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THE CREATION OF A KNOWLEDGE SHARING CULTURE FOR EFFECTIVE KNOWLEDGE MANAGEMENT

J. Hallam, B. Hodges, K. Tabeshfar and X. Velay

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1. Introduction

This paper is based on research carried out as part of a workpackage concerned with change management in the 'Experts Enablers in the Machine Engineering Domain (XPERTS)' project. XPERTS is part of the Information Societies Technology (IST) programme sponsored by the European Commission.
This workpackage seeks to solve problems of machinery and engineering companies in the knowledge management (KM) domain by:

i) providing means to capture and store the collective knowledge and experience of designers;
ii) providing means for its management; and
iii) the determination of agreed company standards and procedures for design.

By making available the expertise of senior designers to junior designers, XPERTS aims to shorten the learning process for the latter. Product quality will also be improved by the application of consistent standards and best practices in product design. New - and potentially more effective - ways of organising work, such as distributed teamworking and homeworking, should also be made possible.

2. Retaining the expertise of the expert designer

From a recent survey of over 150 designers [Hodges 2001], it was shown that during the 1990's many older engineers were made redundant resulting in a loss of knowledge and experience. It also showed that the average length of time that designers aged up to 40 years stayed in one company was 3.5 years. This could be attributed to the movement of younger engineers from company to company gaining experience, better working conditions, and salaries.
XPERTS could play a significant part in retaining these young engineers since it could provide greater job satisfaction by i) shortening the learning process and progressing them onto more complex projects; and ii) through the use of new technology enhancing job satisfaction and promotional prospects.
Most junior design designers become initially involved with the detail design process - production of final assembly drawings and manufacturing drawings which detail dimensions and specifications necessary to make the design. This includes defining the part geometry, choice of materials, tolerances, surface finishes, heat treatments, Bill of Materials - and details regarding the manufacturing techniques to be employed such as forging, sand casting, machining, fabrication.

3. System architecture

The system architecture is shown in Figure 1 and comprises of five main components for the management of the design knowledge, two components are used for knowledge gathering and formalisation (KBE and CYGMA). The other three are software related, for the management of design knowledge and its sharing and exploitation (PDM, IDEFO and Microsoft ASP).

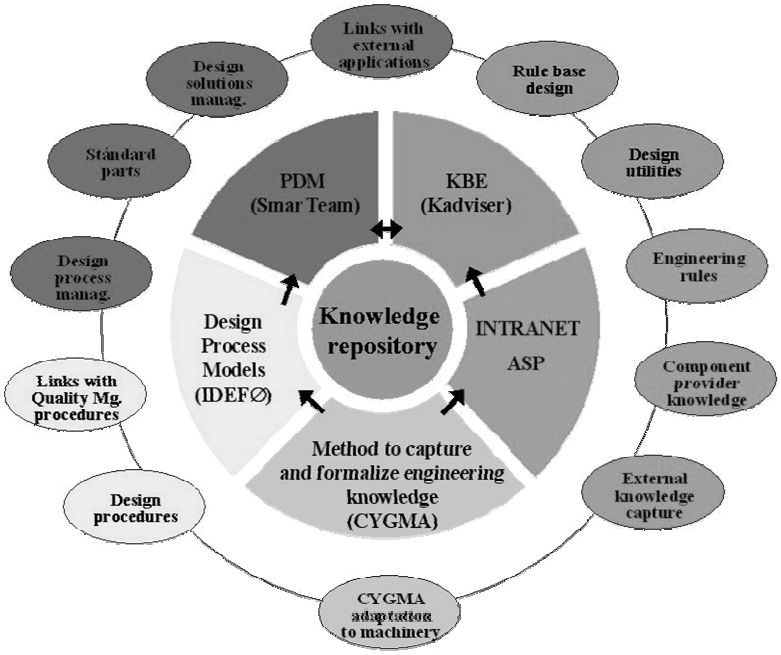

Figure 1. Architecture of the system

KBE provides the software environment in which a skilled knowledge engineer creates Knowledge Based applications, which are then used by the designers. Kadviser provides the KBE software and tools for generating knowledge based 3D geometry of the design.

CYGMA methodology is used for the gathering of knowledge that is commonly required to efficiently undertake routine activities in the design process, this knowledge would include design rules, tasks and vocabulary. The outcome of this knowledge acquisition are 'knowledge books' that contain descriptions of design processes and rules etc, compiled by experienced designers and knowledge engineers.

IDEFO are diagrams or 'knowledge sheets' that describe design processes and associated rules. They provide graphical communication for the designer to identify what functions are performed and what is needed to perform those functions.

PDM is used to control and maintain all shared data, the system keeps track of the volumes of data and information required by design, production, manufacture and others services. The electronic vault used as a repository is a data store that contains some data within itself and controls other externally generated data by managing access to it. Functions include data vault and file management, classification of objects: entities, attributes and constraints on values, documentation of all steps/activities of the design process.

ASP for document and content management on intranet. This system manages information about design processes, rules, standards, catalogues etc. This has been developed for the designer to access and search rapidly information, either within the company or in a distant location. For more details on the system architecture see Bueno et al [Bueno 2002].

The use of these tools makes the complex work of spindle design easier and quicker for the junior designer, as the system holds, and manages information relating to the design process, design rules to be adhered to (based on previous knowledge and experience), European standards i.e the ISO-STEP (10303) geometry standards for the design of mechanical components, standards for quality management, and manufacturers/suppliers information via catalogues or the Internet.

4. Social issues in the introduction and use of XPERTS

The introduction of XPERTS - the technical system - into the design task, though, may cause unease among the people - the social system - who will be expected to use it and incorporate it into their ways of working. Their unease, and thereafter their resistance to its introduction, will be reflected in a range of potential barriers - social barriers. Whilst XPERTS may potentially improve the efficiency and effectiveness of many aspects of the design function, the existence of social barriers - and the failure to overcome them - will render it unacceptable to the potential user.

Introducing XPERTS into the design department would be expected to cause changes to the jobs of individual designers. They may be unwilling to cooperate if they think that the new system will affect their jobs in a negative manner. They may, for example, fear:

- losing their job - designers might think that they would no longer be needed by the organisation after they have given their expertise to the system;
- deskilling - although XPERTS might be welcomed as a tool which could perform many routine, monotonous tasks, there still remains a potential barrier from the perception that jobs could possibly become deskilled. In detailed design, the system would be employing heuristics learned from skilled designers, who may be concerned over a loss of control - that they do not need the same level of knowledge and skills required previously to do their job; and
- unreliability in the system - designers may think that it is impossible to capture expertise in a way that can be used effectively by others. Similarly, if the system produces unsatisfactory answers, it will no longer be trusted.

Also, designers usually work in teams and design decisions are often a result of collaboration between several team members. They may think that the introduction of XPERTS into such an environment may adversely affect the nature of that interaction and the quality of decisions reached - as well as harming their social interaction. Again, people may be unwilling to cooperate in its development if they are concerned about how XPERTS will change their working arrangements.

5. Removing barriers through communication

Such barriers may make XPERTS unacceptable to users and they will resist its introduction. They may not wish to share their knowledge and without this the aims of XPERTS will be defeated. It is necessary that a culture is created where people - especially the experienced designers - are willing to share their expertise. This can only be done if these people are made aware of how they can benefit from using XPERTS. They need to trust the system.

To this end, measures must be taken to ensure that designers know that:

- their jobs are not in danger;
- XPERTS will enskill rather than deskill their jobs, for example, by taking over some of the more routine workload - freeing the designer to learn new skills. This should produce not only greater motivation for the designer but also a more skilled workforce which would enable the organisation to respond more effectively to new challenges; and
- the design process will be made more effective. The solutions given by the system to design problems, for example, should be optimum solutions based on both the rules and knowledge used being correct and updated as they evolve. Additionally, the design task will be performed faster with the aid of XPERTS.

Communication is of paramount importance. Managers wishing to introduce XPERTS will need to know what to tell the designers who will be expected to use the new system. This can be seen as training, not in the more conventional sense of learning how to use the system, but in a wider sense of learning why they should use the system, and what benefits they can expect from its use.

6. Training programme design

The XPERTS project has now reached the stage where testing has been started by the industrial end-users of the XPERTS consortium. The testing has been divided into four groups, regarding the different developments and modules to test. These comprise of:

- adapted CYGMA and IDEFO tests, in order to check the method to formalise the design knowledge,
- validating the PDM modules,
- ASP related tests to verify web server tests using the Intranet portal,
- and KBE tests, in order to assess the developments for the knowledge based generation of mechanical parts.

The prototype has been specifically designed for use within the machine tool sector - for the design of machine spindles. Major factors that affect these designs are: the power to be transmitted, the spindle speed, cutting forces (torque required), mechanical and thermal loading, and spindle dimensions. Within XPERTS, component calculation and definition programs have also been written to include drive systems, the design of slots, pulleys, couplings, bearing guideways, spindle and linear drive bearings, springs, and material selection. These programs or tools are the result of the collaboration of mechanical designers, component calculation experts and software developers, producing a set of tools adapted to the needs of the designer.

As people become increasingly familiar with the various facets of XPERTS, a clearer picture is emerging of how using XPERTS can benefit the design task. More data is being obtained as the testing and validation phase of the project proceeds. Additionally, interviews have been carried out with people directly involved in the test programme. A sample of those who will either manage or use XPERTS was interviewed in order to find out their thoughts on how XPERTS might affect the work of the designer - from the level of their individual job content through to ways in which the organisation of work might change.

From this and other data, it is becoming possible to envisage the content of training programmes which will communicate the benefits of XPERTS to designers. Training programmes are aimed at removing resistance to change by creating a culture where designers will be willing to share their knowledge. Telling them how this will advantage both themselves in terms of more rewarding work, and the organisation - in terms of using knowledge management to achieve their goals more effectively.

Examples are given below of early attempts at deciding upon training content. Two areas have been chosen: one to show the various aspects contributing to how the design process can be made faster by using XPERTS: the other to demonstrate how and why XPERTS can improve the reliability of the design process (Figures 2 and 3) Based on hierarchical task analysis, the overall goal of training is progressively broken down into its constituent (or subordinate) elements. Such a methodology enables identification of all those factors, which contribute to the benefits afforded by XPERTS. These are the factors which designers need to know about in order to appreciate what XPERTS offers them.

6.1 Speed up the design process

Some of the areas where XPERTS can speed up the design process are:

- Design calculations,
- Design alterations and changes,
- Using design rules to generate 3D geometry,
- Initial design stages.

An example of how XPERTS will speed up the calculations for determining the dimensions of the main machine spindle is shown in Figure 2. The first stage consists of analysing the customer specifications and producing the conceptual design of the machine tool, the third stage consists of defining in detail the main machine spindle dimensions: the components, the size, the positioning etc In order to achieve this, different parts of XPERTS are used: KBE and PDM contain rules, calculations and activities that must be adhered to in order to produce the desired outcome. It follows that all these calculations and rules are interrelated i.e. if one dimension is changed this would affect other subsequent component sizes and positioning. Also affecting these calculations are the incorporation of standard manufacturers parts i.e springs, bearings obtained from the ‘Designers Intranet’.

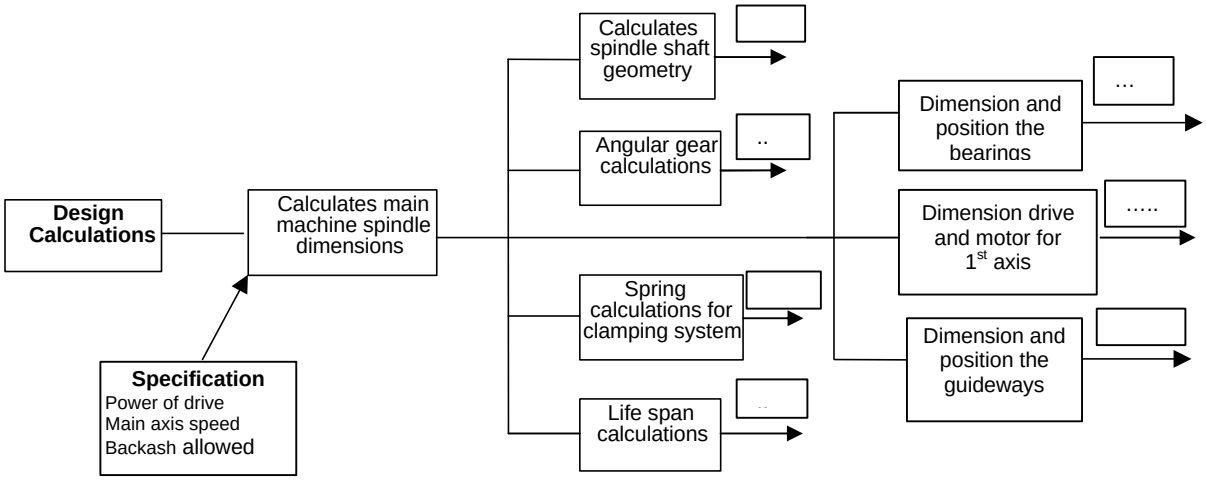

Figure 2. Design calculations

6.2 Improve the reliability of the design process

Similarly Figure 3 breaks down how XPERTS will obtain error free and reliable solutions using the rules, data and instructions/activities within the system.

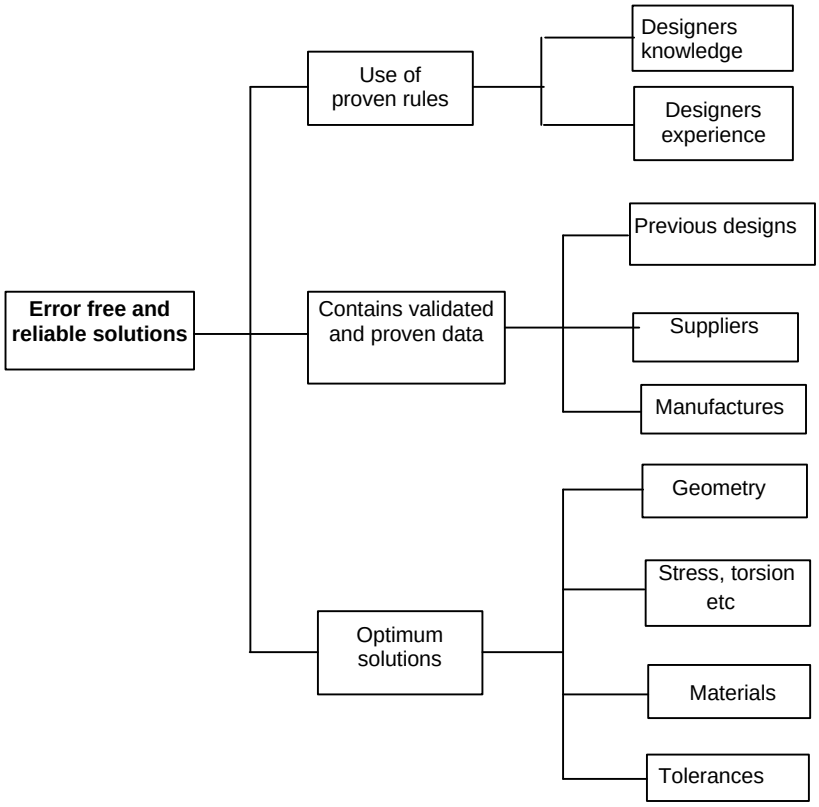

Figure 3. Reliability of the design process

7. Conclusion

It is not yet been decided how such content will be delivered to designers. Methods, though, will range from the provision of simple information packs to actual use of the prototype. With the latter, designers will be able to see what XPERTS can do for them, and they will be able to practice aspects of spindle design themselves.

This training is part of a wider people-centred approach to implementing XPERTS, which accepts that the participation and involvement of those affected is crucial to the management of change process. A key feature of such a sociotechnical systems approach to design is the involvement throughout the system development of those people who will use the new technology. The approach provides a mechanism for communication between the system designers and users, enabling the former to explain what is envisaged to the latter, and the latter to contribute to development. In this way, new methods of working can be designed so that, not only is the technology usable, but the users will accept it - and the changes it has made to their jobs.
Finally, for such training to work - so that the desired sharing culture can be created - there has to be an organisational culture which is sympathetic to the needs, aspirations and expectations of the people who work there. It is important that management interest, support and involvement is high throughout the development process. This will provide a suitable infrastructure for genuine user involvement in the management of change.

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J. Hallam, B. Hodges, K Tabeshfar and X. Velay
Bournemouth University, School of Design, Engineering and Computing
12 Christcurch Road, Bournemouth, Bh1 3NA, UK
Tel +44 1202 503750
Fax +44 1202 503751
Email: bhodges@bournemouth.ac.uk