences, qualifications
- general conditions, e.g. the necessary infrastructure of the company, possible fields of application for tools.

In contrast to the boundary conditions, which are implemented directly in the system *Methodos*, the supported task has to be partitioned for the aimed selection process. Based on the abstraction of the procedure steps within the method application the task is divided into a set of basic activities. The kind and number of the basic activities is characteristic for each method and is stored in the assisting system.

Among the mentioned boundary conditions, procedure steps, basic activities, input and output parameters the user is able to retrieve detailed examples of application and further literature.

This information is mapped to a method model. The advantage of this method model is that all methods are described in the same way. This standardisation of method description is necessary with regard to a combination of methods. This combination enables the support of complete processes and the compensation of single methods deficiencies, e.g. the evaluation deficit of creativity methods is to be compensated by combining this methods with evaluation procedures. Figure 2 illustrates the method model of the method synectics.
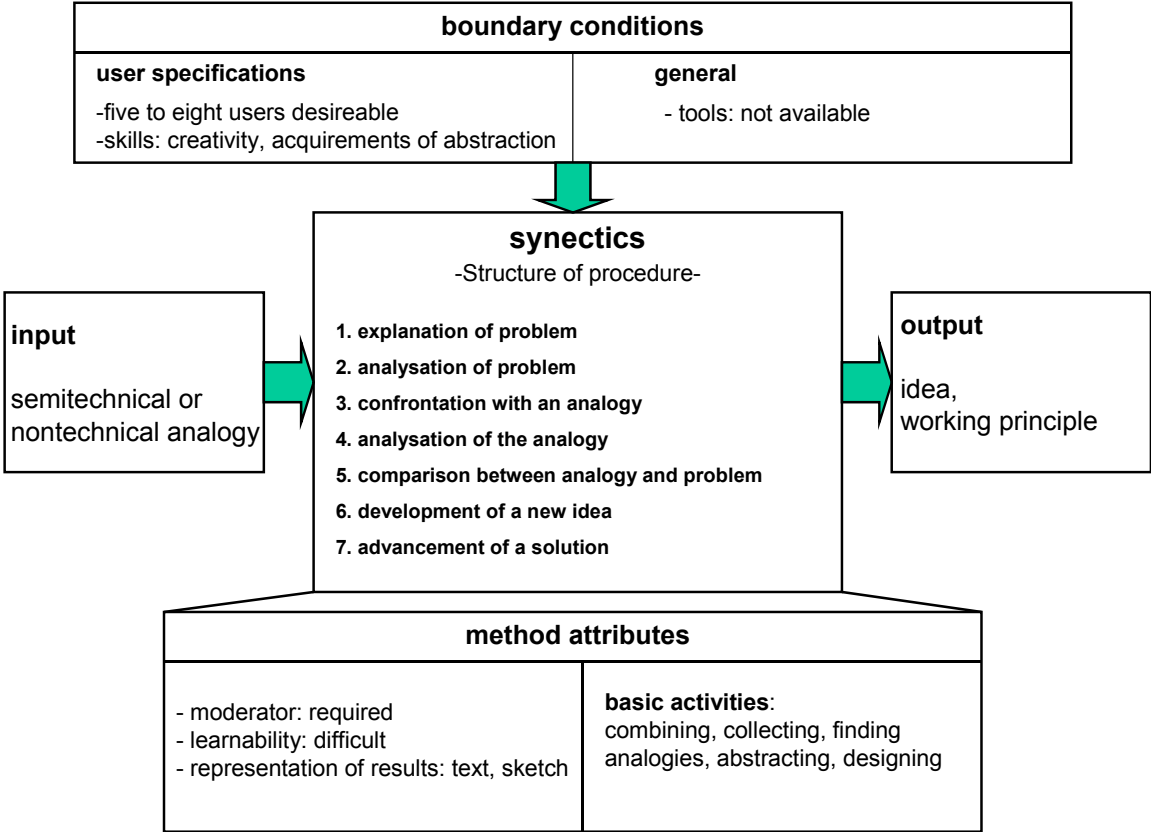
boundary conditions

user specifications
-five to eight users desireable
-skills: creativity, acquirements of abstraction

general
- tools: not available

synectics
-Structure of procedure-

input

semitechnical or
nontechnical analogy

1. explanation of problem
2. analysation of problem
3. confrontation with an analogy
4. analysation of the analogy
5. comparison between analogy and problem
6. development of a new idea
7. advancement of a solution

output

idea,
working principle

method attributes

- moderator: required
- learnability: difficult
- representation of results: text, sketch

basic activities:
combining, collecting, finding
analogies, abstracting, designing

Figure 2. Stored information about the method synectics (excerpt)

2.3 Dialog controlled selection process

At first the methods have to be preselected according to the required task. The second step contains a reduction of the preselected methods by using the boundary conditions and method attributes.

The preselection of methods results from partitioning of the task to basic activities analogous to the methods. The congruence of the basic activities of method and task realises the selection [17]. The precondition is that the basic activities are equally detailed.

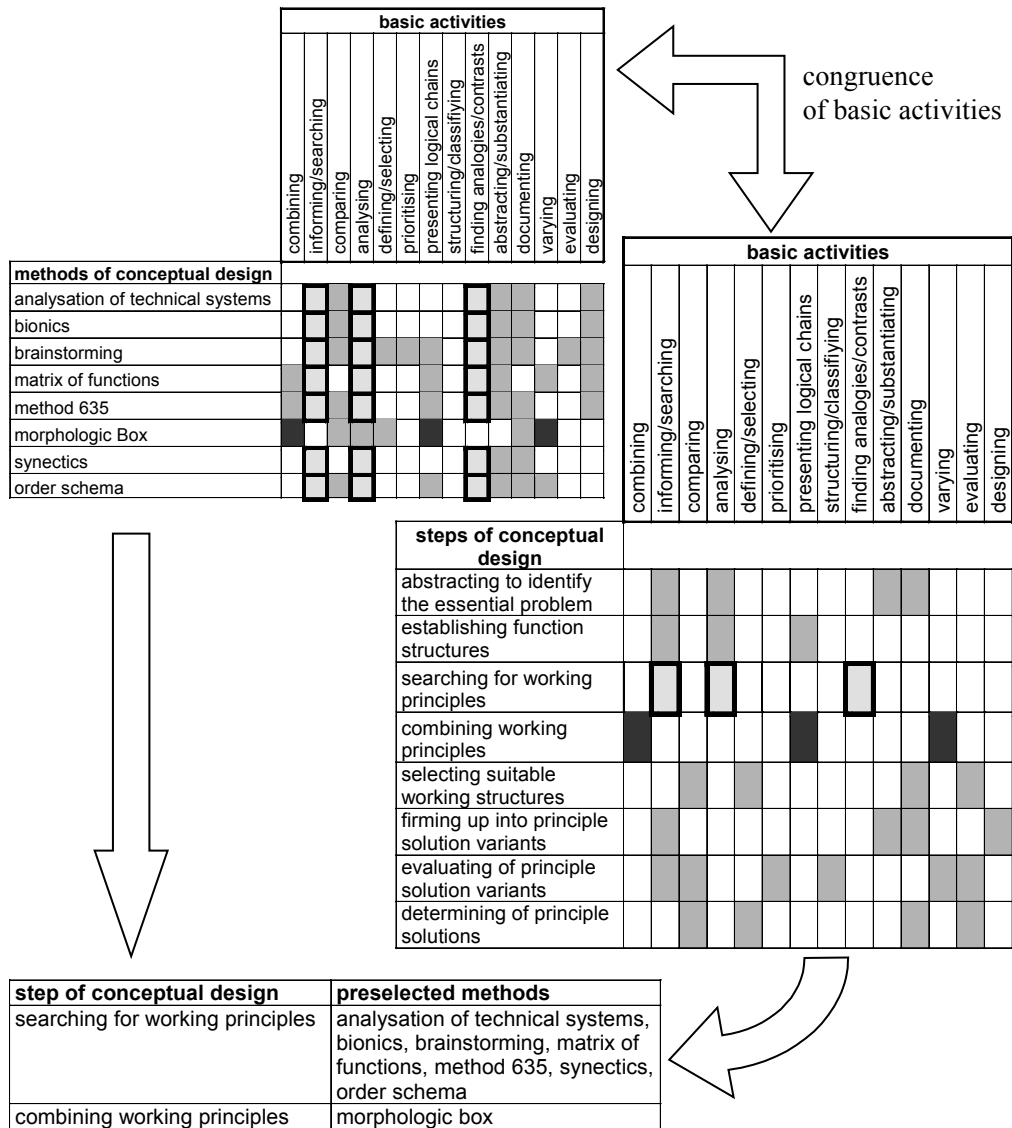For instance Figure 3 shows an excerpt of the preselection of conceptual design methods.

Figure 3. Preselection of conceptual design methods (excerpt)

Subsequent to the preselection the existing user specifications are integrated in the dialog system by the user himself. For the implementation of the boundary conditions *Methodos* provides lists of questions for the working steps of the design process [16]. With multiple-choice questions the user is able to give definite answers which are to be compared with the characteristics of method attributes and boundary conditions. If a conformity between the answer and the according parameter value of the preselected method does not exist, the corresponding method is suboptimal for the support. To achieve high applicability the formulations of questions and answers are simple, short and clear.

2.4 Application of methods

Reasons for insufficient application of methods are missing support for the practical conversion of the abstractly described methods, suitable introduction strategies and sufficient linkage of subsidiary methods to superordinate methods. In order to fill this gap several tools have been transformed to user-friendly software tools that can be used via internet. Above all, such methods were enhanced so that they can be used for various design tasks. This chapter gives a rough view over methods that are already integrated in the system.

Design catalogues are collections of generally design related knowledge (q.v. Figure 4) [3], [4]. They cover physical effects, solution principles, solution concepts, machine elements etc. and are mostly available as textbooks so that they are very uncomfortable in usage. There exists a great number of design catalogues but they are used insufficiently in practice. One reason is the fact that the user is not able to get the right catalogue in time.

Therefore, the development of the computer aided system *"eKat"* [8] enables to work with design catalogues from internet. A main goal of this system is to increase the efficiency of design catalogues by using modern data processing technologies. With this system it is possible to generate, store and present design catalogues with an internet-based access. The computer aided catalogues offer substantial advantages compared to textbooks, e.g. easy modification, integrated calculation, links and availability at all hours.
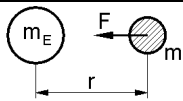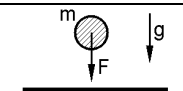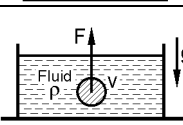
Classifying criteria			Solutions		Selection characteristics		
Force	Physical law	Special effect	Equation	Example	Conditions	Permanent energy addition	Charact. dimension
1	2	3	1	2	1	2	3
Force of gravity	Law of gravitation	Gravity	$F = \Gamma \cdot \dfrac{m_e \cdot m}{r^2}$		two weights	no	$\sqrt[3]{\dfrac{m}{\rho}}$
		Weight	$F = m \cdot g$				
		Lifting force	$F = \rho \cdot g \cdot h$		fluid weight		$\sqrt[3]{V}$

Figure 4. Extract from design catalogue of the function „Generate force with other quantities"

Moreover, a well structured collection of physical effects, solutions and principles can support engineers during the design process. Physical processes are based on physical effects. Roth [14] and Koller [10] collected such effects.

Physical quantities can be classified in design quantities and function quantities (q.v. Table 1). Only the design quantities can be directly chosen, dimensioned and defined by engineers (e.g. masses, resistances of flow or electrical current can be dimensioned by choice of geometric parameters or materials). Function quantities such as forces, speed, electrical current etc. are indirectly dimensioned.

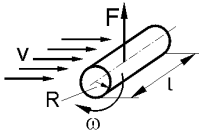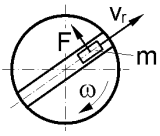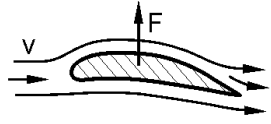Table 1. Classification of physical quantities

Target function		Function quantities	Function equation	Design equation	Sketch
	No.	1	2	3	4
$F = f(s)$	1	F — s pᵢ — v	$dF = cds$	$c = \dfrac{h^3 bE}{4l^3}$	
$p_i = f(v)$	2		$p_i = mv$	$m = \pi \rho\, r^2 l$	

The matrix of functions makes it possible to derive these effects from the inputs and outputs (q.v. Figure 5) [6], [15]. This matrix can be used to find a principle solution based on physical effects. Generally, all physical effects require a geometric arrangement of parts and material. These arrangements can be found in an implemented SQL database in a user-friendly format. Table 2 shows an extract of physical principles including dependency between a force F and a velocity v.

input

output

		F	s	pᵢ	v	M	φ	L	ω	u	π	V	p_d	I	Φ	Q	U	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
F	1	1.1				1.5			1.8					1.13				force
s	2																	displacement
pᵢ	3																	momentum
v	4																	velocity
M	5	5.1.				5.5			5.9				5.13					moment
φ	6																	rotation
L	7																	angular momentum
ω	8																	angular velocity
u	9	9.1				9.5			9.9				9.13					volume flow
π	10																	pressure momentum
V	11																	volume
p_d	12																	pressure
I	13	13.1				13.5			13.9									electrical current
Φ	14																	magnetic flux
Q	15																	electric charge
U	16																	voltage

Figure 5. Matrix of functions

Table 2. Extract of a physical catalogues

1.4		$F = f(v)$	
No.	**Equation**	**Comment**	**Sketch**
1	$F = 2\pi r^2 \rho \omega \, vb$	Magnus-Effect v velocity b width ρ density	
2	$F = 2m\omega v_r$	Coriolis-Force v_r relative speed m mass ϖ angular velocity	
3	$F = c_a \dfrac{\rho}{2} v^2 A$	Lifting force ca lift coefficient ρ density	
...	...	...	...

Another method has been implemented to support the early phases and steps of the design process. TRIZ, a Russian acronym for the Theory of Inventive Problem Solving, was developed by Genrich Saulowitch Altshuller [1]. He examined nearly half a million patents to see if he could isolate common features and repetitive patterns.

Altshuller defined an inventive problem as one in which the solution causes another problem to appear. He found that often the same problems had been solved over and over again using one of only forty fundamental inventive principles. First of all the problem has to be restated in terms of physical contradictions. The user has to find one physical value that needs to be changed and another coexisting undesirable one. Therefore, Altshuller extracted 39 standard technical characteristics, so called engineering parameters. With these parameters the user has to describe the problem. In order to find a solution for the problem Altshuller created the Table of Contradictions. In the intersecting cells the appropriate inventive principles are listed to find solutions.

Altshuller`s Table of Contradictions has been implemented so that it can be used via internet (q.v. Figure 6). The data source for this application is an SQL Server database. It contains the 39 standard technical characteristics and the 40 inventive principles that can be used to solve a technical problem. The database contains useful information on how to apply the inventive principles. Over 400 practical examples have been found and implemented. Engineers looking for suitable solutions may be inspired by this variety.
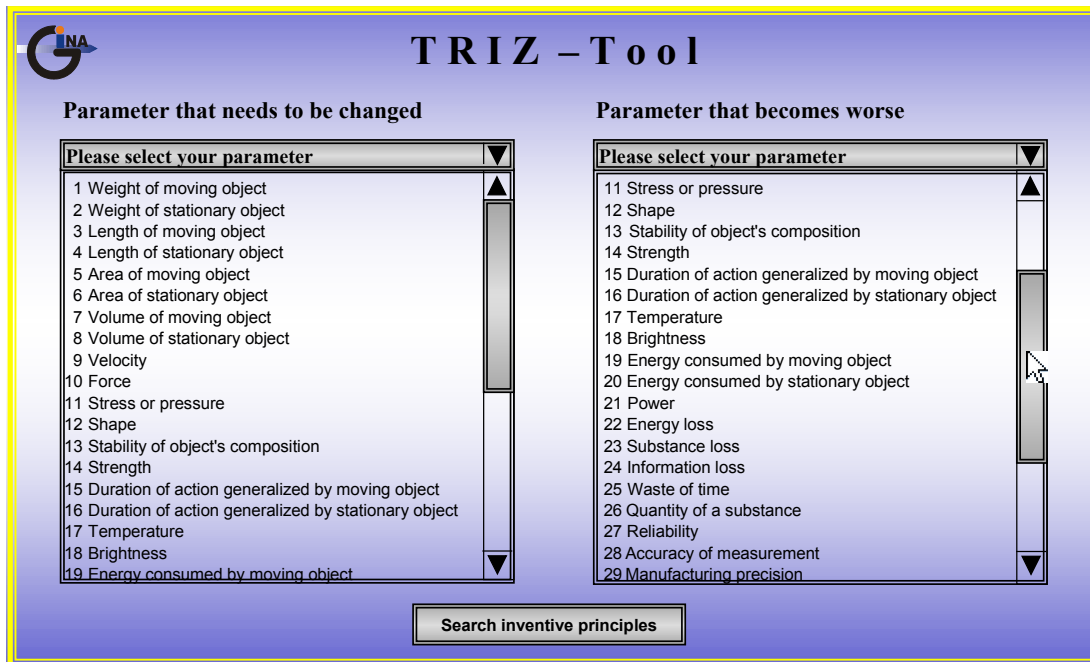
Figure 6. Screenshot of the implemented TRIZ-Tool

3.   Conclusions

The internet-based assisting system of methods *Methodos* supports the user by selecting suitable methods for a holistic design process. The selection bases on a dialog system and integrates user and task specifications. Furthermore the system contains detailed information about methods. The methods are implemented in tools to improve the users methodical consciousness. In that way the weakness of many methods is to be eliminated by further development in the future.

Acknowledgement

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