Advanced IC tools for maximising virtual team creativity and Innovation in Manufacturing environments

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Abstract— **During the last years (basically since 1999), the author and his research team are and have been involved in several research projects within the field of Product Life-Cycle Knowledge Management in the manufacturing domain. The key idea behind these projects is to develop means supporting the collection of all useful knowledge on product and process throughout the extended enterprise, all along the product Life-Cycle from Conception to Disposal and eventual Reuse. Keeping and re-using knowledge is of capital importance for the companies' competitivity to be used in continuous improvement of existing product/processes as well as in new developments.**

In a further step, the knowledge will then be developed into a means of fostering industrial innovations. Innovation is a critical factor in the success of manufacturing companies and it will mainly arise by combining ideas and feedback from all phases of the product life cycle.

I. Introduction

In current Global Markets, innovation is generally one of the most critical factors for success in manufacturing firms. Former advantages based on aspects as costs reduction, natural resources, geographical situation and so on are not so relevant today since globalization is flattening these issues and furthermore, needed natural resources are usually coming from outside. We must always be meaningful of the need of fostering innovation fighting against usual themes as: "cut your costs", "get focused". Nowadays motto should be "Innovate or lose". This new situation needs to introduce relevant changes in the way the companies are working. One of these changes has to be accomplished in the field of new products development that is the basis of the success of manufacturing companies [1].

Focusing on that, it is very important to know exactly what are we speaking about and a good reference is the Green Book on Innovation of the European Commission that has elaborated the following definition of **innovation**:

"*To produce, to assimilate and to exploit successfully a novelty in the economic and social spheres in a way that provides inexistent solutions to the problems and allows fulfilling necessities of the people and the society.*"

This definition from the EC apart from the idea of "*introducing something new*" (already defined in most Dictionaries) bring it the very important concepts of:

- to exploit it successfully
- in the economic and social spheres; that's to say: **"the market"**
- fulfilling necessities of the people and the society

The three points above mean that innovation is useless if it is not successfully exploited in the market, thus fulfilling people's needs. They could be reworded and reduced to: *to fulfill the necessities of the Market* meaning that the real success of any commercial activity will only arise from a good fitting to the Market.

In summary, as it can be seen in the following Figure 1, **Innovation** may be defined as: "*The transition from a novel idea to a successful product in the market"* (from the Green Book on Innovation of the EC).

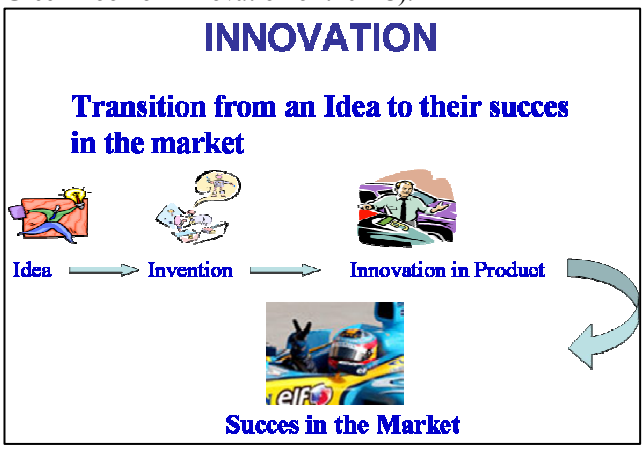

Fig. 1. Expanded Definition of Innovation.

Besides that, two big types of Innovation may be considered:

- Radical or breakthrough innovation
- Incremental innovation

Radical or Breakthrough innovations should have a significant impact on the market either by creating a new category of products fulfilling a previously inexistent demand (walkman, mobile phones….) or by increasing

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performance level of existing products (injection engines, plasma video screens…..)

Incremental innovation on its side is very close to the quality concept of "*continuous improvement"*. Any change in the right direction, adding value to the customer, can actually be considered as an Innovation.

The starting point for innovation is the *idea* and ideas arise from Creativity.

Creativity is defined as: "*Ability to produce something new through imaginative skill, whether a new solution to a problem, a new method or device, or a new artistic object or form*".

This can actually be done on an individual basis but it is not easy. In fact people are very creative in childhood but most of us bury creativity along time under layers of rules and norms, counter-creative education, boring tasks and corporative restrictions as well as a growing (with age) fear to fail [2].

Team work fosters creativity by adding extra value to the simple addition of the individual skills of the team members. Most of the existing tools for creativity are actually intended to team working: *Lateral thinking, Thinking Hats, Brainstorming, Think tanks, 6-3-5, Nominal Group Techniques, TRIZ* [3][4]…

The real challenge on a Virtual Collaborative Environment is how to "re-invent" these tools or create new ones and use them within the new virtual working frame, create new ones and integrate them all [5][6]. A very important drawback is that virtual environments fail to create the warm, human, freewheeling atmosphere necessary in any "Creative process" [7][8].

Here is where new IT tools can contribute and that's what next points deal about.

II. CASE STUDIES

On this field, a selected sample of business cases developed by Labein in the frame of European funded Research as well as National and regional programmes, are going to be presented and discussed from this point on.

A. **e-Manufacturing: WECIDM.** *Europe&Asia Link project WECIDM (ASI/B7-301/3152-99/72553)*

1) Objectives and description.

Long Title: Distributed product design and manufacturing with Innovative approaches.

WECIDM project has developed an internet-based platform allowing a distributed team to perform a collaborative design in which the knowledge from different parts of the value chain (like design rules imposed by the manufacturing process) can be collected and reused.

Collaboration is particularly vital for product design since this upstream activity in the product life cycle has a decisive impact on the manufacturing processes as well as in the overall market success of the particular product [9]. In addition, new requirements need new infrastructure, a distributed cooperative product design capability is now necessary [10][11].

The core application of the system manages the distributed design and manufacturing process between different teams through internet, including the management of all the relevant product/process knowledge. The basic structure of the system includes a Database and Product Data Management (PDM) and Knowledge Based Engineering (KBE) modules.

2) Main Modules

The main modules developed for the project final prototype are the PDM application and the KBE modules for the manufacturing process considered, both residing in a central Server.

- *Product Data Management (PDM).* This application performs the basic product data management features and manages the KBE modules and the Database. This PDM application is linked to a MS Access database where all the relevant information related to the assemblies, parts and documents is automatically stored.
- *Knowledge Based Engineering (KBE).* KBE allows companies to capture and reuse the knowledge and experience of their engineers, together with manufacturing best practice, legislation, costing, and other rules for the product development. In this system prototype, different modules are developed for each process and for each part family, in order to implement the specific design rules and process parameters.

Figure 2 shows the graphical user interface that allows a remote authorised external user to introduce the values of some design rules parameters (such as flash land geometry, pre-form volume, draft angles and convex radius) corresponding to a typical forging process.

Designers can in this way get the parameter values in order to apply the design rules to the product design. These data will be automatically used inside the local CAD system through the appropriate API application developed for that specific CAD package, thus obtaining a product design which fulfils the manufacturing restrictions given by these design rules.

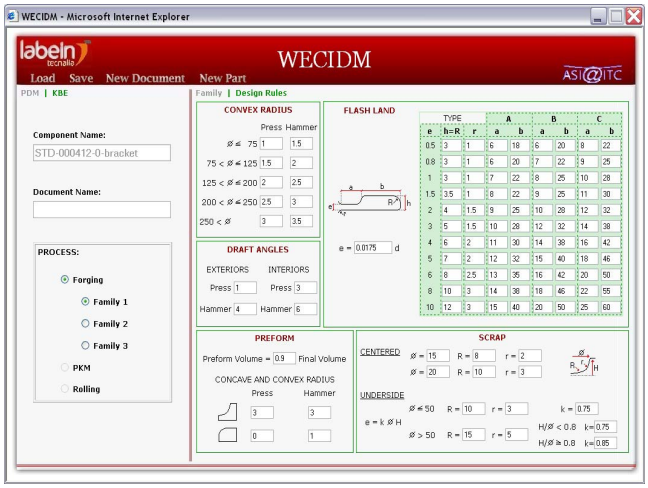

Fig. 2. Design rules for a forging process

The CAD model is in this way generated applying the knowledge from other stages of the product lifecycle introduced by remote users. Neutral format is then used and uploaded (to the remote central server) by the CAD user, so that the CAM user can get the geometry of the part and is then able to generate the CAM files from the geometry for manufacturing stage.

3) Fostering Innovation

In summary, WECIDM is a tool that enables people from different teams from distant locations to work together in a common engineering development. Creativity and innovation don't arise directly from the tool itself. Creativity steams only from the human's brain. WECIDM therefore provides the users with a useful tool for the following topics:

- *Knowledge Based Engineering (KBE)*: The possibility of reusing existing information is always a good path for innovation if the people re-using ideas get the mentality of continuous improvement and improving upon existing solutions.
- *Collaborative design and manufacturing methodology*: Collaborative working has the advantages of more eyes over viewing the same piece and monitoring on line the development process. Different remote teams with knowledge from different lifecycle stages can collaborate, which means that a wider knowledge is being taken into account. This circumstance results in lesser errors (that can be spotted earlier) and higher (and better) amount of solutions or design alternatives.

*B. **e- Innovation:** AIM, Acceleration of Innovative Ideas to Market. IST – 2001 – 52222*

1) AIM objectives

AIM system [12] has been developed to support the collection of innovative ideas and relevant knowledge throughout the extended enterprise for new and existing process and product developments. These ideas and knowledge could later be developed in a collaborative way fostering industrial innovations, as Team Work will be enhanced by co-operation between manufacturers, customers and suppliers by means of the Internet facilities provided by the AIM System, "accelerating" innovation into the market [13].

As stated, one of the most important targets for the AIM tool is the collection of ideas throughout all the extended enterprise [14]. For this, every agent on the "Extended Enterprise net" is called to provide ideas and opinions on how improving the productive process, product quality, etc.

A distinction of the AIM users in three categories (administrator, process designer, and standard user) is done. For the standard user, the introduction of ideas must be friendly and easy, only needing to relate them to the product, unit or process for which the idea could be useful.

Specific achievements out of the full implementation and validation of the AIM system are:

- Providing companies the means for stimulating the creation of innovative ideas and collecting them from the extended enterprise level.
- Developing ways of processing these ideas and storing them into a structured knowledge repository [15].
- To enable the viability of ideas to be assessed.

2) AIM System Approach

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 tool. The AIM system follows and supports the activities identified in the idea life cycle as shown in Figure 3.

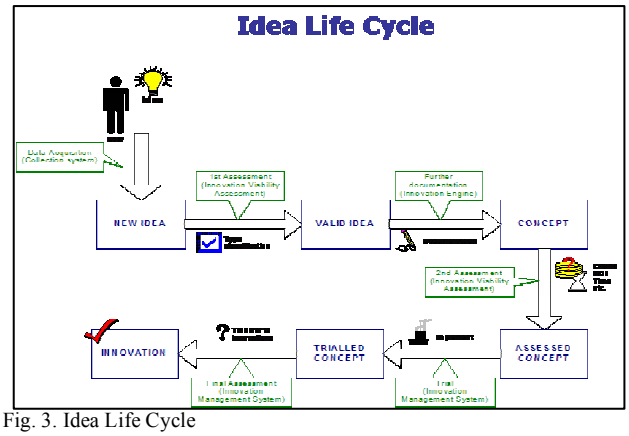

Fig. 3. Idea Life Cycle

i) The life cycle starts with data acquisition, where ideas are collected using an appropriate graphical user interface, accompanied by knowledge acquisition methods. The users of the extended enterprise will use remotely the system to document their thoughts and viewpoints concerning the products and services of a company.

ii) AIM system performs a first assessment of the **New Ideas**, with the purpose of making a rough classification. 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.

iii) With **Valid Ideas** classified by type, a responsible staff member develops them further, by first collecting any additional information that might be relevant for the **Valid Idea**, and further elaborate it. 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, **Concept**.

iv) Company's staff members responsible for ideas' evaluation realize a detailed assessment of each **Concept**, with the objective of supporting a decision of trying or not the idea, considering implementation cost, ROI etc. The result defines an **Assessed Concept**.

v) When the assessment provides positive results, the **Positively Assessed Concept** is tried, and the complete development process is documented in the repository. The result obtained from the trial implementation defines a **Trialled Concept**.

vi) Based on the assessments and the trial implementation it is possible to identify if the idea is successful, and therefore has become an **Innovation**.

3) AIM. Innovation Management Support System

As conclusion, AIM System seeks to encourage innovative creation in every people involved with the product lifecycle and the manufacturing processes. It also encourages team working between people from different sites (and working off-site), and between organizations, customers and suppliers, allowing companies to master and monitor real progress of the innovative manufacturing processes, assuring success to the market just allocating the planned resources at the planned time.

Moreover, based on the practical tests and results collected from AIM Consortium Industrial End-users, we can conclude that systematic approaches applied to incremental innovation lead to increased efficiency within innovation development process, confirming the basis and initial assumptions.

The AIM system, thus leads to important business benefits on the fields of:

- Reduction of product innovation cycle-time
- Reduction of time and efforts for solving product/process problems
- Improvement of process efficiency and reduction of wastes

*C. **e-process**: KNOW-CONSTRUCT. Collective project (COLL-CT-2004-500276)*

1) Objectives:

Long Title: Internet Platform for Knowledge-based Customer Needs Management and Collaboration among SMEs in Construction Industry

KNOW-CONSTRUCT project [16] (not yet finished) is developing a common internet-based platform for SMEs from the construction sector to provide an effective combination of two general functionalities: an innovative decision making support system regarding the products characteristics, applications and other consultancy services for SMEs' customers applying the "web enabled dialogue", and a system for SMEs to support an advanced form of co-operation through the creation of Knowledge Communities.

The project goal is to contribute to enable the European SMEs in construction sector to increase the application level of the knowledge-based ICT solutions in their business relations to customer and mutual co-operation.

The innovative system responds to the following aspects: low cost for the involved SMEs and customers, Internet based, efficient customer support, collaboration between actors in the construction process, record of key information assuring traceability, common terminology and ontology, security, mobile users support (knowledge reachable anywhere, at any time), etc.

2) Innovation

Starting from the stated objectives and basing on the analysis of the state-of-the-art and current standards, the main problems addressed leading to innovations are:

- **Methods for creation of Knowledge Communities of** SMEs in construction industry, where the **Associations** get a crucial role.
- To establish or re-use an adequate domain related **ontology** [17][18], as well as **classification system** for this sector applicable in SMEs environment [19].
- An inter-organisational knowledge management system (method & tool) for Construction Industry Knowledge Communities.
- To provide a "web based dialogue" between SMEs and their customers aiming at an **interactive decision support tool** to be used for customer problem solving.

3) Research approach

KNOW-CONSTRUCT does not develop new methods but re-uses the most appropriate ones and enhance/adopt them for specific e-support needs for SMEs. The main functionalities of both CNM and KCS modules the following:

a) CNM - Customer Needs Management

- Browsing community resources,
- Searching materials/products/components/procedures
- Searching services/domain/context
- Interactive, web-based consultancy.

CNM also features a portal service, providing the customers with access to individual community members e-commerce/e-business systems, integrated with information search and consultancy functionalities. CNM provides functionalities in terms of collecting and organizing feedback and knowledge from customers, and managing consultancy services.

b) KCS - Knowledge Community Support

- Knowledge community building
- Content management
- Knowledge structure management
- External search manager

Semantic web technologies are fundamental for eKCS in order to provide complex information retrieval, both internally and externally to the knowledge community. The eKCS core services are divided in *Semantic Resource Management* and a set of functionalities that provide the systems/applications with access to the semantic resources, namely: Ontology manager, Indexing and knowledge extraction, Semantic searching and navigation, Aggregator/integrator, Business data model wrapper.

4) Innovation in team working

Summarizing the Know Construct project, we may highlight its impact on Innovation by managing the Knowledge Communities specifically on the Construction industry sector.

So, in this case we may talk about "Communities" concept that actually is an expansion of the team concept. In this case, the working teams are expected to form and part themselves in a dynamic way depending on the specific temporal needs of the tasks under realization within the "Communities".

III. Future trends

In that work, some tools for collaborative working have been presented. Other interesting ones are emerging in the ICT market. For sure that IC tools will continue growing and will ever increase capabilities and performance.

However, innovate is a serious job that can't rely only on software tools as sophisticated as they could be, there is a real need of methodologies helping people to innovate. Furthermore, innovation means team working which means sharing information. People are in general very reluctant to share information unless they will obtain something in change.

We think that very promising research lines in the near future should be:

- Combination of methodologies to promote innovation techniques for team working and promotion of information sharing by creating "win-win" situations, in order to enhance the possibilities of the emerging web based collaborative working environments.
- Integration of engineering tools and human sciences tools in the above mentioned way.
- Adaptation of existing local tools to the web based collaborative environments.
- Development of new ICTs focusing on the new working paradigm and even shifting it in order to enhance and empower their possibilities.

IV. Conclusion

Creativity and innovation don't arise directly from the tool itself. As it has previously been said, creativity steams only from the human's brain and become an innovation when applied to solve specific technical problems that will increase the added value to the final consumer. Let's remind that only combination of the three factors is the real way of achieving innovation.

One of the key resources for creativity is "spare time" to think creatively. Notwithstanding, in current industrial arenas, most of the time people are devoting their efforts to perform low value added tasks, fire-fighting coping with small repetitive problems and nuisances and in many cases working only for the organization in a much inbred way. Furthermore, if you try to be creative, the organization may tend to believe that you are kind of wasting your time (Figure 4).

Fig. 4. Time to be creative

Within this framework, the increasing introduction of ICT tools and the expanding web facilities are facilitating the transfer of people's activities from hard tasks manually done to soft ones more depending on intellectual abilities.

As a final consequence, people exercise their mental skills and get more free time becoming more and more liberated from manual repetitive tasks. Next step is to use this time to really be creative and being rewarded by that.

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