HYBRID KNOWLEDGE AND PERFORMANCE SUPPORT SYSTEMS FOR PAPER MACHINE OPERATIONS

Ismo Laukkanen

Development Manager
UPM-Kymmene Corporation,
P.O.Box 380, FIN-00101 Helsinki, Finland
Ismo.Laukkanen@upm-kymmene.com

Abstract: This study focuses on the applications of web based performance and knowledge support systems in the paper industry. Two different systems – a generic KnowPap learning environment and a customized electronic performance support system (EPSS) were evaluated. The results indicate a very limited usability of generic systems for operational and knowledge support. The customized KnowFine system was found very useful to support the operations and maintenance. In future this kind of customized systems will be integrated to process control and information management systems. Optimally the lice-cycle of these systems follows the life-cycle of the plant.

Keywords: Knowledge based systems, Knowledge transfer, Decision support systems, Paper Industry, Process simulation.

1. INTRODUCTION

As a result of the increased level of automation, the content of the process operators' work has changed. Traditionally, the tasks of the operators have been directly related to process operation. The recent trend is to include simple maintenance tasks as well as tasks related to the process control and automation to the job. The level of education needed will be broader and higher.

In the modern paper machine line the importance of the operators' skills, knowledge and degree of motivation will make a difference in the profitability of production line.

1.1 Recent trends in the paper industry

The following trends have increased the importance of the knowledge and performance support in the paper industry:

- The speed of paper machines has increased. The design speed of a modern paper machine producing printing and writing papers has increased from 1,300 m/min to 2,000 m/min between 1990 – 2003. Meadows (1998 a,b) studied the challenges of increased speed of the paper machine for the stock preparation area and for the wet end process. Bennett (1992 a,b) focused on the effects of the increased speed of the machine for the press section and for the process control and automation of a paper machine. The increased speed increases the production losses in process problem situations, which emphasizes the importance of operational support especially in infrequent situations.

- The amount of data and information has increased. In the modern production line, there are normally the following process control and information management systems: process control-, machine control-, quality control-, web inspection-, process analysis-, condition and runnability monitoring systems. The quality control in paper machine has two dimensions – machine and cross directions, which increases the number of control points even further. The worst case for this development is data and information overload, which emphasizes the need for performance support.

- The level of automation has increased while the number of operating personnel has decreased. As a consequence, the frequency of process disturbances or problems per shift has decreased, so the operators are facing the problems very infrequently. The operational performance can be supported by providing the best practices knowledge related to the infrequent tasks.

- The optimisation of the efficiency of the paper machine process is another trend aiming for minimal tank volumes, simplified process flowsheet and piping networks. The operability of the simplified paper machine process in transient conditions is enhanced, because the dead-times, which currently cause problems for the process control, are minimised. The tanks and silos are feed buffers for the paper machine, but also filter flow, consistency and pressure fluctuations. In the simplified process, a more precise control of process dynamics in different situations is required.

- Ranta et al. (1992) studied the effects of information technology and automation on the flexible paper production. A general trend which they found out was that the number of paper grades in production has increased while the customer order sizes have decreased. More grade changes are needed and the minimisation of the grade change time is a critical factor in the productivity of the paper machine. The control of the process in transient situations is emphasised.

- Environmental goal of papermaking is the minimisation of paper mill effluents, which leads to minimal use of fresh water in the process. The reuse and circulation of white water can cause chemical problems in the wet end process. Precipitation and paper chemistry problems can also cause runnability problems. Flow and consistency disturbances can propagate through the integrated flow network and process stability can be difficult to achieve.

A modern closed-cycle paper machine process is not a set of subprocesses which interact loosely. Rather, it is an integrated process, in which the problems and disturbances are also integrated. Due to the complexity of the internal interactions in a paper mill, it is extremely difficult to predict the overall time dependent behaviour of the process.

The operation and runnability of the modern paper machine process is a result of the co-operaration of three major functions: production, automation and maintenance (Figure 1). This gives the framework for the system structures and the focus to the knowledge and information management. Depending on the target group and on the case some of these areas can be prioritized.

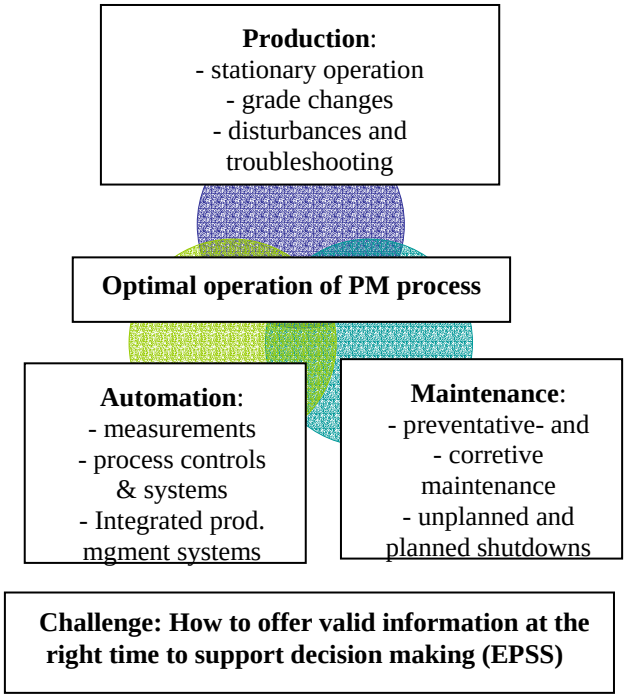

Fig. 1. The Electronic performance support systems (EPSS) supports the operational decision making including knowledge in the areas of production, automation and maintenance

These are some of new challenges which have increased the importance for knowledge and performance support in the paper industry and in the paper mills. This study focuses in the development and use of knowledge and performance support systems in a paper mill and as a part of paper machine rebuild project. The experiences of using that kind of tools are highlighted and discussed.

2. KNOWPAP LEARNING ENVIRONMENT FOR PAPERMAKING AND AUTOMATION

2.1 Electronic performance support systems (EPSS)

The concept of electronic performance support systems, was first introduced by Gloria Gery (1991). Her definition for EPSS was "an integrated electronic environment that is available to and easily accessible by each employee and is structured to provide immediate, individualized on-line access to the full range of information, software, guidance, advice and assistance, data, images, tools, and assessment and monitoring systems to permit job performance with minimal support and intervention by others." Some of the benefits of EPSS listed by her included:

1. reduction of the complexity or number of steps required to perform a task,

2. providing the performance information an employee needs to perform a task, or

3. providing a decision support system that enables an employee to identify the action that is appropriate for a particular set of conditions.

Recently EPSS has been active research area see e.g. Kasvi (2003). Kasvi emphasized the adaptive functionality of these systems in learning organizations for networking and collaboration or personnel. The fast development of multimedia, Internet and web technologies have increased the possibilities of these systems further.

2.1 Concept for the development

The starting point for the development of KnowPap system, was experiences of using full-scope dynamic simulator in a paper mill. The feedback was that for some users, it was too difficult too to use as such, because of rigorous model. The need for on-line support material related to process operation, equipment and process control was noticed see Laukkanen (2001).

On the basis of these results, a web-based multimedia learning environment, called KnowPap, was developed. KnowPap can be accessed though the Intranet by using a standard web browser (Internet explorer 4.0). The goal was to develop a web-based system with the latest knowledge of papermaking collected as multimedia material and combined with hybrid simulation models see Laukkanen et. al (1999) and Hämäläinen et al. (1999).

The target users for KnowPap were paper machine operators. The scope of the system covered the following areas: raw materials, paper technology, paper mill automation, paper and board products, quality properties, maintenance and operational environment. These areas are illustrated in Fig. 2.

Fig. 2. KnowPap learning environment provides generic information about the different areas of papermaking (Laukkanen et. al, 1999)

2.2 Structure of the system

To multimedia material linked to KnowPap platform is divided hierarchically into four levels: main user interface, subject, display and multimedia content levels as illustrated in Fig 3. The target was to provide fast access to the material for the user e.g. start with main user interface -> subject level -> display level -> multimedia material. In practice, however, the subject level consists of sublevels, causing browsing to be more complicated.

Technically the KnowPap is a common XHTML/Javascript based platform for the management of multimedia content. The platform has common templates for user interfaces, style and font definitions (CSS stylesheets), common Javascript functions, icons and it covers also some common functionality e.g. search, map and dictionary which are used throughout the system.

Fig. 3. The structure of KnowPap, web based learning environment The multimedia material is managed by KnowPap platform

2.3Results in the use of KnowPap

The usability of the KnowPap system for operator knowledge support was evaluated. Ten subjects volunteered for the usability test, which was carried out as a questionnaire study. All of the volunteers were students of an industrial institute, who within a year, would be working as paper machine operators. In this case, the KnowPap system was used as the primary tool for knowledge support related to papermaking. The test cases included real-life troubleshooting exercises and self-study.

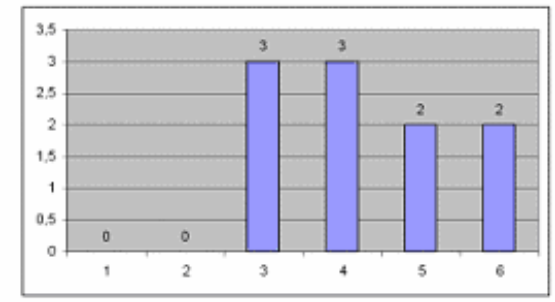

Fig. 4. Statement – Did you find KnowPap important tool for your knowledge support needs

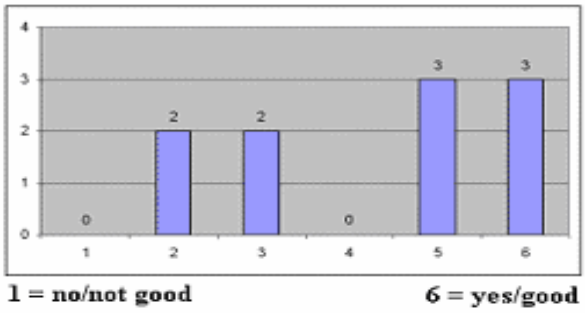

Fig. 5. Statement – Did you find easily the information you were looking for in the KnowPap?

The results clearly indicate deviation in the usability of the system. The following problems in the usability of the system were found in the interviews: some materials are too generic for knowledge support, the system is very large and complex to navigate, there is too much text material and not enough multimedia material for performance support e.g. in the key tasks.

These results were a starting point for customized knowledge and performance support development.

3 KNOWFINE - A HYBRID PERFORMANCE AND KNOWLEDGE SUPPORT SYSTEM FOR FINE PAPER MILL

3.1 Concept for the development

The system was developed during the paper machine rebuild project. The development was combined with the process and automation engineering. The system was used both before start-up in a classroom training and after start-up as an on-line support system.

3.2 Application areas forKnowFine EPSS system

The applications of EPSS system in the paper mill can be divided into following areas:

1. *On-line knowledge and performance support*
- database for information sharing between different control rooms
- support in troubleshooting situations
- sharing of best practices related to tasks (videos + multimedia materials)
- documentation of infrequent tasks

2. *Competence development*
- tool customized competence based personnel development
- sharing of critical knowledge
- customized training of own production line

3. *Other applications*
- orientation of new employees
- database for technical customer service

The different user levels with their different needs were taken into account in the design of EPSS system. For expert users, fast access to information needed and the flexibility are key factors. A net-type cross-linking of the subjects provides the possibility of switching directly from a subject, e.g. stock preparation, to a related display in automation or other subject area as illustrated in the Fig. 6

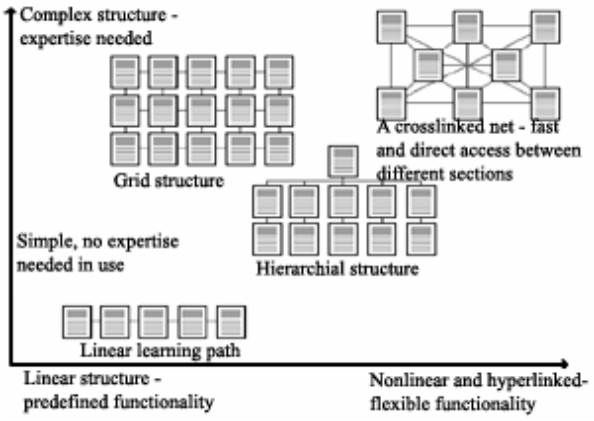

Fig. 6. The EPSS platform provides tools both for novice and expert users (Laukkanen, 2001)

For basic users, the predefined functionality and limited complexity are important. For them, the linear, predefined learning paths can be constructed by choosing just the materials which are needed in knowledge support, and linking them into a specific order. The paths can be implemented on different detail levels e.g. for non-technical employees, for operators or for experienced professional operators.

3.3 Results in the use of system in the fine paper mill

Customized EPSS system was developed during the paper machine project. The usability of the system for knowledge and performance support was verified as a questionnaire to 20 key operators of the production line.

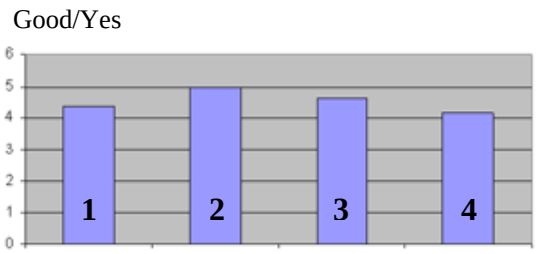

Fig. 7. The results from the EPSS usability test

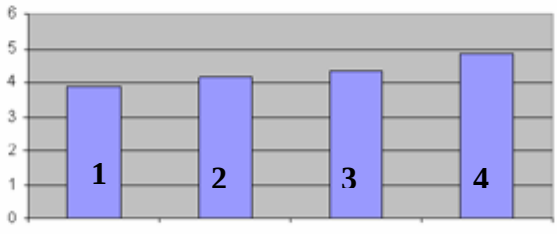

Fig. 8. The results from knowledge support features

4. DISCUSSION AND CONCLUSIONS

The preliminary results in the use of knowledge and performance support systems in paper industry are promising. The results indicate a significant trend, which is independent of the user group or the background of users.

The KnowPap web-based multimedia system is a good tool for initial or recruitment training purposes. The scope and detail of the system are however very limited for real knowledge and performance support especially when compared to the customized EPSS systems.

The customized KnowFine EPSS system is suitable for troubleshooting, operator support and quality optimisation. The customized system permits personalisation, enabling tailored views for each user, depending on their knowledge support needs.

These results are well in line with the previous studies see e.g. Laukkanen (2001) and Kasvi (2003). The efficiency of using multimedia in knowledge support is the combination of the different elements in an interactive way.

From the industrial point of view the hybrid knowledge and performance support systems can provide a lot of benefits to the paper mills. These tools can be invaluable in the shift work, where the knowledge transfer between the shifts many times is very difficule. By the documentation of troubleshooting situations and best practices the performance of the production line and its personnel can be improved. The systems can be invaluable in many infrequent troubleshooting cases.

4.1 Future research

In future the efficient management of knowledge supporting the decision making is more and more important. The clear trend in the development of process control systems is to include features for knowledge and information management see e.g. Paunonen and Oksanen (2001). The increased use of multimedia and latest web based tools e.g. streaming media in these systems, will however take them to the next level. In future the knowledge and performance support systems, will be integrated as a part of process control systems, making it optimal solution to support operations in the whole production line.

REFERENCES

Bennett, M.A. (1998a), Focusing on the future of controlling the process, *Tappi J.* 81 (1998) No 3, 64-68.

Bennett, M.A.(1998b), The press section from the machine clothing perspective – removing more water at faster speed, *Tappi J.* 81 (1998) No 6, 65-68.

Gery, G. (1991), *Electronic performance support: How and why to remake the workplace through the strategic application of technology*, Gery Assoc., Boston 1991, 303 p.

Hämäläinen, J., Laukkanen, I., Mäenpää, T., Kittilä, M., Honkio, J. (1999), KnowPap - Multimedia learning environment for papermaking and process control, *Automation Technology Review*, 1999 No 1, 56 - 60.

Kasvi, J.J.J (2003), *Knowledge support in learning operative organizations*, PhD Thesis, Helsinki University of Technology, Department of Production Management, Espoo 2003, 129 p.

Laukkanen, I., Honkio, J., Jakobsson, S., Mäenpää,T., Kittilä, M., Hämäläinen, J. (1999), KnowPap – a multimedia learning environment for paper technology and paper mill automation, *Proceedings of Automation Days 1999*, Finnish Society of Automation, Helsinki 1999, pp. 118 - 123.

Laukkanen, I. (2001), *Studies in using hybrid dynamic simulation through the life-cycle of paper mill*, Tech. Lic. Thesis, Helsinki University of Technology, Department of Chemical Engineering, Espoo 2001, 117 p.

Meadows, D.G. (1998a), An eye to the future: Stock preparation, *Tappi J.* 81 (1998) No 2, 70-83.

Meadows, D.G. (1998b), Pushing the limits of headboxes and forming sections, *Tappi J.* 81 (1998) No 4, 55-60.

Paunonen, H., Oksanen J. (2001), Knowledge management as a part of process control systems, *Proceedings of Automation Days 2001*, Finnish Society of Automation, Helsinki 2001, 6 p.