Applications of innovative methodologies and IT tool to support European SMEs in Product Innovation Processes

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Abstract

The systematic support of the innovations process in small and medium-sized enterprise (SME) is still a challenge because innovation is only done sporadically and often with external consultancy in order to gain sustainable competitive advantages. This paper describes a methodology to cover the conceptual development of new products, which is typically structured into a number of specific steps and introduces an IT-tool that provides the transition from isolated tool support towards an information management along all the phases of the conceptual development in an innovation process. The application of the method in a use case is explained as well.

Keywords

New Product Development, Conceptual Design, Information Management, Innovation Methodology

1 INTRODUCTION

This contribution is presenting work from the collaborative research project KNOW-IT that is addressing one of the main challenges of European SMEs: how to develop a systematic process of product innovation to keep competitiveness in the international market. The primary goal of the project is the support of the conceptual development of the innovation process in companies.

It is widely recognized that one of the key factor for European SMEs to maintain competitiveness in the market is to focus on product and/or process innovation. In spite of this recognised need, SMEs lack a systematic approach that supports them in the overall innovation process. The so called "Innovation Management Techniques", considered by policy makers (e.g. the European Commission) as an useful driver to improve competitiveness, are still underutilized by SMEs; in particular, among such techniques (which include knowledge management, market intelligence, creativity development, innovation project management, business creation, etc.) the Creativity Development Techniques are the less used among SMEs.

The current Innovation Process within SMEs is realised through several steps, each providing one or more challenges that a Systematic Innovation Methodology should be able to solve. These steps are briefly outlined below:

Step 1) Idea Generation: the stimulus to innovate within SMEs come up from a set of possible sources:

- Specific engineering needs (ex: increase reliability within a manufacturing process)
- Specific market needs: a) competitors offering better products; b) customers requesting for advanced functionalities; c) the market is mature and the profits are lowering
- A "concept idea" born in brainstorming sessions, or through internal talks among engineers and/or through specific "intuition" of some bright professional in the company

Step 2) Innovation concept definition: depending on where the innovation request has been generated, different needs emerge, that could be faced by the responsible person of production, and/or R&D, and/or of marketing:

- Solving the engineering needs: the engineering problem needs to be defined, then internal sessions are held among engineers to search for a solution. Usually, no knowledge outside of the company is used in such case, and if no solution is found, then somebody takes the responsibility to start searching for solutions using knowledge available outside
- Market needs: the request coming for the market is very demanding for SMEs. In this case, the marketing responsible of the company is asked to search for "what the customers wants", or for the "hidden needs of customers". The SME market responsible (if any) needs to start searching for customer explicit and hidden needs: a market analysis should be performed, which should bring to a set of functionalities and/or performance that the improved product should deliver. If the analysis delivers a set of functionalities/performance required by customers, technical feasibility of such improved functionalities should be evaluated by engineers, leading to possible Engineering Problem (process and challenges of previous point)
- Technology push: the idea coming from engineers could be the one that brings to face hidden customers' needs (difficult to be identified through market researches). Most of the time, nevertheless, technology-push innovation are or incremental, or fail to bring to the market successful products.

3) Technology Plan: the different concepts should be merged at a certain point to support the SMEs manager in defining the innovation strategy, providing the correct elements to make a conscious decision on which technology development the company should focus on.

A comprehensive approach aiming at supporting SMEs in their innovation process, should be able to provide a methodology (guidelines and tools) accompanying the SMEs from the analysis of its internal technology and market need to the definition of its technology plan.

2 THE PROPOSED APPROACH

The presented approach is aiming at facing the evident SMEs need in the overall innovation process. The usage of an IT tool should help to support consultants (or SMEs professionals) in doing their daily business. Gathering the huge amount of needed data and the possibility to store this information along a well structured workflow is the outcome of the developed methodology. It combines the different process steps needed to innovate, which are typically divided into requirement analysis, the development of innovation path, evaluation of the options and finally the conceptual innovation as a result that initiates a product development.

Therefore the conceptual development of the innovation process in a company starts with the analysis of the current technical system (TS) that is being inspected. This current state of the TS will be projected on the curve of technological trends which then provides a description of the current situation. From there possible developments of the current TS in a possible future TS according to technological trends and market requirement will be derived and the appropriate development process is selected. The Systematic Innovation approach (TRIZ) will be used as a core methodology. Furthermore, the aspect of combining technological as well as market driven factors is essential for the business success.

The main objective from an information technology oriented point of view is the support of weak signals [1] that can be derived from a domain specific information base and the abstracted indicators of the TRIZ/QFD-methodology to stimulate the innovation process. Weak signals are new emerging features in the present that can be used for fore-sighting the future and that often appear as far-fetched and irrational from the current perspective (e.g. new disruptive or alternative technologies). At very early stages they cannot easily be detected but will have a big impact on product development and innovations once they are identified. Ansoff proposes the information flow from the perceived environment to a specific action that is illustrated below. In the case of KNOW IT the environment will be the available options for new innovations inside and outside of the company (technology or market driven) and the action will be the innovation process or a new product development.

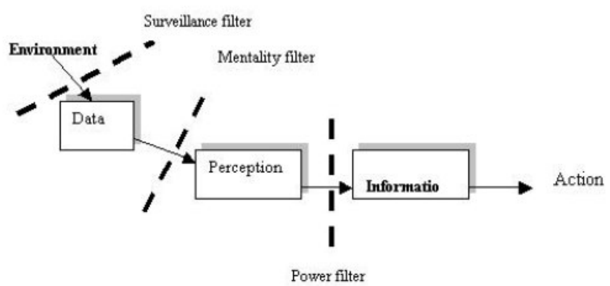

Figure 1: Ansoff filter from Environment to Action

The technology part of the KNOW IT project will help to unlock the available data within the company and in public sources for potential new attributes for product innovations that evolve into new product features (“delighters” or “satisfiers” according to the model of Kano [2]). The interesting aspect of KNOW IT is that it combines an information mining approach with a methodology (TRIZ and QFD) to implement the appropriate filtering in the model of Ansoff. The surveillance filter will be implemented by the crawler engine of the KNOW IT that regularly scans relevant information sources and extracts information from it. The used technology is widely accepted and well implemented in search engines and knowledge management solutions. The mentality filter is implemented by the help of TRIZ and Kano methodologies to focus on the aspects that are the most relevant ones to consider for a new product management. The power filter at last transfers the information along a process oriented perspective that supports the innovation process itself. As the goal of this process towards a new product development becomes clearer, the information will be processed in a more structured way, such that the initial creative phase can be transferred into the already established product development cycle.

An important aspect of our approach is the integrated tool supporting all these activities along the early phases of new product development (NPD) that can take day or even weeks. A consistent support of the information management along this process ensures that all relevant information is captured and taken into account and creates also a source for future NPD-processes that can use the recorded information as a knowledge base. Finally, the whole process will be executed in a more systematic way and automatically documented during its execution.

3 THE KNOW-IT METHODOLOGY

In the project KNOW-IT an integrative methodology has been developed which includes technology and market aspects and fits the SME requirements. Dealing with the complexity in the early step of innovative new product development as well as the usability of the method are major aspects of the approach. The high level framework for the conceptual development of the innovation process will be centred on the following steps:

1. Outline the current TS-function in a systematic way with respect to technology and market situation and foreseen development.
2. Positioning the TS on the technological trends chart, through the support of analysis methods on relevant information sources
3. Identify possible developments of the TS using the Systematic Innovation approach with respect to identified relevant technology trends.
4. Evaluate the possible development directions and choose the most appropriate ones in a cost-time-benefit scenario.

This high level framework should be supported by an IT-tool that provides information and analyses for every step, as illustrated in the following figure.

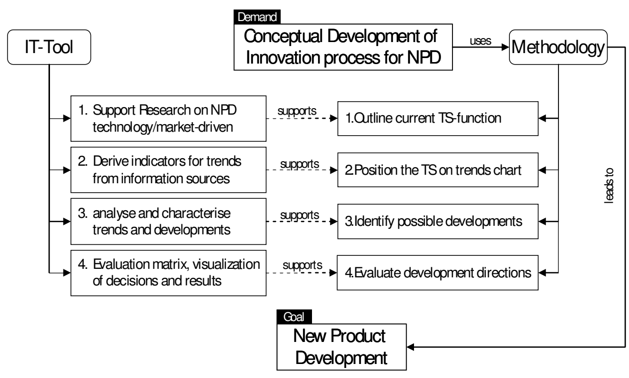

Figure 2: Methodology and tool support

The IT-system is supporting the usage of the methodology to increase the efficiency of information research and knowledge organization. Thus, the retrieval and the organization of information are based on formal and flexible information structures.

4 THE METHODOLOGY

The KNOW-IT methodology consists of a reference process that should capture all relevant aspect of a conceptual NPD process. It has a main process (depicted in the figure on the next page) and consists of several subprocesses for the Trend-Analysis of the Technical System, the Selection of the High Potentials of the Technical System, the Market Analysis, the Conceptual Development and the Conceptual Evaluation.

The process starts with a company environment analysis that basically has two objectives. One aspect is to determine the departments or areas of the company that are relevant for the conceptual development of the intended new products. This step reveals important factors in the company environment that will be used as the initial parameters for the following market analysis, which will be carried out through the help of an IT-tool that was developed in the former project AMI-SME (see [3] for a detailed description).

The second aspect is related to the product that should be innovated. Again, the aspects and characteristics of the product that are important factors for the innovation process should be derived from the environment. Both aspects should be a result of the first interview with the SME representative personnel. The intention of this analysis is to fix the framework in which the NPD will be carried out; it does not necessarily mean that the needed level of detail is already fixed. This will be obtained during the subsequent activities.

The next steps in the main process are the trend analysis of the technical system under study and the evaluation of the high potential candidates that emerge from this trend analysis. First, a hierarchical product model (product structure) is constructed on which the trend analysis is carried out. This produces a list of relevant functions and functional objects at which the NPD is carried out.

The selection of the high potential solutions from the objects in the product structure defines the technology areas that need to be explored in the NPD and it should identify some initial development direction that can be followed in the next steps. This phase could also make use of structured research methodologies for patent databases, like the one of Cascini & Neri [4] and Nani & Regazzoni [5]. Both results will become a part of the integrative model that is described below.

A parallel activity to the process above that is not reflecting the technology perspective, but the shaping pressure of the market for the NPD, is the market analysis that is fuelled by the company profile that was obtained in the first contact with the customer.

The Results of the previous activities will be fed into the integrative model that is acting as the central repository for the subsequent iterative activities. It unifies the technology aspects and the market demand into a unified model that is building the base for the selective development in the next steps. These are the conceptual development and the concept evaluation, which are repeated until the innovation potentials of the product structure are exploited. The conceptual development is subsuming the TRIZ-based innovation activities for the identified components of the product that have the highest innovation potential. Classical TRIZ methodologies will be applied here. More specifically, we are aligning our methodology at the TechNav-process of Fey & Rivin [6] and the ARIZ-algorithm of Petrov [7]. The new product structure with the applied innovation will be evaluated for its potential performance and this will generate a modified product structure for the next iteration cycle. The evaluation is done based on the forecasted performance of the solution candidates and a multidimensional evaluation of a single domain expert or several domain experts.

The final phase of the process consists of a ranked list of the development options that were evolved from the product model and an estimation how this development options can be reached (e.g. by technology-transfer or by research and development). As a by-product this additional information will be added to the final result of the process that is necessary for the NPD. This can be information about the possible suppliers that can contribute to the NPD or companies that can be used as cooperation partners.

The important aspects of this reference process are the two different viewpoints of technology push and market-pull that steer the conceptual development, thus covering both mayor influential steps in NPD (also described in [8]) and the integrated model. The latter is used as central scaffolding on which all the research findings or discovered solutions are aligned. Due to its iterative nature that loops between building the model, executing a conceptual development of one part and finally evaluating the resulting integrative model, it helps to improve the innovation aspects gradually and in a structured way. The use of such an integrated model was inspired by the IPDP-methodology of Yamashina [9]. A basic benefit of this approach is the connection between all the components that are connected in a mechanism tree and an associated function tree. KNOW-IT is extending this model by aligning the information object to the relevant functions and mechanisms, which is thus extending the scope from an integrated calculation model towards an integrated information model.

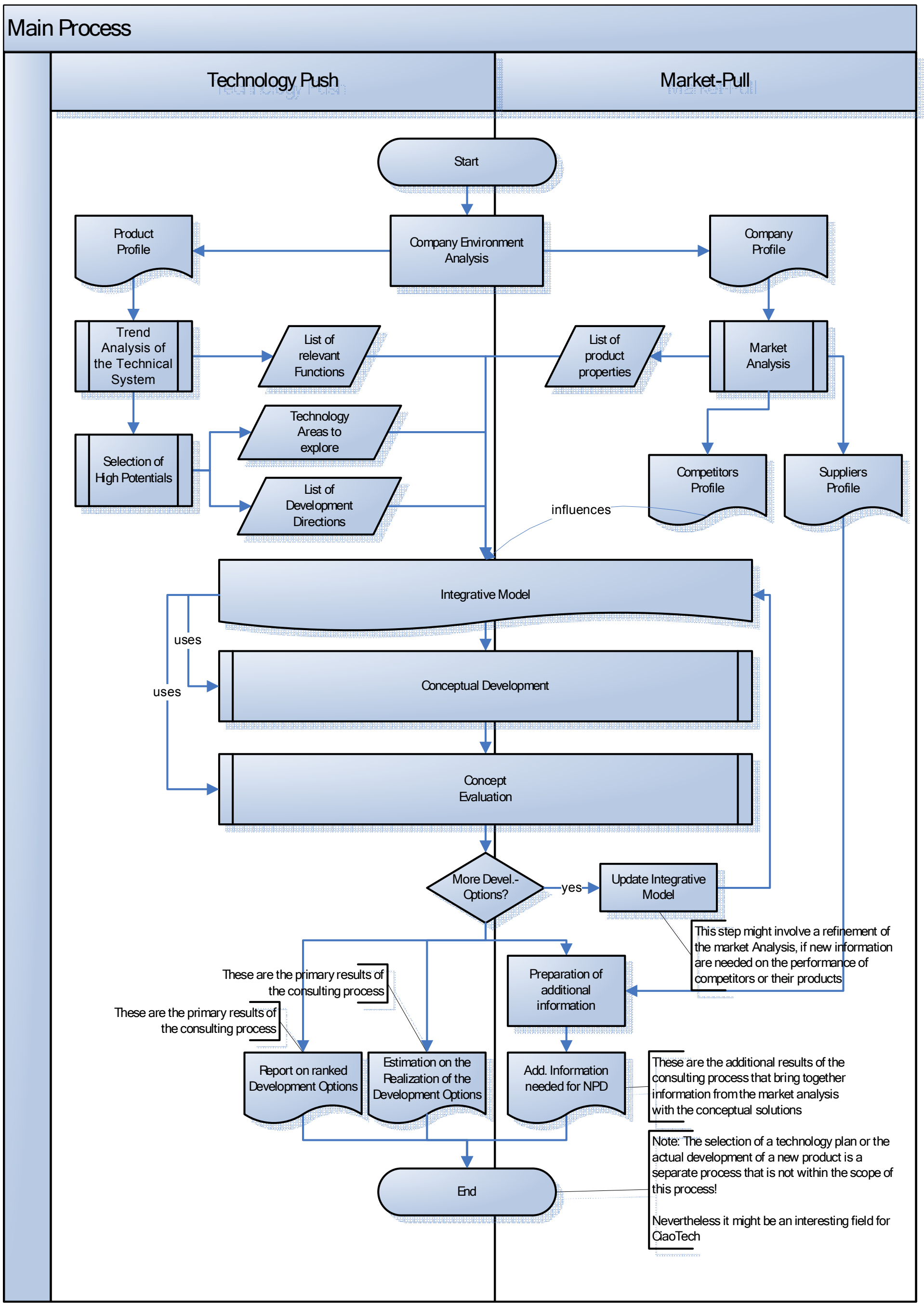

Figure 3: The KNOW-IT Methodology

5 THE IT-TOOL SUPPORT

The following section highlights various aspects of the technical design and implementation of the KNOW-IT system and of the QFD/TRIZ methodologies integration approach.

It is clearly recognized that a full automation of the entire KNOW-IT workflow is now neither advisable nor possible. The implemented software tool aims at supporting and assisting the user rather than replacing him. For this reason, single application components have been defined as modules that consume input data, produce output data, fulfill a task and are bound to a set of requirements.

Java was chosen as development platform for the KNOW-IT software system, due to the following reasons:

- *Portability* (platform independence) – the JVM (Java Virtual Machine) is available for all popular operation systems.
- *Availability* of open source libraries – there are many available open source libraries written in Java that can be used for enriching functionality of the system and accelerating the development process.
- *Reuse of further project results*: the software should be integrated with an existing system that was written in Java, so this choice was allowing a tight integration at source code level.

5.1 Architecture Overview

The KNOW-IT platform was designed as a framework for supporting the KNOW-IT process. The user builds the process by means of individual, customizable steps.

A step is built by means of actions performed in the step, and data required for performing defined action.

For the architectural design several assumptions have to be made. These include the ability to modify and to extend the information structure in the software which is closely related to the requirement of a modular architecture. Finally, platform independence was a major issue.

Easiness of modification

While the KNOW-IT process has been defined at this point of the project, it can be assumed that there will be further requirements in the future which will result in new steps and supporting functionalities. Thus, the easiness of modification and the easiness of adding new functionality is one of the most important postulates that should be taken into consideration in the architecture of the platform.

Modularity

The KNOW-IT platform is designed as a system consisting of separate modules. The separation paradigm is applied not only for large modules as subsystems, but also at programming component level. It means the large modules can also consist of different elements. With modularity another assumption is related, namely each component should be fully functional on individual level. Therefore the expected functionality has to be provided without intervention from other components. For example, if a given component implements text mining algorithms, it should also provide the graphical interface for setting parameters of the algorithm. This resembles a service-oriented approach on the level of the application framework that can be further extended to integrate distributed components.

Platform independence

The hardware and software platform independence is an important property of the resulting KNOW-IT software. Therefore it was decided that the implementation should be based on Java and should rely on libraries and technologies that are cross-platform.

5.2 KNOW-IT Platform description

The KNOW-IT software tool represents a typical client/server system. The client side is provided by a rich client, which is the main part of the system including the business logic, while the server side is basically limited to the database system, providing persistence of data and some data validation. The client side of the system provides all the functionalities directly involved in assisting the user throughout the KNOW-IT workflow.

Figure 4 shows the KNOW-IT architecture in terms of its main subsystems and their high-level interaction. The platform consists of five subsystems: the process manager which supports performing the KNOW-IT process, a searching subsystem, a local repository searcher, a data storing subsystem, and a patent analysis subsystem.

The architecture forces that interaction between components in the platform is carried out at the data level; there are no protocols for communication between components. The interaction at the data level means that one component produces data required by another component and such data is read from database (data component). Thus the architecture is following the Model-View-Controller pattern (MVC), where the view is presented in the process subsystem, the controller encapsulated in the active components and the data is stored in the model.

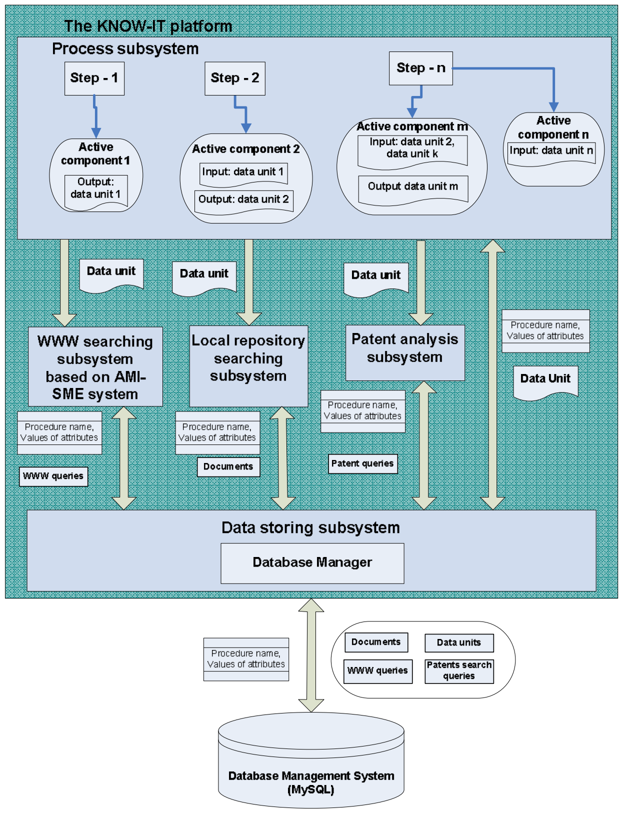

Figure 4: Architecture overview of the KNOW-IT platform

5.3 KNOW-IT Subsystems

The main types of objects that build the Process subsystem are the following:

- *Process manager:* The process manager object is responsible for managing the entire KNOW-IT process. It has the collection of objects (Step) which represent the phase of the KNOW-IT process. The process manager object offers also methods for creating new steps as well as new active component objects.
- *Step*: A step object represents a single phase of the KNOW-IT process in the KNOW-IT platform. It consists of a collection of the active component objects. The step object has assigned the sequence number.
- *Active component:* An active component object represents a single tool from the KNOW-IT process. The Process subsystem includes several different active component objects. The active component object operates on data unit objects. It can also produce a new data unit object.
- *Data unit:* A data unit object represents well defined unit of information which is used in the KNOW-IT process. The data unit object consists of a collection of attributes and it is responsible for retrieving data from and saving data into a database by using the Database Manager object. A data unit object can be associated with additional pieces of information e.g. documents or Web-queries.

The Web-searching subsystem is dedicated to searching in Internet and it is the separate part of the KNOW-IT platform. It is loosely connected with process subsystem and it is based on the results of formal projects. The subsystem provides also functionality for downloading resources from Internet.

The Local repository searching subsystem is dedicated to searching for documents stored in a database and provides functionality for extracting text data from several types of documents and enables saving documents into a database.

The patent analysis subsystem is responsible for supporting analysis of patent database. The subsystem consists of elements for searching patent databases and for presenting results obtained from the searches. In the current implementation the esp@cenet patent database is used.

And last but not least the data storing subsystem consists of the objects which are directly responsible for retrieving data from and saving data into a database system. Such action is done by invoking an appropriate, indicated by name, stored procedures.

6 A CASE STUDY

In order to verify the applicability of the developed methodology different case studies were done, following the methodology of McNamara [10]. To pursue this objective, the reference process has been converted from the methodology into an executable workflow, which was then tested for its usability in a consultancy process. To validate the process the type of evaluation has been fixed to value usability and operability of the established workflow. Therefore a simple Bad-Middle-Good evaluation was used.

To grant a practically case study the pilot study was reviewed by different team members with different expertise knowledge. So failures were eliminated before the next case starts. This was done by a following discussion and by an on the fly adapting of the pilot case study. Later on the case study was revised in an iterative way in each new step. To ensure the reliability of the whole process, several case studies should be performed with the same set of validation parameters. As an illustration one case study will be discussed in more detail below.

The case of Solarsystems

The case study of a Solarsystemproducer which is a company located in central Europe producing and selling solar systems. The speciality of this company is the solar system which includes collectors and storage in a combined system, without the usage of electrical energy. The company has more than 20 years of experiences of production, however, there has been nearly no improvement of the technology within the last few years. Also restrictions given by current law influence the sales and the usability of their solar systems. A few points of improvement possibilities are already mentioned. The main issues are:

- The design of the storage system should be changed because of the problems with regional laws
- The effectiveness of the solar panels should be improved

The major benefit of the system is its ability to operate without any electrical energy. So there is nearly no maintenance needed after installing and using the system. With a very cheap price, compared to other more complex system the Solarsystem (SS) is paid within the first 3 years. The storage system has about 10 years of warranty.

The goal of the innovation process is to obtain a leading market position in the national region. There are currently no plans for internationalization, which still might be an option in the future. After doing the developed workflow based on the methodology following results are obtained:

Results

Analysing the interview and product description 17 quality characteristics (QC) and 10 customer requirements (CR) have been discovered. This amount of parameters which are used in the ongoing steps e.g. for building the house of quality has been too high. The matrix becomes more unclear and confusing. If the number is too high one might fall in to two types of problems:

1. If the quality characteristics are too detailed, it is difficult to determine value for relation between QC and CR.
2. Some quality characteristics are related with each other and this might increase the number of calculation without a really useful effect for the analysis. (e.g. the panel dimension length and width is related to global surface)

For the reliability of the activity it is better if the selection is reduced to 6 or 7 quality characteristics and 5 or 6 customer requirements.

The market analysis used federated search functionality on the web resources to capture the relevant information. Different search strings for the accumulated content (QC, UR, and product description) were used during the search. It turned out that the level of linking to the information was not detailed enough and needed manual intervention to capture the link to the correct resource. A revised implementation will take that into account.

The next step – calculation of HoQ – delivered the value of innovation potential for components out of each technical system level. So in the fist level the highest innovation potential was the primary circuit (0,91) of the solar system followed by the tank (0,88) and the panel (0,80). Moving forward to the next level the mechanism with the highest innovation potential was the heating exchange (0,61) followed by the tank isolation (0,42) and the panel (0,33). Selecting the heating exchange and his subcomponents leads in the last level of mechanism that the chamber for heating exchange (0,56) is the most interesting mechanism for innovation on the lowest mechanism level. But Performing the house of quality calculation and the mechanism high potential selection, a column reporting the mechanism weight without considering the innovation potential value would be necessary. The user should have the possibility to choose the mechanism also based only on the level of relation with QC and CR because of the maybe misleading innovation potential evaluation.

For the ARIZ approach the final Work Flow (WF) has been used. The final WF combines the Petrov approach [7] with the Fey-Rivin [6] technique. It foresees to apply all the TRIZ knowledge base in parallel to identify possible solutions. At the same system conflict all the techniques Ideality tactics, separation principles, contradiction matrix, standards, suffield analysis are applicable. The focus on the chamber of heating exchanges takes to problems to solve: the optimized thermal energy transfer as well as the visual impact of the system. To find a solution for the energy transfer problem we run through seven main steps with a few sub steps of the ARIZ approach. Starting with the formulation of the technical conflicts and describing the harmful effect (losing too much thermal energy) the technical conflict has been selected, which was expressed by the intensified conflict: The chamber is transferring a high level of energy inside but loosing also a high level of energy to the outside environment. The performed sufield analysis, ideal final result definition leads to the physical conflict and the corresponding physical solution. The standard solution of breaking harmful effect brought up the solution to replace the chamber from outside to inside, so the chamber itself looses no energy to the outside environment.

The Laws of Evolution have been applied in order to study the position of the technological system compared with the TRIZ trends. The lines of evolution defined for each single law are used for both, position analysis and innovative solutions identification. Again the focus was set on the chamber for heating exchange. The Laws of 'completeness' got the highest value (6) followed by the laws 'increasing dynamism' and 'transition to micro level' (4). The lowest value had the law 'harmonisation of rhythms' (0) and 'transition to higher level system' (1). So the last two mentioned laws let discern the most potential of improvement while the law of 'completeness' and 'transition to microlevel' are already well developed.

It appeared that the effectiveness of the Laws of Evolution is higher if they are applied on a node that is not situated at the deepest level of TS tree. Therefore, it might be useful to apply the laws also to the overall product at level 0 to identify possible radical solutions.

7 RELATED WORK

This section describes architectures and IT-Tools that are currently available on the market to provide a baseline for the conceptual development of new products according with the TRIZ methodology. This section evaluates the most important from the KNOW-IT perspective highlighting those functionalities that are most relevant to support the intended KNOW-IT methodology.

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There are a few tools that seem to be established in the market of TRIZ-tools and that are widely used. Furthermore, some new tools have been developed recently, that contain interesting features such as the support of Ontologies (Pro/Innovator).

However, most of the tools focus on the innovative problem solving part only. KNOW-IT is trying to capture the whole process of conceptual NPD and therefore provides a wider range of information management capabilities, than the specialized tools listed below.

Software Name	Short Description
Creax Innovation Tool	Tools to systematize creativity; to help user to manage the complexity of problems; to analyze user current products in short time; solve user problems using the strategies of the best inventors worldwide
Goldfire Innovator	Structured process to inventive problem-solving, easy-to-use problem-identification, problem-solving and solution-generating capabilities.
Innovation Workbench	System that provides engineers with expert I-TRIZ assistance in solving challenging technological problems, helping users to develop implementable solutions that at times represent true technological breakthroughs
Pro/Innovator	Pro/Innovator is a knowledge-based innovation tool that guides strategic thinking by integrating TRIZ, ontology, modern design methodologies and natural language technique to assist engineers breaking psychological inertia during the conceptual design stages of product development. It helps the professionals and corporations to identify engineering problem correctly, develop engineering concepts inventively, evaluate alternatives comprehensively, generate patent application draft, and accumulate knowledge systematically. This tool is used across many different fields of science and engineering. Source: www.iwint.com

Table 1: Overview of IT-Tools for Conceptual Innovation

8 SUMMARY AND OUTLOOK

To summarize the steps before, a well established workflow has been generated from the designed methodology considering the market and technology aspect of products in their lifecycle. Along the structured innovation process, according to the IT Tool support, consultants have the possibility to increase the business value of products that have to be innovated due to different reasons. Complexity becomes more usable in the separated modules which are implemented in the software tool. Due the usage of a structured process also the reproducibility of results is well supported.

However, it is also necessary to mention some shortcomings which were identified during the project. The exact reproducibility can only be granted by limiting the freedom of the consultancy process, which is typically not advisable as the consultant has to react in an agile, flexible and dynamic manner to changing conditions in the NPD-process. This leads e.g. to dictionaries that has to be used to build the System Tree or formalize the product based on the object-action-tool description (OAT). Also the negative correlation in the House of qualities, if quality characteristics affect each others in a negative way has to be well understood by the user of the workflow. Ignoring this will lead to shifted innovation importance and so to the wrong focus of innovation.

Nevertheless – the developed methodology and the established workflow are a good base for ongoing applied research projects. One of the next steps should be a full implementation of different sets of innovation tools like TRIZ, Advanced Systematic Inventive Thinking (ASIT), and so on. Also the adaption of developed methodology and tool to the possibility to innovate services is an interesting and worth aspect to focus on.

Currently the final implementation steps are carried out as well as a more detailed evaluation of the toolset in more case- studies.

To conclude, the KNOW-IT platform provides an IT-tool supported methodology that does not only help to find innovative solutions, but embedded the whole process of conceptual NPD with regards to an integrated information management.

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