CHAPTER 4

Internet and manufacturing knowledge management

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Abstract

In this chapter, the intrinsic relationship between Internet hyperlinks and the knowledge representation is broadly explored, with particular reference to design and manufacturing knowledge management. Furthermore, Internet-based intelligent systems are researched with a number of application systems developed by the authors.

1 Internet characteristics

About a decade ago, most of the world knew little or nothing about the Internet as it was mainly used by computer scientists and researchers to interact between each other in their respective disciplines. Nowadays this phenomenon has largely been extended to households and companies as shown by several surveys conducted by Oftel (the UK Office of Telecommunications). Taking the United Kingdom as an example, it appears that on the 4th of February 2003, 42% of UK homes [1] and just under 7 in 10 SMEs [2] now have Internet access. This survey therefore highlights that because more and more people are becoming familiar with using WWW resources, Internet is becoming a strategic tool for today's companies through the use of a widely available and common interface: a Web browser.

According to Nejmeh's [3] predictions in 1994, the organisations are currently using the Internet mainly for communication (via emails), or as a marketing, sales and promotion tool (via a company's web site). This is

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understandable because much of the development to date has been driven by the customer access to the Web content and business-to-customer commerce. Leading-edge organisations have efficiently adopted the potential of the Internet as a medium to maintain their competitive advantage on the marketplace, in regard to their services, products, processes, technologies and management practises. Following this, they have also acquired large and costly networked applications, which enable them to reach decent levels of collaboration and communication internally as well as externally. According to Scupola's [4] analysis, however, as a general conclusion it seems that SMEs appear to be reluctant to adopt Internet technologies at the core of their business, for reasons listed as follows:

- Lack of education, information, knowledge, and adequate IT support.
- Lack of habit to use the Internet.
- Poor communication between the IS consultant and the SMEs.
- Fear of releasing information about their products which could be violated via the Internet by the competitors.
- Difficulties in reaching trading partners, such as suppliers, customers and banks.

There is, therefore, a need to improve on the general awareness of SMEs concerning Internet and Communication Technologies (ICT), in particular, because the power of ICT resides in providing a new kind of services-enabled Internet, and is able to deliver distributed, scalable, high performance and adaptable applications to diverse access networks and terminal devices. In an attempt to address this issue, Chesher and Skok [5] tried to provide a roadmap for successfully adopting Information Technology (IT) for SMEs. Through their concept of a "roadmap", they enable SMEs to identify their level of the use of IT, and the possible directions to take for improving it.

Although it is clear that most businesses vaguely realise the need for using the Internet within their organisations, it is less sure that they understand the real benefits of building on online workspace. In fact, according to current predictions for the decade to come, it is very likely that a digital workspace, among many other advantages, would impact on two major aspects of an organisation:

- Improve and ease collaboration, which would have a direct impact on the company's activities, allowing time-savings, cost-savings, to eliminate redundancies, to build strong alliances, and to foster teamwork.
- Provide a strong basis to manage in a highly intelligent way all the information generated and used by the organisation.

It appears that so far Internet services seem to be applied to the business and commerce sides of industrial organisations, but far more potential lies in the internal processes and the data management. First of all, companies should try to adopt the Internet or an Intranet as the backbone of their business, allowing them to vehicle any type of information among the several persons, teams, departments, and/or sites of a company's infrastructure. Nevertheless, this amount of data should not be made available in an unclassified manner, as low cost web-based intelligent systems should help in keeping all this information well-organised. This could well be applied to any part of the company, from the human resources information, to the manufacturing process of any given machine on the shop floor, or even to a marketing solution for packaging a product. Therefore, the needs for companies to become smarter in the way they collaborate and they manage information should include a combination of the following key points:

- Content management: digital content management and support for rich media.
- Collaboration: messaging, alerting, real-time application sharing, monitoring, presence and discussion.
- Communicate effectively: across distances, time zones, company borders, and to a wide range of equipment and mobile devices.
- Information retrieval: information capture, storage, categorisation, and retrieval.
- Knowledge management: enabling users to facilitate acquiring, storing, and retrieving knowledge.
- Community technology: building and maintaining online communities.
- Process management: providing mechanisms to support the knowledge of workers, and not only the processes themselves.
- Portal framework: providing a consistent user interface for business-to-employee (B2E) users.

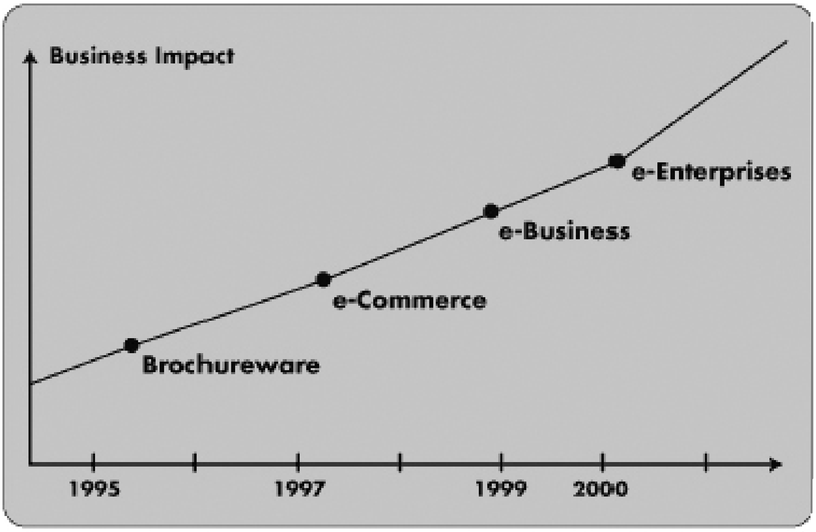


Figure 1: Enterprise type evolution [6].

Following the concepts previously mentioned companies are now going to rely exclusively on ICT and more particularly on the Internet and/or Intranets to create a new kind of enterprise model: the e-enterprise, as defined by Hoque [6] and as depicted in Figure 1 (previous page).

Furthermore, as agreed by the industry, based on the several key aspects enumerated previously and the evolution of the enterprise model depicted in Figure 1, the trend for the next decade seems to be to focus on managing companies' information and knowledge. In this context, in July 2002, The Gartner Group claimed that ICT are to help in leveraging the Intellectual capital of companies as they stated: *"...for businesses, acquiring and exchanging information about products has become at least as important as the product themselves...*" [7]. They further represented the Intellectual Capital as shown in Figure 2.

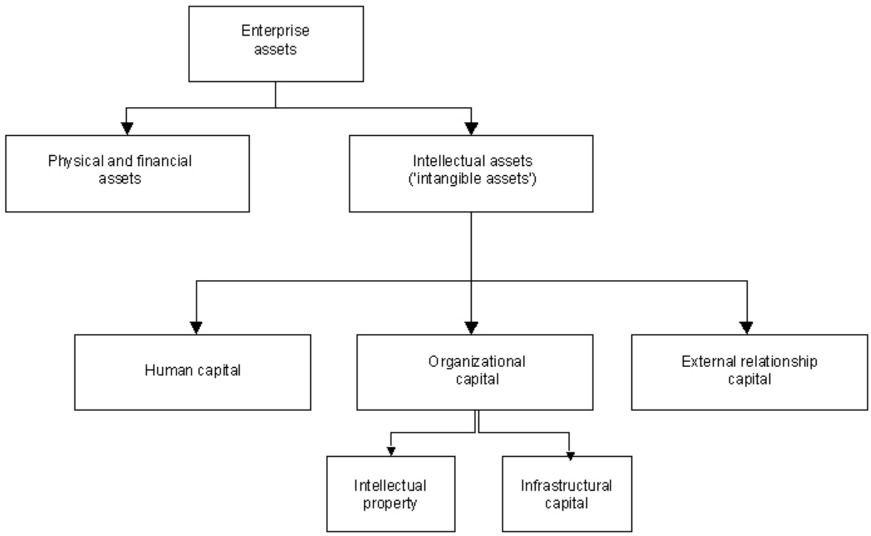


Figure 2: The elements of Intellectual Capital [7].

In addition to this model, Blumentritt and Johnston [8] have published further explanations concerning the Intellectual Capital by dividing it into information and knowledge. According to their findings, sharing or diffusing knowledge requires it to be translated into information (or data) and transferred. A successful transfer will then lead to re-translate the data into knowledge. However, they identified that in order to be translated back into knowledge, the information has to "make sense" in the context of the user. This context is constructed from experience, culture, social links and education. This entire process is depicted in Figure 3.

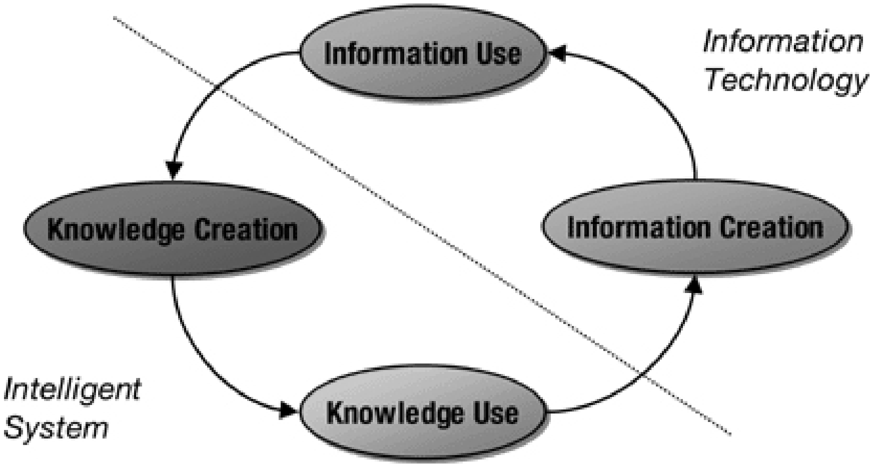


Figure 3: Information/knowledge cycle.

In parallel, Choo [9] attempted to define the cycle from capturing information to diffusing knowledge through the following five stages:

- *Identifying, acquiring or extracting valuable knowledge from documents, discussions or interviews, usually accomplished with the help of subject matter experts.*
- *Refining, writing up and editing "raw knowledge" (such as project files, presentations, email messages), turning it into "processed knowledge" (such as lesson learned, best practises, case studies).*
- *Organising the processed knowledge and making it accessible by adding index terms, subjects headings, cross-reference links, and metadata.*
- *Packaging, publishing and disseminating knowledge through a variety of channels, including intranet web pages, CD-ROMs, subject-oriented pathfinders, and "knowledge portals" that are focused on particular business needs or issues.*
- *Designing and managing the overall information architecture consisting of a set of well-defined standards and schemes for organising, classifying, publishing, and navigating the organisation's intellectual content.*

More particularly and concerning their approach towards project management issues, Fruchter *et al.* [10] made the supposition that design intent and knowledge capture, representation, sharing, and team interaction tracking is far less costly than the re-invention of comparable design and/or knowledge. Therefore, there is a need for creating intelligent systems to manage the different types of information across an organisation, which could then be accessed from anywhere by anybody at anytime. The WWW has the potential for supporting these web-applications, as well as the languages and the technologies to enable them. This is the reason why networking should not be "integrated" to an organisation, but the organisation should be built on the networking capabilities. This will lead to a new type of enterprise structure, based on the e-enterprise concept, and which embraces the increasingly dynamic character of business and technical innovation by sustaining continuity while organising knowledge and information within an enterprise and in enterprise-to-enterprise models. According to the Gartner Group's [11] prediction for the next decade regarding the evolution of software infrastructure, they foresee: "*The advancing power of information processing, driven by the increasing sophistication and maturity of software infrastructure, will drive this revolution of business empowerment through IT*". From these previsions, as well as from the general trend expressed by the consulting communities and the industry, it is now possible to try to depict the organisational layout of future organisations as shown in Figure 4.

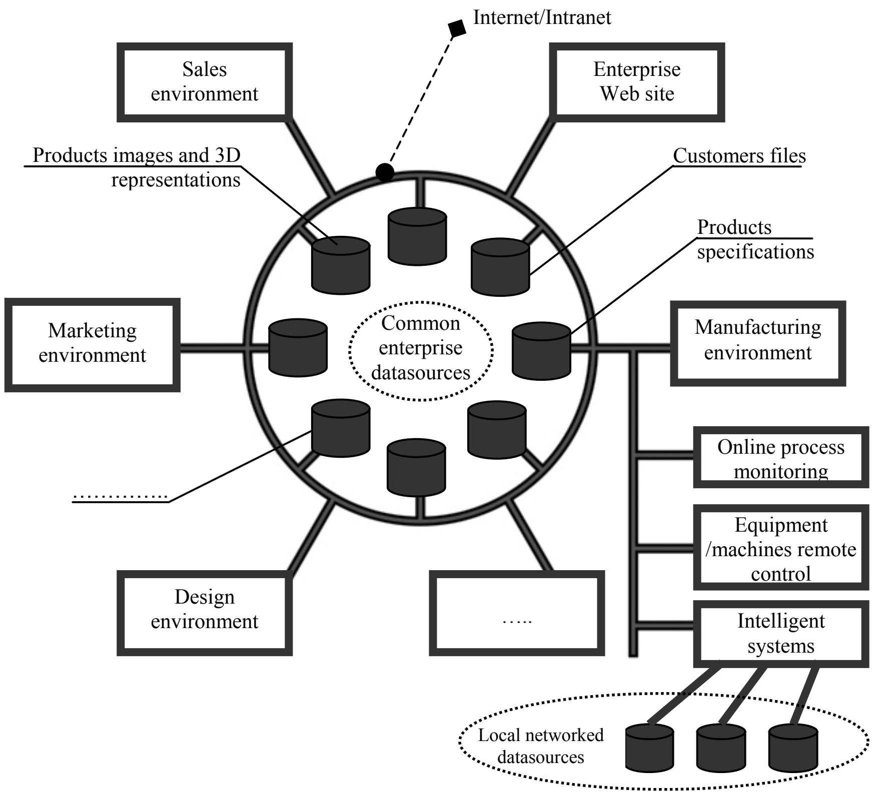


Figure 4: The organisational layout of a network-based enterprise.

In a very simplified way, Figure 4 highlights two major concepts of the enterprise in the future, namely: the interconnection among all services, departments, and datasources of one or several organisations, and the integration of intelligent systems for enhancing the capture and storage of the Intellectual Capital. Each environment represented by a square box corresponds to an enterprise activity's portal, and has the function of organising several sub web-based applications in its tree. Because everything is interconnected, the design team could for example work on new concepts based on results gathered by the manufacturing activity, and thus enable a better DFM (Design for Manufacture) approach. Similarly, the organisation's web presence could be improved by featuring 3D representations of the concepts prepared by the design team, or the marketing teams could use web-surveys performed electronically to potential customers in order to better define the demand from the ever fast changing market.

It is pretty certain that such a networked-based configuration would enable companies to benefit from a great advantage on the marketplace in terms of agility and responsiveness. Furthermore, thanks to the technologies used, such a configuration is readily implementable by leading-edge organisations as well as SMEs. This is probably for these latter that the potential is also the biggest, considering the low implementation costs as well as the very small risk of using ICT at the core of their activities. The next two sections, therefore, aim to demonstrate the advantages that could be gained by using Internet/Intranet solutions for the design and the manufacturing activities. The last part of this chapter will demonstrate a working example of an intelligent Web-based system which aims to help the decision-making in manufacturing operations.

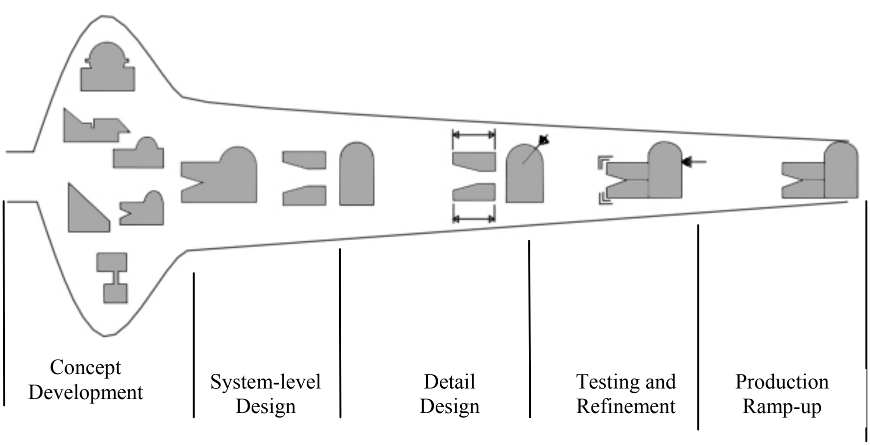


Figure 5: A generic product development process.

2 Design agility and the Internet

Engineers have always managed to achieve creative and inventive solutions to design problems. It does not matter where the problem is from, or in which particular area. Wherever there are people there are problems needing a solution. This last sentence has been true for hundreds of years and is still true even with the technology advances, because the number and the complexity for new products or solutions never stop increasing. However, the design process is still the same, and even if computerised tools, such as CAD/CAM applications, have helped designers to achieve their goals, the process can be represented as in Figure 5 and itemised as follows (Ulrich and Eppinger [12]):

(1) Concept development
As explained in detail by Voland [13], the concept development phase consists in evaluating alternative design solutions, in order to choose a single concept for further developments. The final solution will probably not be the ultimate solution, but it will aim to be the best one that meets the original needs while solving the problem in the most effective yet economically feasible manner. This final solution will be the result of a comparison of the strengths and weaknesses of the several alternative designs proposed. Also, different techniques are available to the engineering community in order to help in determining the best solution. The generic process can be listed as follows:

- To rank and order the design goals
- To produce a set of rules to assign ratings to design concepts
- To merge the scores of the two previous tasks, in order to obtain the best rated designs which fulfil the best design goals
- To identify the best overall solution
- To re-analyse this solution in order to try to simplify/modify it further in anticipation of the implementation phase

(2) System-level design
The aim of this phase is to decompose the found solution into sub-systems in order to generate the product architecture. The output will usually be a geometric layout of the product, as well as the functional specifications of the different sub-systems. The architectural decisions at this stage will be very critical, as they will probably impact on:

- Product performance
- Product change
- Product variety
- Component standardisation
- Manufacturability
- Project management

The product architecture will have profound implications for subsequent product activities, for the manufacturing and marketing of the completed product.

(3) Detail design
As accurately stated by Pahl and Beitz [14], the detail design phase is part of the design process and aims to entirely define the final instructions on the overall

product. These instructions will concern the layout, form, dimensions and surface properties of all individual components, the definitive selection of materials and a final scrutiny of the manufacturing methods and costs. Another critical task which has to be carried out during this phase is the editing of production documents, such as the detailed components drawings (including workshop drawings), the assembly drawings, and the parts lists. The design department has therefore to provide the production department with assembly, transport and quality control documentation and the user with operating, maintenance and repair documentation. Pahl and Beitz have illustrated the detail design phase in Figure 6.

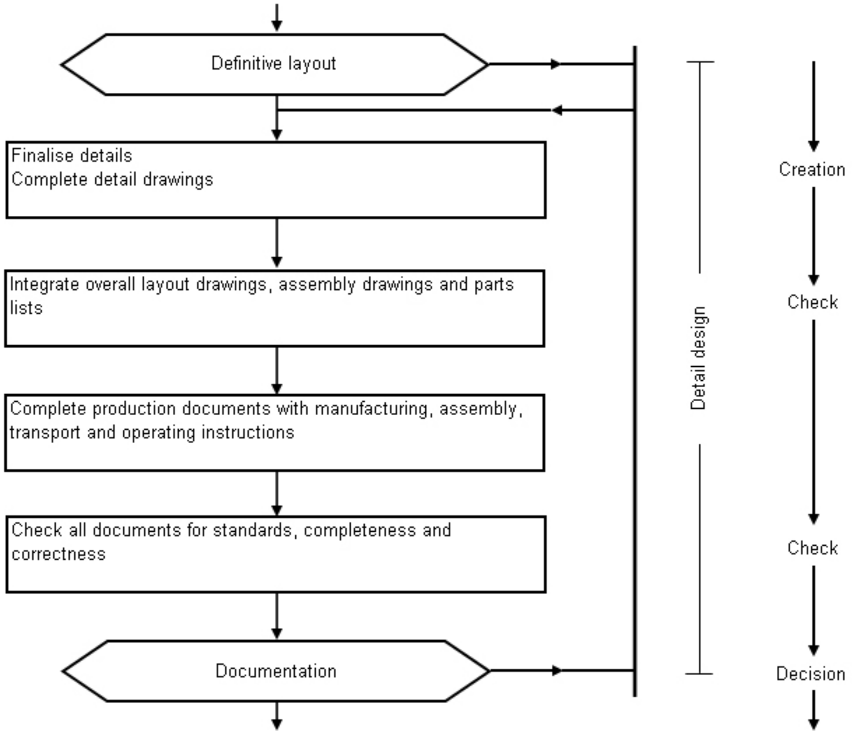


Figure 6: Steps at the detail design stage.

Finally, it is at this stage that economically successful designs will ensure high product quality while minimising manufacturing costs. Detailed design decisions will have a substantial impact on manufacturing costs, which is a key determinant in the success of a product.

(4) Testing and refinement

This stage, which follows the detail design, has the purpose of building and evaluating versions of the product prior to the production. The first versions are usually necessary to assess whether the product fulfils the original design specifications, and also whether it satisfies the key customer needs. Second prototype versions will aim to test and to define the assembly process, and will be used by customers in their own environment, in order to study performance and reliability issues. If necessary, this might lead to re-engineering the product in order to bring some design changes to the final product version.

(5) Production ramp-up
This last phase aims to study the manufacture of the product using the final production system. This will help in training the work force to the production and the assembly of the final product, as well as identifying possible production output problems. If successful, this will lead to launching the production on a much bigger scale and also to synchronize yield with the possible suppliers and/or providers.

The design process model above has been established by making the assumption that the product is marketable and that it can be manufactured. It is now going to be demonstrated that with the introduction and the availability of new technologies such as Internet, the way new products are introduced has changed product designers' work processes. Designers not only need to know what the product is, but also to have a proactive view of forthcoming changes due to the market evolution in order to curtail changes. Changes come to the least possible from both the demand side, driven by such needs as improving price/performance/functionality or creating features and variants for a market opportunity, and the supply side, driven by components shortage, quality issues, or part going end-of-life. In fact, the rest of the "old" design process has also been modified, and with the usage of other technologies such as Virtual Reality (VR) (Summers and Butler [15]), each step within the process could respectively be re-written as follows:

(i) Problem recognition

- Need for creating more products better and faster
- Need for creating product variants to reach a bigger range of customers
- Changes now come from both the demand and the supply sides

(ii) Investigation and definition

- The functionality of the product
- The appearance which could now be required or defined on the web by the future users
- The material(s) which could also now be required or defined on the web by the future users
- The construction, with a direct link to a virtual factory, the methods required to manufacture the product could be agreed or decided without the intervention of a third-party.
- The related safety issues

(iii) Development of alternative solutions

- With the availability of CAD/CAM tools, designers are now able to sketch a far bigger number of alternative designs under an electronic format
- It is also possible to reuse previous solutions (partially or entirely) by just reloading the previous electronic data

(iv) Choosing a solution with a comprehensive consideration

- Within the virtual factory environment, designers are now able to plan in advance the way the product is going to be manufactured
- The material(s) could now be retrieved with an up-to-date dedicated database, or ordered in advance if needed
- The time needed to build each solution could be directly known by using e-manufacturing simulators, also allowing testing of several manufacturing solutions
- The cost of each solution could now be obtained immediately with a better communication with the purchasing and sales departments over the web

(v) Elaborating models and prototypes

- The CAD/CAM model could be easily converted into a highly portable VR model, which could also be published on the web, for customers to review
- The VR product could also be implemented in its virtual working environment to appreciate all its functionalities
- The VR models could be sent over the web and allow a much quicker and handier access in comparing competing designs
- Another operation could be directly added to this stage, which is the edition of VR procedures (using several media such as VR models or video clips) that could be dedicated to the customers or even for a maintenance purpose

(vi) Testing and evaluating

- This last stage could now be merged with the previous step, as VR and Internet allow delivering real-time interactive 3D graphics in unprecedented quality and speed, as well as fully animated 3D scenes, ranging from simple sequences of motions all the way to complete interactive 3D presentations

These improvements in the design agility would possibly be achieved thanks to a network architecture allowing all the different departments within a company to be linked together, but also having feedback available from the customers over the Internet. In addition, the design team would also need to be in contact with the sales and the purchasing departments by sharing a common database over the web, which could radically change their work manners (Anderson and Pine [16]). With information such as costs and selling prices, designers could compare, with great accuracy and almost in real-time, the benefits and costs of various designs, while these designs were still on “the drawing board”. Added to this, such granularity of cost data, if accompanied by knowledge of customer desires, could permit designers to design products for ever-smaller better-defined market segments. The design team could be represented as in Figure 7, as opposed to the “old” linear layout.

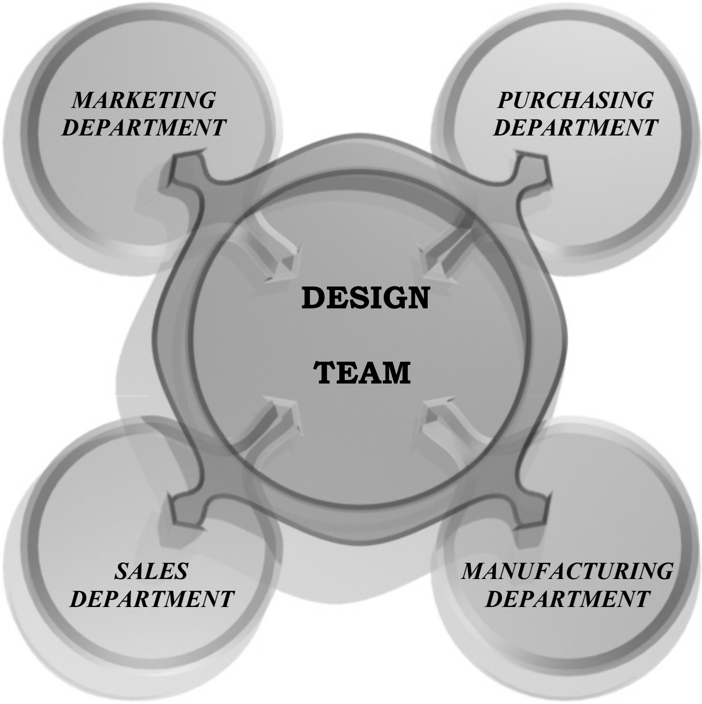


Figure 7: Design team with a new role within the company’s architecture.

In fact, the concept “Design Agility” could easily be associated with the concept of “Design for Supply Chain” or “Design for Manufacture”, as it describes an approach to design where supply chain issues are given strong consideration during the design phase. Companies and partners collaborate over their Intranets or over the Internet by sharing design information, in particular with:

- Engineering data:
  - Material information
  - Product drawings
  - CAD geometry/models

- VR models:
  - Product as an animated VR object, either on its own, or integrated within its future working environment/assembly
  - Realistic rendering of the finished VR prototype

Any partner who fabricates, assembles, tests, and/or procures components for the product, participates in the review of the product design and configuration. Making information flow quickly and accurately between all team members is a fundamental requirement to make the whole process go forward. Problems of delivering product information across the enterprise drive manufacturing costs way up. The agility to communicate product data and engineering changes instantly to employees, suppliers, and customers is critical in modern manufacturing industry.

3 Manufacturing responsiveness and the Internet

Modern manufacturing is based on an ever-increasing variety of processes, and the engineer's challenge is to select the most economic combination of processes to make a product with high quality at the right price. This has led to the need for engineering the transition of the product from design specifications to manufacture of a physical product. A simplified view of the manufacturing system can be described as in Figure 8 (Toussaint and Cheng [17]):

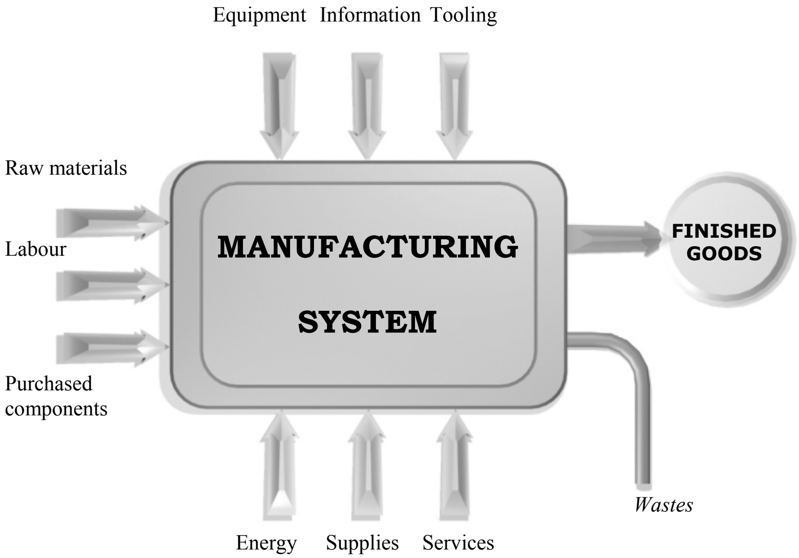


Figure 8: The simplified layout of manufacturing processes.

The scope of manufacturing engineering includes many activities and responsibilities that depend on the type of production operations accomplished by a particular company. Usually, these activities are namely: Process planning, Problem solving and improvement, and Design for manufacturability.

(1) Process planning

Process planning is typically the task of determining the most appropriate manufacturing process in order to manufacture a given part or product specified by the design engineering. This task is usually performed by manufacturing engineers who are knowledgeable in the particular processes used in the factory and able to read engineering drawings. Thus the details to be considered and the decisions to be taken during process planning can be listed as follows:

- Processes and sequence (processing steps on the work unit)
- Equipment selection (use existing or purchase new one)
- Tools, dies, moulds, fixtures, and gauges (needed tooling for each process)
- Cutting tools and cutting conditions for machining operations (machining parameters)
- Methods (methods for manual operations and manual portions of machine cycles)
- Work standards (work measurement techniques)
- Estimating production costs (usually thanks to cost estimators)
- Material handling (moving material and work in progress in the factory)
- Plant layout and facilities design

The first requirement for the manufacturing engineer is to know about the material the product has to be manufactured with. This information is usually provided by the product designer and will have a direct impact on, and thus reduce the choice for, the manufacturing processes. Determining the most appropriate processes and the order in which they must be accomplished relies on the skills, experience and judgment of the process planner. If necessary, this person or this team will also have to prepare the assembly instructions that must be followed, either for low production on individual workstations or for high volumes on production lines. Another task for the process planner is to decide whether a given part should be manufactured internally or outsourced and purchased from an outside vendor. Rembold *et al.* [18] provided a graphical representation of the principal supervisory activities as illustrated in Figure 9.

The tasks involved by the process planning activity are various and very critical for correctly and cheaply producing quality products. This requires highly qualified and skilled staff to look after these tasks, and this has recently been modernised with the integration of CAPP (computer-aided process planning) tools.

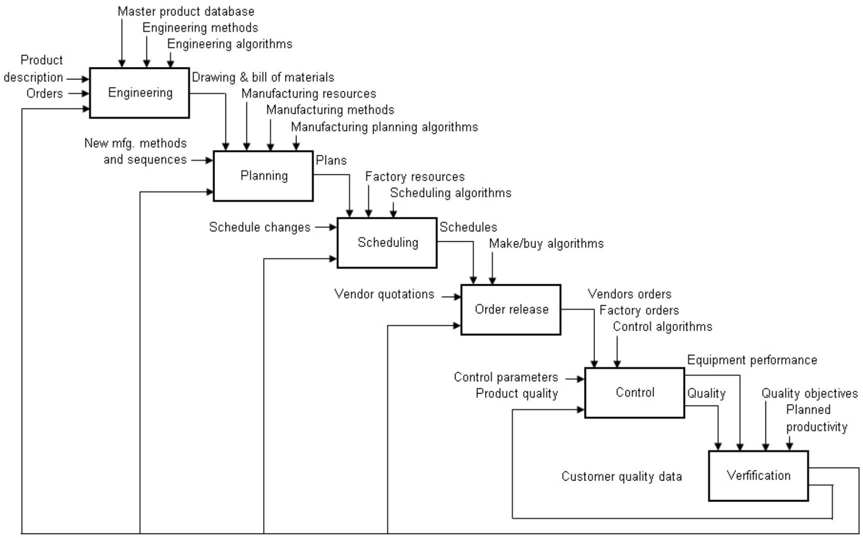


Figure 9: Principal supervisory activities in manufacturing.

(2) Problem solving and improvement
The second task manufacturing engineers have to get involved with is problem solving and continuous improvement. There will always be a need for technical support, because problems will always arise in manufacturing due to the complexity of the parts to be machined, the parts' tolerances, the parts' materials, and the machining conditions. If the problem occurring creates the need for changing the original design, the manufacturing engineers will often have to re-design a solution that matches the manufacturing requirements. This new design will then be submitted and proposed to the design team for re-engineering. Manufacturing engineers are also responsible for analysing changeover procedures and finding ways of reducing the time necessary to perform them. Finally, in addition to solving occurring problems, manufacturing engineers have to continuously search for methods, modifications, and alternatives to manufacture the product faster, with a better quality and for a lower cost.

(3) Design for manufacturability
As accurately explained by Ettlie and Stoll [19], manufacturing engineers have to work closely with the design engineers in order to design in a way that leads to a product inherently easy to manufacture and support. This can be achieved through a two-way communication model between the manufacturing and design teams, which will accelerate the rate of product knowledge growth. In the long run, this will lead to better guiding and evaluating of the product and process design decisions. As Figure 10 illustrates, the results of using such a cross-

functional team approach will shorten time-to-market and provide a higher product quality at lower costs.

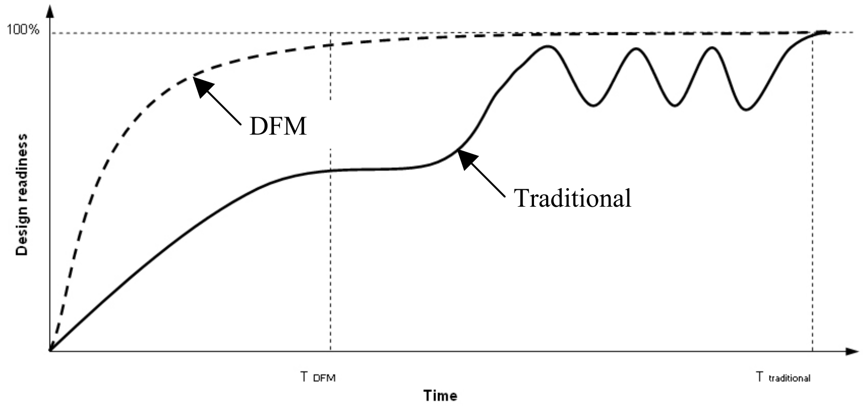


Figure 10: Time history of the design process.

The above Figure 10 shows that compared with traditional design, the integration of DFM (Design for Manufacture) effectively speeds up the design cycle. It also serves to avoid the oscillations due to manufacturability and assembly difficulties that occur at the end of the traditional design cycle. Therefore it is important for the manufacturing engineer to act as an advisor to the design engineer in matters of manufacturability. While presenting in a general way the manufacturing process, there has been a large focus on supporting the activities in manufacturing, instead of providing an exhaustive list of all the existing manufacturing processes. Therefore, the emphasis has purposely been put on explaining the involvement of the manufacturing engineers within the manufacturing activity. Because their daily tasks mainly lie in organising, communicating, and data sharing, they are very likely to take great advantage of using enhanced communication tools provided via the Internet.

It is clear that the manufacturing engineers have a deep knowledge of all the previous issues, which is probably not the same case for the design team. Therefore, being able to share on a real-time basis all the information of a product – design and manufacturing data – would improve the feedback between the two departments, and so improve the overall process responsiveness. It has previously been demonstrated how manufacturing responsiveness could be applied to linking the design and the manufacturing departments. There is also an enormous potential in increasingly using the Internet with 3D technologies for enabling the manufacturing departments to become more responsive by allowing multimedia-rich collaboration. In addition to providing a powerful communication and collaboration medium, the Internet could also be used for information sharing and reuse in a very intelligent way. This could be achieved through the implementation of networked database systems in order to ensure real-time access to the enormous amount of information generated daily by the manufacturing activity. In relation to the manufacturing engineering's activities, multimedia and Web technologies could therefore allow one to:

- Virtually test and evaluate manufacturing processes/operations from remote locations. This provides cost-free testing on an infinite number of iterations.
- Create easily accessible and well-designed dedicated management applications of their standard processes. This would enable a much faster and smarter data access for modifications in case of changes from the demand. This would also shorten the preparation/planning times of manufacturing processes.
- Partially/entirely replace paper-based product specifications with electronic versions for better archiving.
- Partially/entirely replace paper-based assembly instructions with electronic versions for easier training and/or maintenance. These electronic versions could feature 3D visualisations and animations in great quantities. This offers great advantage in managing the assembly instructions, their update, their replacement, or their deletion.
- Access manufacturing parameters and conditions on-line by designers and suppliers to ensure product quality.
- Perform more effective costs enquiries via networked applications with the rest of the enterprise and the suppliers.

The above list itemises the straightforward advantages of implementing Internet solutions at the shop-floor level. However, the most profitable use of the Internet within the manufacturing department would be to easily create intelligent systems for handling manufacturing data. These intelligent systems could concern process selection, tooling selection, material selection, machining condition selection, and so on. They could easily be made available to most of the staff within the department, thus helping in generating enormous knowledge databases, while empowering employees. Intelligent web-based systems could then be written and implemented, so this knowledge could be updated, completed and reused by remote access. From De Meyer's [20] "view of manufacturing", it is possible to extrapolate by saying that manufacturing responsiveness requires an organisation with production managers who are empowered production entrepreneurs. They are attracted enough by the company's manufacturing vision to orientate their experiments in a similar direction, and to quickly share the results with the rest of the organisation. The manufacturing staff's role in such an organisation is no longer the learning and development of new manufacturing processes off-line. Instead, it must stimulate production entrepreneurs to carry out on-line experiments, provide support to increase the value of the experimentation, and facilitate the diffusion of the knowledge throughout the company.

4 CBR and web-based computational intelligence

Today's powerful technologies enable the user to track, to retrieve and to analyse information coming from industrial equipments and machines for further reuse, but this does not usually include the technical knowledge acquired by people. Accordingly, it has therefore been decided to design a system to try to capture, to store and to organise people's technical knowledge via a Web-enabled interface. The system is based on tooling data for turning operations and aims to provide a responsive solution for helping in decision-making when choosing a tooling configuration. The use of the WWW as a vehicle for this application is supported by the need for accessing this type of information from geographically dispersed locations, by different types of people, all having various inputs into the system.

After having conducted a comprehensive literature survey among different knowledge-based techniques, it was decided to use the Case-Based Reasoning (CBR) approach. Case-Based Reasoning is a general paradigm for problem solving based on the recall and reuse of specific experiences as explained by De Silva Garza & Maher [21]. CBR is also a practical approach to incremental, sustained learning, since a new experience is retained each time when a problem has been solved. Because one of the main aspects underlying CBR theory is learning from experience, it requires a well worked out set of methods in order to extract relevant knowledge from the experience, to integrate a case into an existing knowledge structure, and to index the case for later matching with similar cases.

In general, the key issues to formulate the CBR theory include:

- Situation assessment/retrieval
- Case application and evaluation
- Case adaptation
- Storage

Aamodt & Plaza [22] have described a framework for CBR methods and systems which is illustrated in Figure 11.

A new case is defined with one or more parameters at the beginning of the cycle. Some elements from this newly created case are used to RETRIEVE similar cases previously recorded. The new case and the retrieved one(s) is/are combined together in the REUSE sector which results in a solved problem or case. Then the REVISE part of the graph enables one to confirm the found/generated solution, and the new combined case can be stored in the database through the RETAIN process. The cycle shown in Figure 11 describes each step of a CBR application, which has to be implemented in order to create/develop intelligent decision-making systems.

In the past, most of the CBR applications have been developed as standalone desktop applications with a connection to a standalone local or networked database. This trend is starting to change, as there are more and more web-based applications, mainly due to the wide availability of the Internet. CBR has been extensively applied in various fields including: Design, Testing, Sales, Software modelling, Medicine, and Law, but there have been rare applications of this technology in the e-manufacturing area. Thus, as manufacturers are working towards mass customisation driven by growing customers' expectations for feature-rich products, their processes will tend to change more often with only very slight modifications. This means that being able to become agile in reusing previous presets or configurations for similar processes could be a non-negligible asset.

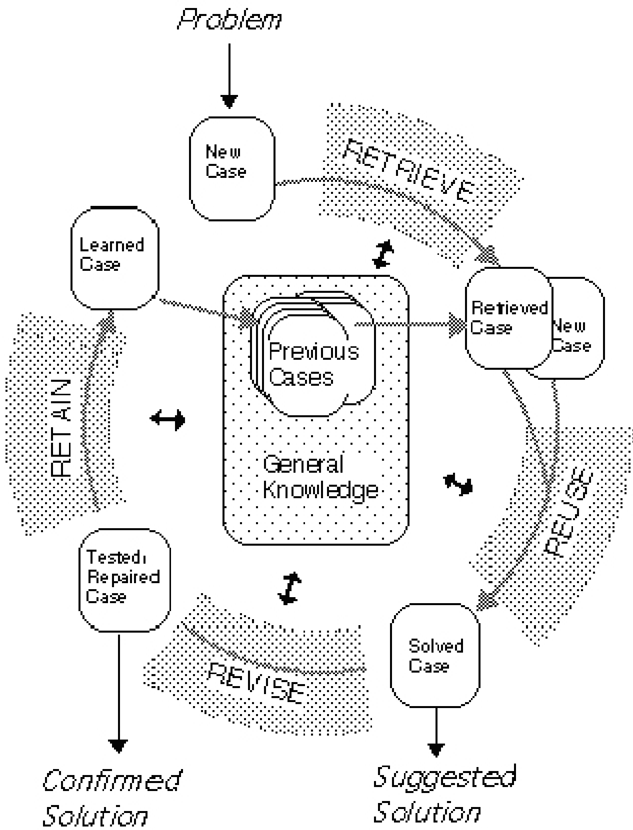


Figure 11: A typical case-based reasoning (CBR) cycle.

Based on the author's own experience in manufacturing as well as aiming to use a well-known process, it has been decided to develop the decision-making system for tooling selection. The approach for designing the system has been based on some considerations for its future usage. One of the main driving criteria was that the system should be equally accessible and understandable by several types of users, ranging from shop-floor workers to design, manufacturing and sales engineers, perhaps even customers. Another concept was that the system should offer two basic options, such as either performing a thorough search using AI, or a simple search for a reference as in the original electronic catalogue. Also, in the eventuality of having such a system implemented in a professional working environment, the application should provide some sort of security in terms of user access. Finally, the author decided that in order to avoid web-based application redundancy or “cloning”, the language aspect of the web-based application should be taken into account, and therefore integrated as an important factor in the final system. Based on the above considerations, an architecture for the application has been designed as in Figure 12.

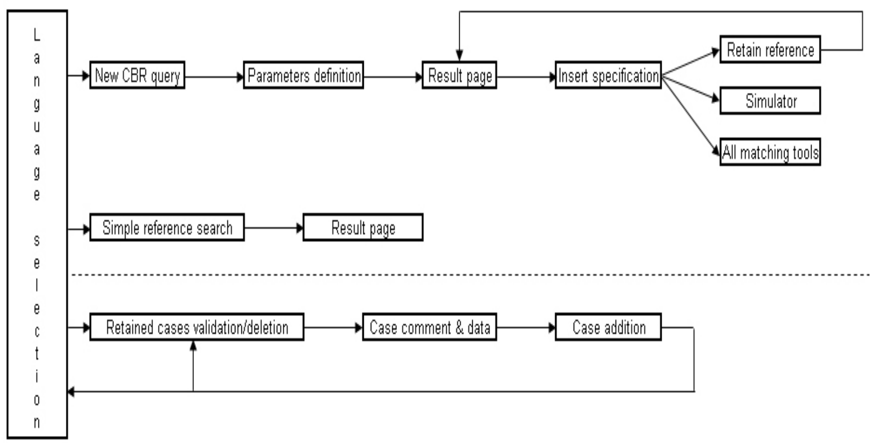


Figure 12: A proposed system architecture.

The two loops above the dotted line represent the two options of the system, such as a CBR search and a catalogue search respectively. The third loop is dynamically integrated to the system, according to the CBR loop’s outcome. This is through the main loop of the web-based application that the user performs a search on a tooling configuration for a given problem. After a successful login, a session is opened on the server and bound to the application, and lasts until the client’s web browser is closed. As a session can only be created from the login page, this will prevent users trying to access any page of the system by providing the correct URL. So after having selected a language to browse the web-application with, the user is presented a first page allowing him/her to perform either a CBR search or a simple catalogue search as depicted in Figure 13.

Having chosen the CBR search option, the user is directed to the initial step in which two search parameters have to be provided. In order to demonstrate the principle of such an application, only two entry parameters are requested this example, but this could easily be extended to any number or type of entry parameter.

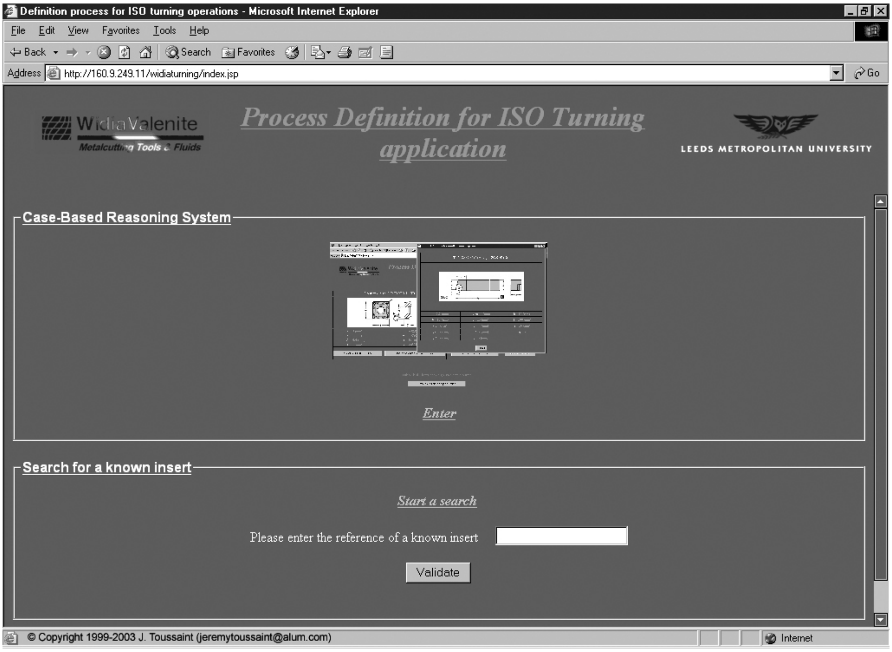


Figure 13: A CBR-based tooling catalogue selection system page.

The first parameter to provide is the type of turning operation, which can either be for internal or external turning. The user can either make a selection from a pull-down menu list, or use the graphical selection via two extra pages. The second parameter to provide is the material type. Again, as almost any type of user is supposed to be able to utilise this system, the material type definition is done by classification selection. This way any material should belong to one of the proposed standard classes. Figure 14 features the main page for parameters' entry, as well as the annexe pages at the end of each dotted line.

Once the user has made a valid selection for both parameters and submitted the request, the system loads in a result page. Behind the scenes several database queries are executed in order to retrieve two lists of insert reference: the exhaustive list and the CBR list. The exhaustive list consists of a scan of the entire datasource in order to retrieve all the insert references that match the two entry parameters provided. The CBR list only exists if some previous cases have already been added, matching again the two entry parameters provided. The user has then the choice to either pick a reference which has been validated in the past (case REUSE), or to opt for another reference in the exhaustive list. This result page is presented as in Figure 15, with the exhaustive list on the left side and the CBR one on the right side.

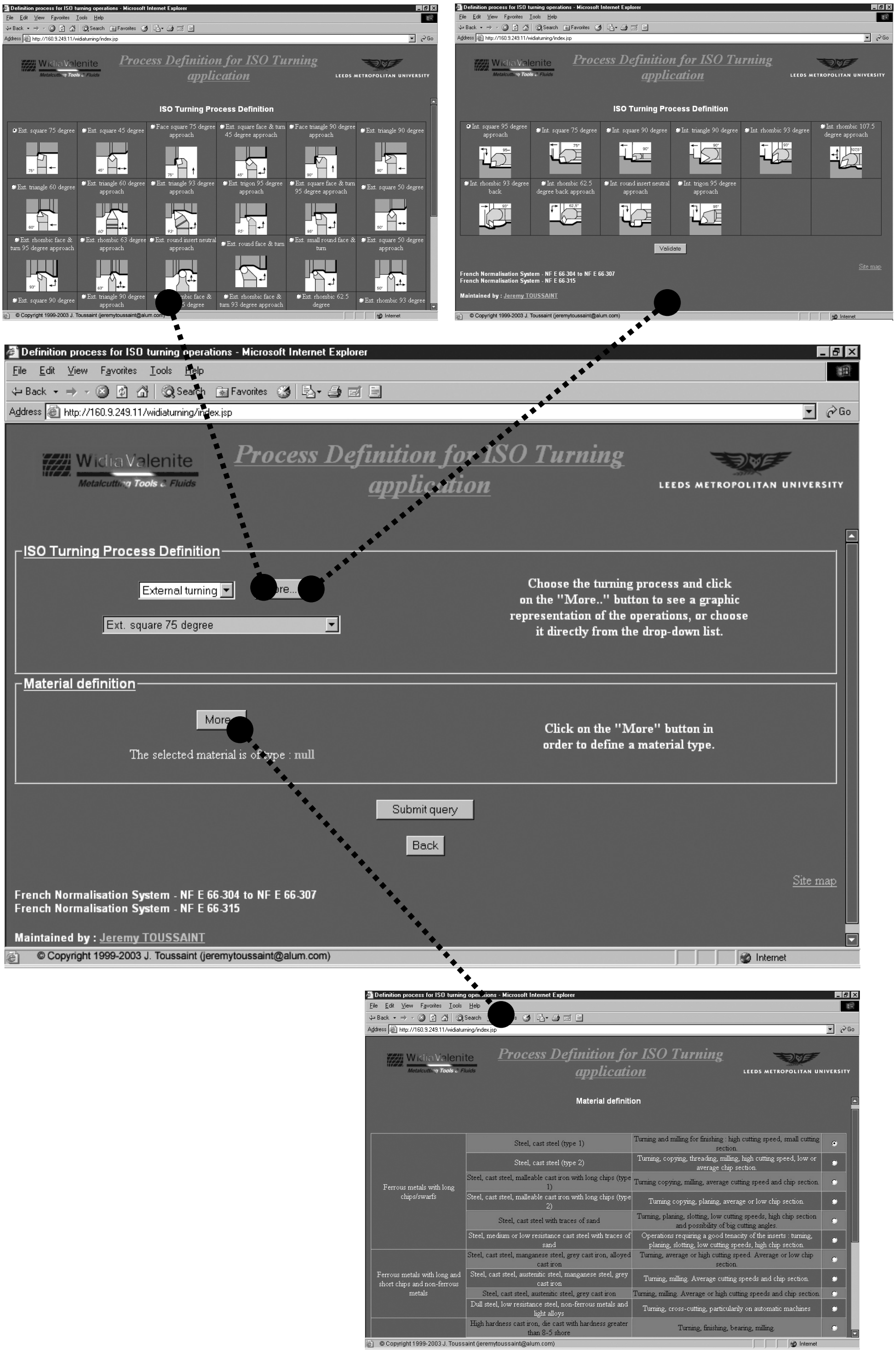


Figure 14: Parameters' entry and annexe pages.

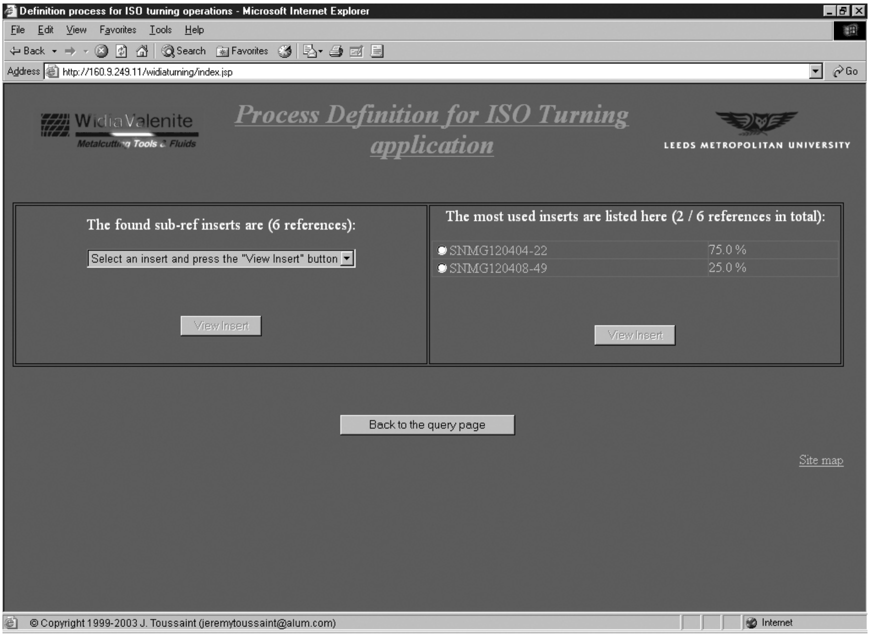


Figure 15: Result page.

As illustrated in Figure 16 (screenshot), after having chosen a reference from one of the two previous lists, the user now has access to various types of data about the insert. A 2D schematic drawing is presented as well as the dimensions of the insert. The page also features the tools matching the entry parameters and able to hold the insert. Finally, if the reference belongs to the CBR list, then comments from previous users will be accessible. For further clarification, more information is accessible through different windows, which contain (starting clockwise in the screenshot):

- 2D matching tool definition and dimensions
- fully-interactive turning simulator (to be further described)
- exhaustive list of matching tooling with the selected insert
- a 3D representation of the tool holder selected

Being now aware of the type of insert that can perform a machine operation based on the two entry parameters provided, the user can now retain the insert for further testing. Having recognised that in a working environment, a user would not leave the web-based system on for testing the insert in deciding whether or not to create a new case, a more suitable process has been considered.

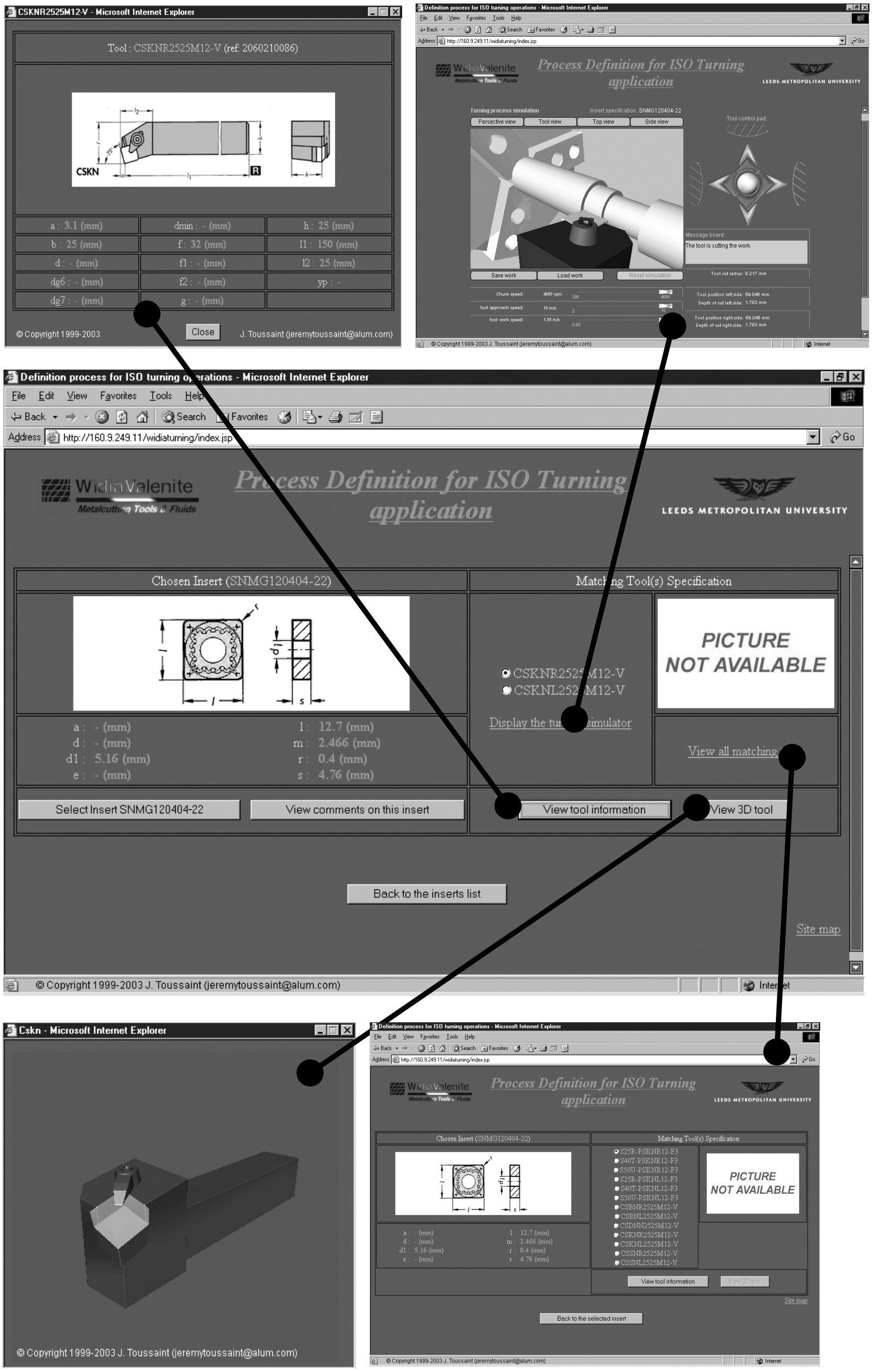


Figure 16: A tooling insert's related information page.

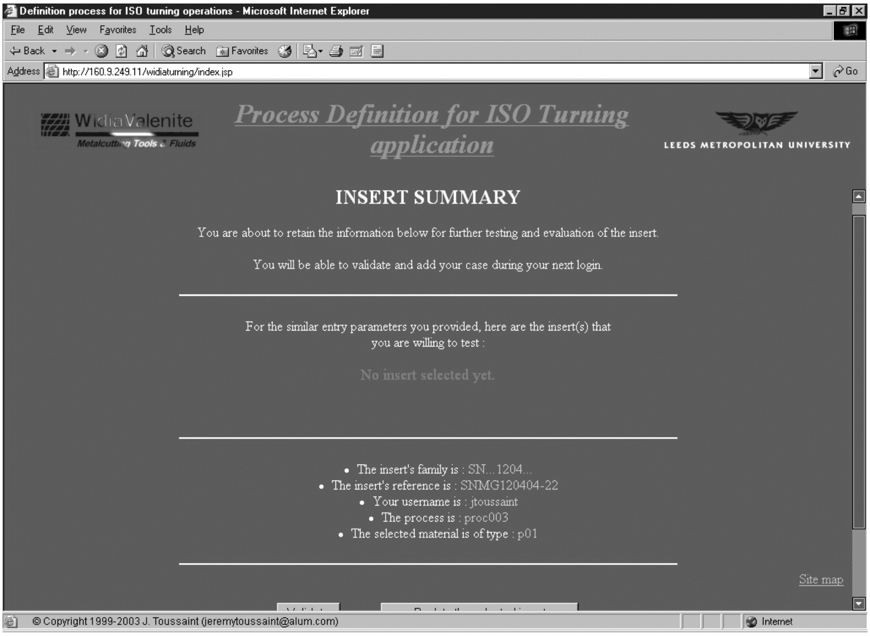


Figure 17: A tooling insert selection page.

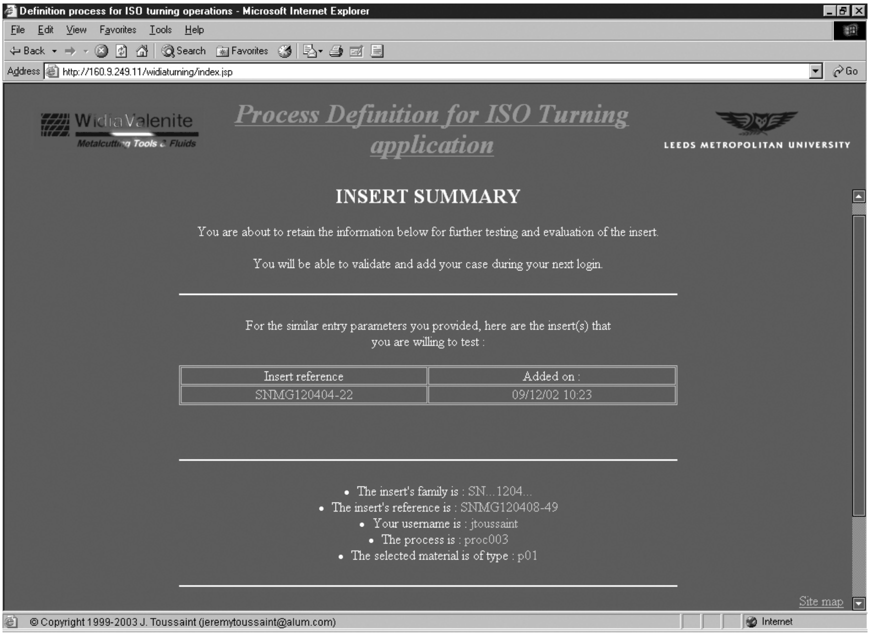
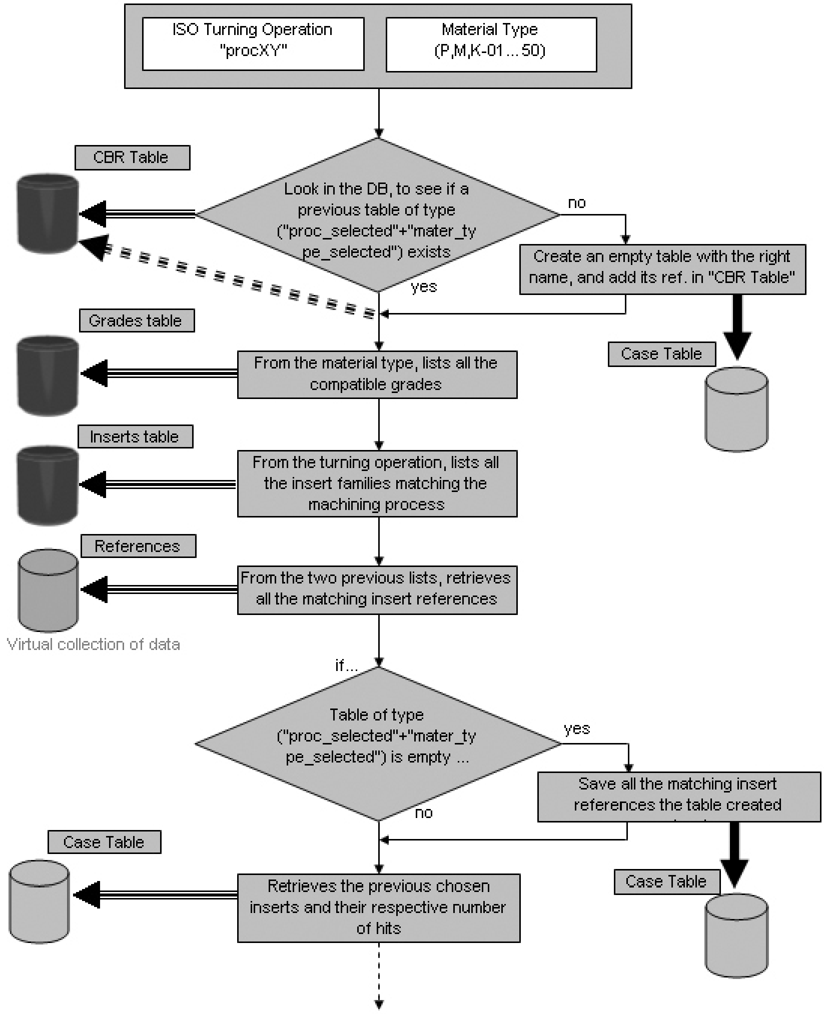


Figure 18: The selection page with previously retained reference.

Inspired from e-commerce web applications, it has been decided to create a "cart" of chosen inserts for future validation or deletion. This sensible approach enables the user to select an insert for testing and process to the validation during a future login. The selection page also summarising the chosen insert is illustrated in Figure 17.

After validating the selection, the user is redirected back to the page displaying the two lists of inserts matching the entry parameters. This enables further investigation on the proposed references, and maybe other inserts selection for further testing. In this case, when reaching the same selection step, the user would be given information on the selection made previously, as shown in Figure 18.



(Figure 19 continued on next page)

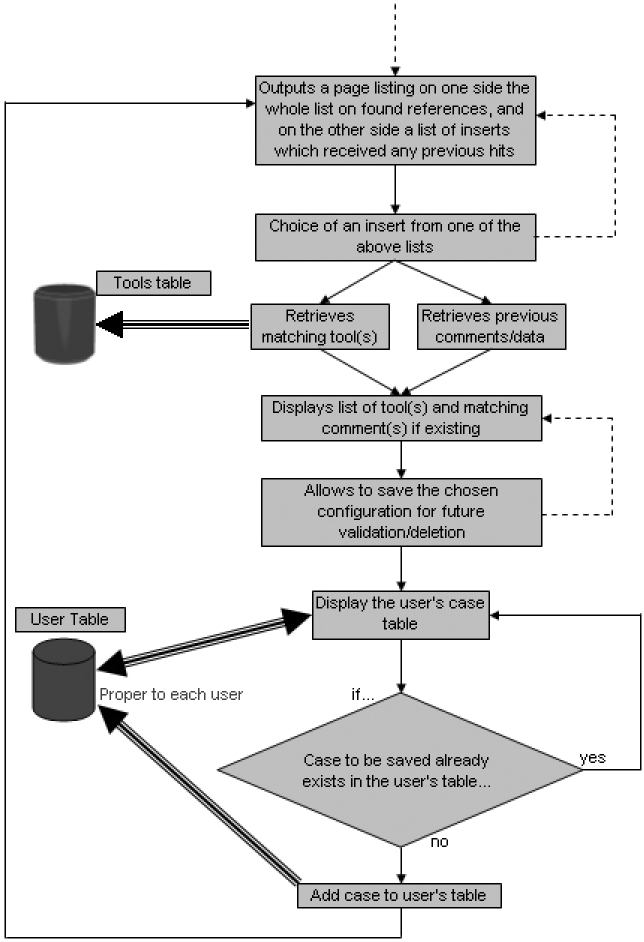


Figure 19: The flow chart of the tooling insert selection process.

At this point the user is supposed to have successfully found insert references and matching tooling information for the entry parameters provided. The user has been given the choice to either make a selection from the entire vendor's list or from a possible CBR list created dynamically by the system usage. In any case, the "tooling cart" now contains references to be tested, so that the user will be able to access for validation or deletion during the next system access, as further explained in the next section. A summary of the process starting at the original parameters' entry to the insert selection is presented as in Figure 19.

During the connection, the system will enable the user to access the insert reference(s) retained previously. The initial page has had a new accessible menu created dynamically as shown in Figure 20.

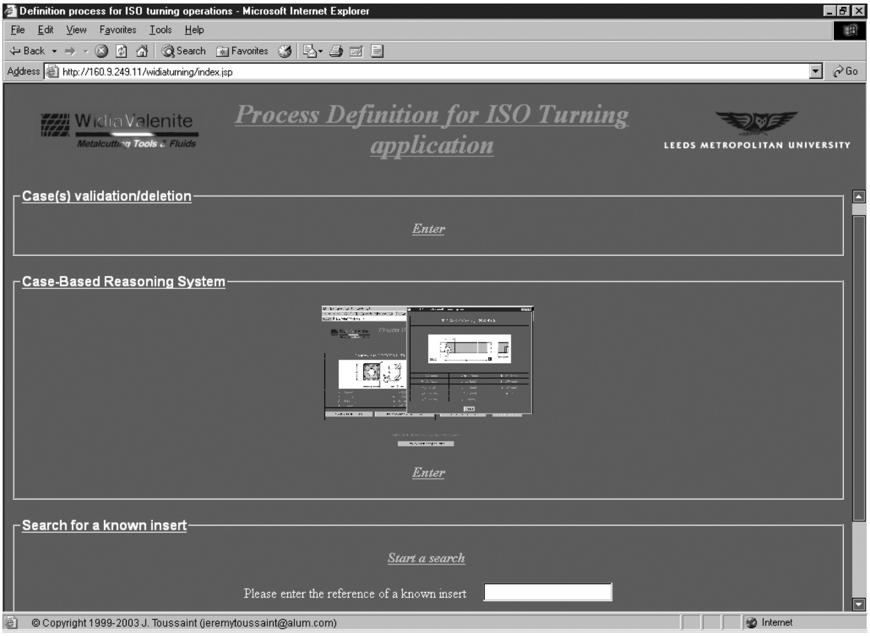


Figure 20: Initial page featuring new menu.

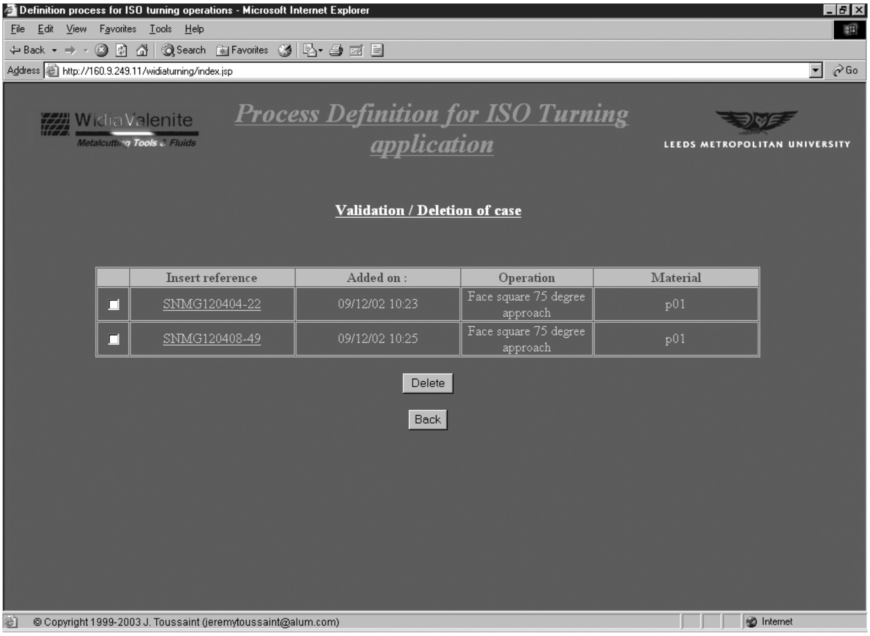


Figure 21: A summary of previously selected references.

Entering the case validation/deletion loop, the user is presented with all the inserts previously selected. All the references have been sorted in a table, reminding the user of the time and date of selection, as well as the process and material type the query was submitted with. This can be depicted as in Figure 21.

The user now faces two choices: either to delete a reference as it is not suitable with the machining operation performed, or to validate the case. This latter option enables the user to share the successful use of the selected reference by adding a case to the general datasource. At this point, many scenarios could have been possible, depending on what type of information has to be provided by the user for adding a case. For demonstration purposes, the author designed the system for saving a comment on the machining operations, as well as three machining parameters: the tool feed rate, the work speed, and the average depth of cut respectively. An example of this page is shown in Figure 22.

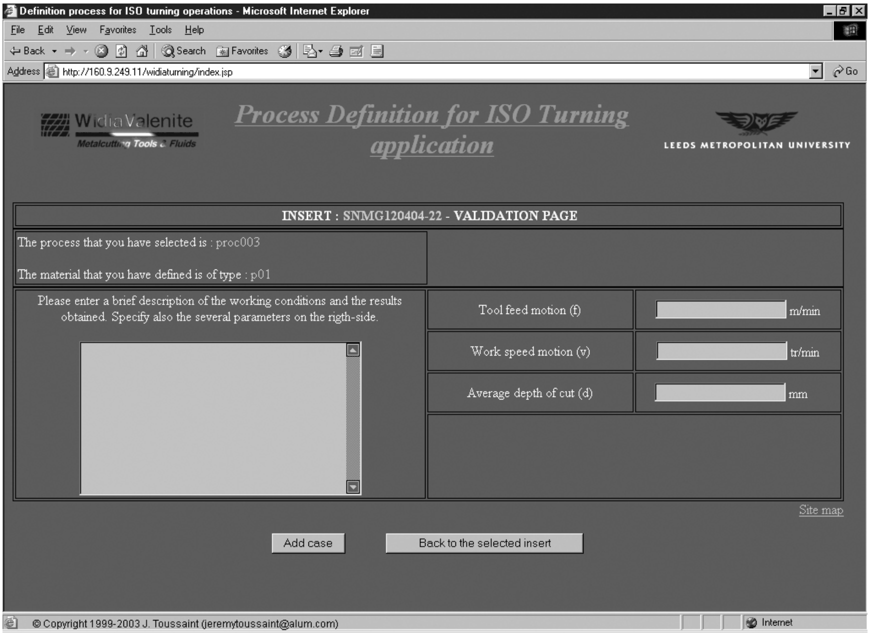


Figure 22: Input page for a case validation.

Providing that the user has filled in correctly all the required fields, a summary of the case to be added is displayed prior to the validation. This is the last step of the entire CBR process, adding the case to the general knowledge. The way the web-application has been designed enables it to retrieve, to reuse, to revise and to retain cases in a very agile and responsive manner. A summary of the validation/deletion process can be depicted as in Figure 23.

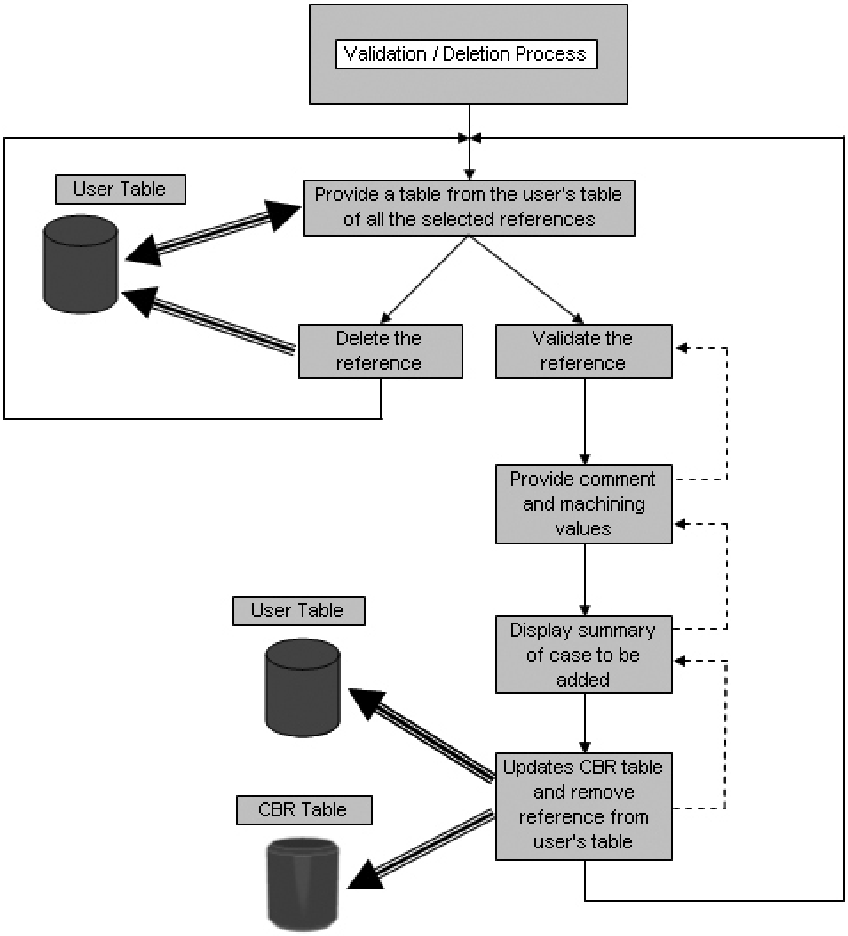


Figure 23: The validation/deletion process.

The application presented above provides a fully working example of implementing web-based CBR intelligent system for manufacturing purposes. This example shows that through the use of low cost and open-source web-based technologies, it is possible to implement or to enhance technical knowledge capture and management. The approach has focused on a manufacturing example, but similar developments using an adapted model could be used for other activities within the company. Environment-oriented or activity-oriented applications offer a natural and realistic transition from the decades of investment in monolithic, closed and rigid business applications to the now-essential flexibility of modular, standard and accessible software services. The cumulative effect of these web-applications is the gradual transformation of ICT from an undifferentiated tool for the opaque enterprise to an adapted tool serving, in a targeted way, a user taking a specific role (for example, a decision maker, operator, researcher, user, customer or consultant).

5 Conclusions

Industrial companies have been generating technical data for many years in order to respond to the ever growing market demand. The processes used in creating these products are in some cases still in use, and in other cases have been replaced or updated. The labour force has also been changed and its knowledge has been passed from generation to generation. Nowadays, in the early years of the twenty-first century, the use of IT has revolutionised the world of communication we live in, by providing real-time connection between communities via the use of the Internet. This chapter attempts to demonstrate that Internet and Communication Technologies should not only be used for communicating, as they could also enable the knowledge management of manufacturing companies. Efficiently managing the immense amount of information generated by organisations via their local Intranets or the internet would enable them to work faster and smarter by being able to intelligently reuse knowledge that has been created in the past. The chapter offers a comprehensive review of the potential of using Internet technologies within the design and manufacturing activities respectively, and concludes with the demonstration of a system prototype for the intelligent selection of tooling configurations. In the same way, a similar approach could be applied to other engineering areas, as well as other enterprise's activities in order to store, retrieve and reuse companies' intellectual capital.

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