

KM System to support Incremental Innovation in Manufacturing Industry

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ABSTRACT: This paper presents a novel approach aiming to develop a complete Knowledge Management (KM) system to support the collection of innovative ideas and relevant knowledge throughout the extended enterprise for new and existing process and product developments, and to develop these ideas and knowledge into a means of fostering industrial innovation. The main objective of the approach presented is to develop a means of stimulating the creation of innovative ideas in general, and specifically on problem solving and on potential product/process improvements, and collecting them from people involved with the products and processes. This paper starts by briefly describing the motivation that has led to this work, as well as the project AIM, Acceleration of Innovative ideas to Market, under which the approach is being developed. Afterwards, an overview of the methodology and the AIM system is presented, and finally some of the business cases that the project is dealing with (both large multinational enterprises and SMEs) are described.

1 INTRODUCTION

The accelerated pace of technological development continuously increases time and market pressures on manufacturers, capacity to innovate new products, the respective designs, and to develop the manufacturing processes that realise these products. The relentless race to develop new, higher quality products, simultaneously reducing time to market, reduce product cost, improve quality, is a major challenge for all the companies.

Many companies have the required corporate breadth-of-experience to improve their products and processes, but they lack the financial capacity either to invest in the latest technology as it reaches the market, or to hire specialists to integrate new methodologies and systematically to improve their products. If the companies could only make best use of their knowledge resources internally, and in partnership with their suppliers and customers, they would be able to respond more effectively to the new market challenges. Stimulation of Innovation is a means by which these knowledge resources could be channelled.

This paper presents a novel approach to support incremental innovation in manufacturing industry, by supplying the companies with the necessary means to make the best use of their knowledge resources. An analysis of market needs and the state-of-the-art indicates that an appropriate infrastructure

or system to collect and stimulate innovation in industrial environment does not exist presently.

The novelty of the approach presented consists in stimulating innovation by providing all the knowledge needed (on products, processes, problems, ideas, innovations etc.), and in developing a new system to foster this incremental industrial innovation. Although a new system is to be realised, there is no need for new technology development, since a combination of existing advanced technologies seems to be promising and adequate.

The work here described is being developed under a project called AIM, Acceleration of Innovative ideas to Market, which is described in section 2. Sections 3 and 4 of this paper explain the basic concepts of Idea and Innovation adopted, and the approach being followed, and section 5 presents the system to be realised to support the complete methodology. This approach will be tried in three end users, in order to validate the complete system, gather results and lessons learned. The three business cases are briefly described in section 5 of this paper. Finally, some conclusions of the work performed so far are presented, together with future expectations.

2 THE PROJECT

The Project AIM, Acceleration of Innovative ideas to Market (IST-2001-52222), has started in June 2002, and runs under the Intelligent Manufacturing

Systems Program (IMS). AIM has an international consortium that comprehends partners from Spain, Germany, United Kingdom, Australia, Korea, Japan and Switzerland.

The project's goal is to develop a system to support the collection of all useful knowledge throughout the extended enterprise, for new and existing process and product developments, and to develop this knowledge into a means of fostering industrial innovation. Innovation by combining the ideas and feedback from all parts of the product life cycle, and including customer service, field engineers, suppliers, and pooling of knowledge between multiple sites. Innovation is a critical factor in the success of industrial companies.

The objectives of the project are:

- To develop a means of stimulating the creation of innovative ideas and collecting them from people involved with the products and processes.
- To develop a way of processing these ideas and storing them into a structured knowledge repository.
- To develop a means of analysing innovative knowledge to determine which is useful, and which is not, i.e., to enable the viability of ideas to be assessed.
- To develop the best means of delivering innovative ideas to product and process designers for maximum effect.

3 IDEAS AND INNOVATION

AIM intends to provide a system to manage ideas and innovation within industrial enterprises. Therefore, it is necessary to clearly define and distinguish between the terms “Innovation” and “Idea”.

Innovation is something new that was introduced in an environment, i.e. a new product, a new way of realising a process etc. The concept of being “new in an environment” is very relevant since it is also possible to talk about something known and experimented in other fields but never used in a specific one. Therefore, an innovation represents the final stage of a development process, representing the result achieved and implemented successfully.

AIM understands under an Idea a set of knowledge that describes a possible action to be implemented to overcome a problem, to provide an improvement, or to reach an innovation. These ideas can represent different types of knowledge: technical, empirical etc. To illustrate this concept, it is possible to think in the source of the idea. A development engineer will probably present a technical idea, whereas a customer might present an empirical idea, translating his practical knowledge. Every innovation starts with an idea, a rough concept describing something to be implemented. In these

cases, the expression “innovative idea” can be applied, to describe a concept that is new, not contemplated yet in the area, and that can lead to a successful innovation.

The concept of knowledge management can be defined in the way to organise information or data, and this concept is applied to either ideas and innovations or any other kind of information that is to be stored and used somehow afterwards. It is possible to think in the evolution from data to knowledge in the following way: DATA \Rightarrow INFORMATION \Rightarrow KNOWLEDGE \Rightarrow WISDOM and the steps that might be required along a road from knowledge to a contextual, tangible, benefit generating ‘wisdom’.

It is possible to store knowledge in all kinds of expert ways, but this does not make it real for people who need it. It is common sense that, unless we actually do something with this knowledge, it becomes insubstantial for us a mere record of what is passed.

When managing knowledge, representing “Ideas” or “Innovations”, it is essential to keep in mind that the gap between knowledge and its respective use has to be eliminated. This means that the knowledge has to be stored and managed focussing its use.

Based in these concepts, it is possible to identify what kind of information an idea represents, i.e. why is an idea in the ambit of an extended enterprise. Ideas can be:

- 1 New products/processes;
- 2 products/processes improvements;
- 3 potential causes for a problem;
- 4 possible actions to solve a problem.

Ideas will be collected throughout the extended enterprise, aiming to involve all relevant actors in the company's services and products. The users of the AIM system will then be:

- suppliers;
- design and development teams;
- production planning;
- manufacturing;
- sales;
- customer service;
- customers.

3.1 *Life cycle of an Idea*

An Idea will undergo a complete cycle, in order to be collected, documented, classified and used in the AIM system. Ultimately, Ideas turn into Innovations, which is one of the main objectives of the system. This section provides a rough overview of the life-cycle of an idea. Figure 1 shows the complete path that an idea undergoes in the system.

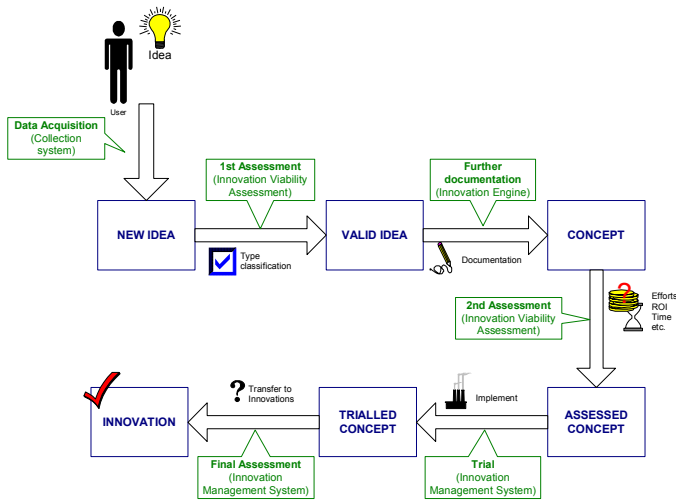


Figure 1: Life cycle of an Idea

1. Data Acquisition

Ideas will be collected using an appropriate graphical user interface, accompanied by knowledge acquisition methods. The users of the extended enterprise will use the system to document their thoughts and viewpoints concerning the products and services of a company. These fresh collected ideas will be marked internally as new. This functionality will be provided by the Collection System, and the outputs from this task are 'New Ideas'.

2. First Assessment

The Innovation Viability Assessment module will perform a first assessment of the 'New Ideas', with the purpose of making a rough classification. This classification will be an identification of the idea type, according to the information that it contains: improvement, potential cause, action or new product/process. The main objective of this first classification is to attribute a type to each 'New Idea', enabling its fast identification by the appropriate staff members of the company. From this functionality results 'Valid Ideas'.

3. Further documentation

With all the ideas classified by type, 'Valid Ideas', it will be easy for a responsible staff member to develop them further. This will be done by first collecting any additional information that might be relevant for the 'Valid Idea'. All the information can be useful to enable the best possible assessment. This step also includes relating the idea to any other ideas, innovations, and information stored, such as products, processes, problems, causes, actions etc. The result of this step is an idea more elaborated, which will be designated by 'Concept', and this function will be realised by the Innovation Engine.

4. Second Assessment

The company's staff members responsible for ideas' evaluation will use the Innovation Viability Assessment module to obtain a detailed assessment of each 'Concept'. The detail of the assessment will depend on the information collected for each idea, and will be based on several factors. The objective of this assessment is to support a decision of trying

or not the idea, i.e. implementing it. Several issues have to be assessed here, such as material, machines, staff members, implementation cost, profit, efforts, ROI etc. The result of the assessment will be documented in the repository, together with the concept, defining an 'Assessed Concept'. This functionality will be assured by the Innovation Viability Assessment.

5. Trial

Based on the assessment performed in the previous step, the 'Assessed Concepts' can have a positive or negative classification, i.e. if it worth trying them or not. If the result of the assessment expresses an expensive and unworthy implementation, the 'Assessed Concept' will probably not be implemented, and this has to be documented. It is then possible to keep the concept in the repository to reuse part of its information, or delete it. When the assessment provides positive results, the 'Positively Assessed Concept' is tried, and the complete development process is documented in the repository. The most important part of this documentation is the result obtained from the trial implementation, which expresses the success of the concept or not, and defines a 'Trialed Concept'. This documentation process is realised with the functions provided by the Innovation Management System.

6. Final Assessment

The complete documentation of the concept i.e. 'Trialed Concept', collected until this step, enables the final classification of the initial ideas. Based on the assessments and the trial implementation is possible to identify if the idea is successful, and therefore constitutes an 'Innovation'. In this case, the complete information is transferred to the Innovations repository, and will be used in the company. This task will be accomplished with the functionality provided by the Innovation Management System.

4 APPROACH

The main objective of the AIM system, intending to support incremental innovation in industry, is to collect ideas and all relevant information on the manufacturing process and products, and use them mainly for two purposes:

- 1 solve problems that arise in the daily life of production and/or product usage;
- 2 generate and/or contribute to the improvement of products and/or processes.

The overall system architecture is presented in Figure 2, describing the use of the different modules.

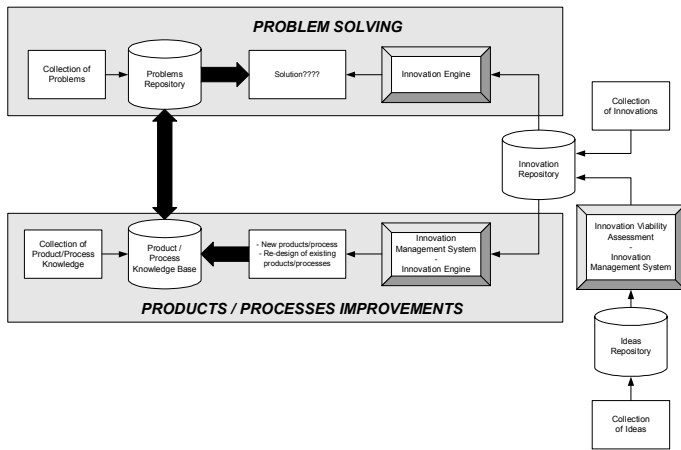


Figure 2: AIM's approach

The proposed modular concept will provide possibilities to easily tailor the system to specific needs (e.g. SMEs may use just modules for ideas collection and assessment, a company may use just modules for collection of problems and ideas etc.)

4.1 Innovation Repository

This repository will classify innovations using an 'innovation' meta classification, and will store them for rapid access. The problem is to enable appropriate classification for different specific products and processes as well as within a specific company concept. This will include:

- Product/process knowledge base: all relevant information and models as well as experience-based knowledge of products and processes.
- Problems/Improvements potential repository: knowledge on problems and potential improvements regarding products/processes. This will cover knowledge on problems identified, their reasons, and/or actions that were used to solve them in the past.
- Ideas and Innovations: All ideas and innovations will be stored using the meta classification. The overall meta classification of the ideas and innovations is defined as a basis for all AIM modules. The classification will be adjustable to specific user needs, i.e. the system will include module for set-up of the classification appropriate for user.

4.2 Collection of ideas and product/process knowledge

The main issue of this module is an appropriate user interface to introduce ideas and knowledge on products/process and about the identified problems. Therefore, four sub-modules are foreseen: to register the identified problems, to collect knowledge on product/process, to introduce innovative ideas and innovations.

All sub-modules must provide information/knowledge on product/process needed to formulate problems and ideas. The sub-module for intro-

duction of innovative ideas must provide easy overview of previous (similar) ideas (so that the user may see other ideas relevant for the specific topic). It will also enable to observe the identified problems for which the ideas are needed. User interface must enable the user to provide his/her idea in a 'free' form but to fit in the foreseen structure. The user interface has to be adapted for specific user needs. This means that the core functionality and common user interfaces will be developed which must be easy adjustable to specific user needs.

Classical RBR and CBR approaches, in a combination with appropriate ontologies definition and an adequate user interface will be used for this module, which has as well to observe the 'innovation' meta classification.

4.3 Innovation Viability Assessment

The essence of this module is to structure the information (ideas) in such a way that enables functional and financial assessments, supporting users in assessing the feasibility of new innovative ideas. This assessment will use the following methods and tools:

- Decision Trees will be used as tools for helping developers to choose between several courses of action, as they provide a highly effective structure within which it is possible to lay out options and investigate the possible outcomes of choosing these options.
- Reasoning tools, such as RBR and CBR, will be used to propose the level of priority of each idea, as their rules can be established gathering information about the business objectives and users satisfaction.
- TRIZ will be used to achieve the generation of innovative ideas, enabling to "get-out-of-the-box" to find real "new" breakthrough ideas with a considerable degree of innovation.

The module will use information/knowledge on process/products and identified problems in order to enable assessment of the ideas.

4.4 Innovation Management

This will be a means of providing structured delivery of the innovations/ideas to the process and product Design Teams.

The objective is to have a means of managing the ideas, enabling their best use for innovative product and process designs. This will involve providing facilities to plan and monitor the use of innovation knowledge during the design activities. This will be a means of providing the information in a structured fashion, with the aid of clear graphical representation, in order to assist the work of the Design Teams in realising new process and products in the companies. In addition, it will also provide an efficient way

for planning and monitoring the use of the innovation knowledge during the design activities. This module will also provide a feedback to the originators of the innovative ideas in order to simulate further innovation.

The approach to be followed is to store the information in small structured pieces, using a classification that is defined according to the final purpose and the context (e.g. the type of company or its objectives). These small pieces of information can then be grouped in different ways, according to the person analysing the data. It is possible to make different combinations and extend them, achieving a complex set of information. This principle also helps to analyse the information from different points of view, or the reverse a course (or grouping) that was not successfully, i.e. varying the level of abstraction back and forward easily. The goal is combining ideas to make new ideas, or combining different pieces of information, that shown to the user are able to start something completely new due to the interpretation made by the human brain. This represents a reference to heuristics, combining the system and the user, and trying that the system also has the heuristic approach of seeking for connections that is so common to the human brain. Another advantage of having the knowledge handled in such discrete units is that is easy to form links between different knowledge domains.

4.4.1 *Innovation Engine*

This module provides a structured means for the development of ideas into innovation concepts. It is oriented to finding innovative solutions following a systematic methodology. For this, it will develop all ideas collected throughout the extended enterprise into small information pieces considering a classification that is defined according to the final purposes and the context. The goal is combining these ideas to make new ideas, or combining different pieces of information, that shown to the user are able to start something completely new due to the interpretation made by the human brain.

This is a collection of methods oriented to finding innovative solutions following a systematic methodology. This facility provides a structured means for the development of ideas into innovation. This will be the means by which raw, creative ideas can be organised and developed by sharing and working on these ideas in a structured framework. The specific requirement is to provide robust solutions to be applied in the industrial environment. The specific challenge of this module is to enable teamwork in development of new ideas by providing means to combine individual ideas.

For Innovation Engine a combination of TRIZ, RBR and CBR will be applied. The important field very appropriate for the use of reasoning tools is the search for a problem's solution. In this area, several

experiences were already made that proved successful. Thinking in the TRIZ methodology and its principles that refer to the use of past knowledge to overcome problems, even in different areas of application, it can be identified that this theory can be applied by the reasoning methods. Either RBR or CBR use past information, gathered in rules or cases, to reach a result that, in this area, might represent a solution to a problem. The necessary knowledge to realise both reasoning methods exists in the AIM system, either as innovations, ideas, or product and process knowledge (included in the product and process models).

The reasoning approaches will be used to combine the ideas into innovation concepts by providing sets of ideas that may fit together, providing previous appropriate combinations etc. The development team can then test or study the solutions proposed by the reasoning methods, which can therefore originate more data for the repositories and the refinement of the rules and cases used. By providing several options, or by using different methods, the engineering team developing a product or a process can have access to relevant information not yet considered and consequently make improvement in their work.

5 END USERS

The project will be based on several business cases, one from each user. These will be used to ensure that the project is driven by industrial needs, and that these needs are met (by validations and assessments of the results at strategic phases of the project). These business cases will be focused on innovations for product development and innovations for process developments. The business cases will therefore use the AIM system in different ways, e.g. while some business cases will be oriented to directly collect innovative ideas and knowledge, in some the motivation for collection of ideas will be realised via identification of problems/improvement potentials asking for innovative ideas. This will enable to develop and test AIM system for different scenarios, ensuring its general applicability.

5.1 *Business Case 1: Product innovations in SMEs*

This business case concerns rapid product innovation in an SME, developing new innovative products internally by getting everyone involved, including field engineers working with customers to generate product ideas. This business case will focus on providing a structured and rapid approach to product innovation, so that the time to market is reduced. This is extremely important for most companies, particularly SMEs, which have to produce innovative products for the marketplace, and where it is essential to have a minimal time to market.

5.2 *Business Case 2: Multiple site process innovations in high volume manufacturing*

This business case will focus upon innovation in multiple site manufacturing process based on the identified problems and improvement potentials. The end-user is a large multiple site company producing high volume products. Currently, many innovative ideas from employees are not used since there is no system to collect such ideas, assess them and deliver them to process designers. In order to collect information on problems in production, for which innovative ideas are needed, the integration and expansion of the IT-Systems implemented in production will be applied. The extension of the systems should mainly be concentrated on knowledge-based methods for the improvement of the production & quality data analysis, providing faster problem causes identification. The special challenge of this business case is that it will address manufacturing process distributed over multiple sites. The industrial partner has several plants in Germany and Europe, but also in US and other regions. Several sites will be involved in this business case. The goal is to collect problems/improvement potentials and innovative ideas from these multiple-site manufacturing plants, i.e. to provide means to put together ideas from actors in different plants. The teamwork on developing the ideas across the multiple sites will be supported by AIM system as well.

5.3 *Business Case 3: Product and process innovations in engineering services and customer and supplier focus*

A medium size company, being part of a larger industrial group is a system provider to industry and is strongly oriented towards sales, service, marketing and after-market. The company is working closely with their suppliers/partners. Therefore, a system for collecting of innovative ideas from both employees and suppliers is an urgent need. The business case scenario will involve collection ideas internally and at supplier sites. Specifically the benefits from collecting ideas at supplier site could be high, taking into account a high interest of suppliers to provide ideas to improve services with their products.

6 CONCLUSIONS

The current market demands for innovative manufacturing companies, which are capable of making the best use of their in-house expertise. However, presently, the companies do not have access to any tool or system suited for the support of gathering innovative information and expertise from all the players involved in manufacturing processes, and making the best use of it.

To support companies in keeping up the pace with technology and the market challenges, AIM's main goal is to increase innovation and accelerate its introduction into the market. This objective will be achieved by combining a strong methodology with a supporting and robust system, which will gather several methodologies already existing and applied in other areas, and help filling in a gap that exists in technology. We expect that the project will be a good help to push manufacturing companies moving towards increasing innovation rates throughout the new paradigms of Extended Enterprise and Knowledge Management.

The main RTD challenges to be faced are the combination of methods for generating innovative ideas (*i.e.*: TRIZ) with "classical" methods for collection of knowledge on products/processes and their problems, and the development of specific ontologies needed to enable efficient exchange of ideas between different experts/actors within the extended enterprise.

The full implementation of the AIM system is expected to realise the necessary means for: stimulating the creation and collection of innovative ideas; analysing the innovative knowledge to determine its usefulness, i.e. performing a viability assessment of the information stored; and delivering the innovative ideas to product and process designers for maximum effect.

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