THE DEVELOPMENT OF PRODUCT DATA MANAGEMENT'S SEARCH SYSTEM FOR THE AT BIOPOWER PROJECT

Miss Chanajit Wongsaengchan

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นางสาว ชนาจิต วงศ์แสงจันทร์ : การพัฒนาระบบการค้นหาข้อมูลของระบบการจัดการข้อมูลผลิตภัณฑ์สำหรับโครงการ เอที ไบโอพาวเวอร์. (THE DEVELOPMENT OF PRODUCT DATA MANAGEMENT'S SEARCH SYSTEM FOR THE AT BIOPOWER PROJECT) อ. ที่ปรึกษา : รศ. ดร. มานิจ ทองประเสริฐ, อ. ที่ปรึกษาร่วม : นาย ชัยรัตน์ อมาตยกุล, 164 หน้า. ISBN 974-17-6593-2

วิทยานิพนธ์ฉบับนี้เป็นการวิจัยเพื่อการปรับปรุงพัฒนาประสิทธิภาพการทำงานของ กองวิศวกรรมระบบผลิตไอน้ำและกังหัน หน่วยงานธุรกิจวิศวกรรม การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย โดยได้มีการพัฒนา เครื่องมือที่จะช่วยให้การทำงานมีความคล่องตัวมากขึ้น ซึ่งก็คือ ระบบการค้นหาข้อมูลของระบบการจัดการข้อมูลผลิตภัณฑ์ ซึ่งข้อมูลผลิตภัณฑ์ในที่นี้คือ เอกสารวิศวกรรม อย่างไรก็ดี เนื่องจากข้อจำกัดทางด้านเวลา วิทยานิพนธ์ฉบับนี้จึงมุ่งเน้นไปที่เอกสารประเภท แบบแปลน และ ข้อมูลทางด้านเทคนิคในส่วนของงานวิศวกรรมเครื่องกล ของโครงการโรงไฟฟ้า เอที ไบโอพาวเวอร์ ซึ่งเป็นหนึ่งในหลายโครงการที่ กองวิศวกรรมระบบผลิตไอน้ำและกังหัน ได้รับผิดชอบในการตรวจสอบเอกสารก่อนนำไปใช้ในการก่อสร้างจริง

ขั้นตอนในการวิจัยประกอบด้วย (1) การวิเคราะห์ระบบการจัดการข้อมูลผลิตภัณฑ์ปัจจุบัน และได้พบว่าปัญหาหลักของระบบคือ การจัดเก็บข้อมูลและระบบการค้นหาข้อมูลที่ไม่มีประสิทธิภาพ (2) การสำรวจความต้องการ ความคาดหวัง และความพึงพอใจของผู้ใช้งานที่มีต่อระบบค้นหาเดิม โดยใช้แบบสอบถามที่พัฒนาขึ้นเป็นเครื่องมือในการเก็บข้อมูล (3) นำผลวิเคราะห์มาใช้ในการพัฒนาระบบการจัดเก็บข้อมูล และระบบการค้นหาข้อมูล ให้มีความสมบูรณ์และเป็นไปตามความต้องการของผู้ใช้งานมากขึ้น โดยในส่วนของการจัดเก็บข้อมูล ผู้วิจัยได้เลือก System Code ของบริษัท BVI มาเป็นตัวแบ่งหมวดหมู่เอกสาร และในส่วนของระบบการค้นหาข้อมูล ผู้วิจัยได้จัดทำระบบการค้นหาข้อมูลตัวใหม่ คือ Search by Form เพื่อเพิ่มความแม่นยำในการค้นหา และมีความง่ายในการใช้งานให้มากขึ้นกว่าเดิม (4) การทดสอบระบบ พร้อมทั้งการวัดประสิทธิผลของระบบในด้าน ความแม่นยำ และ ความเร็ว ของระบบการค้นหาข้อมูลใหม่เทียบกับระบบเดิม (5) จัดทำคู่มือการใช้งาน และเอกสารอ้างอิงเพื่อใช้ในการแนะนำระบบให้กับผู้ใช้งาน (6) ผู้ใช้งานทดลองใช้ระบบใหม่เป็นเวลา 1 สัปดาห์ (7) การสำรวจความพึงพอใจ และ ประสิทธิภาพ ของระบบใหม่ และนำข้อมูลมาวิเคราะห์ต่อไป เพื่อหาข้อสรุปและขยายผล

จากการวิเคราะห์ผลการสำรวจพบว่า ผู้ใช้งานส่วนมากค่อนข้างพอใจในระบบค้นหาที่ได้พัฒนาขึ้นมา รวมทั้งมีความเห็นชอบในการขยายผลงานวิจัยนี้ให้ครอบคลุมทุกโครงการในอนาคต อย่างไรก็ตาม สิ่งที่ควรระวังคือการจัดกลุ่มเอกสาร ที่จะต้องทำโดยทีมวิศวกรและฝ่ายเทคโนโลยีสารสนเทศที่มีประสบการณ์และความชำนาญเท่านั้น เพื่อให้มั่นใจได้ว่าการจัดกลุ่มเอกสารเป็นไปอย่างถูกต้องเหมาะสมและการค้นหาเอกสารจะเป็นไปอย่างแม่นยำ ในส่วนของประสิทธิผลของระบบการค้นหาข้อมูลของระบบการจัดการข้อมูลผลิตภัณฑ์ กล่าวคือ ความแม่นยำ เพิ่มขึ้น 85.3% ความเร็วเพิ่มขึ้น 234.4% ซึ่งส่งผลให้ความพึงพอใจของผู้ใช้งานเพิ่มขึ้นค่อนข้างมาก อย่างไรก็ตามเพื่อประโยชน์ และประสิทธิผลสูงสุดของระบบการค้นหาข้อมูล การจัดเก็บเอกสารในทุกโครงการควรได้รับการปรับปรุงให้เป็นในทิศทางเดียวกัน

ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต ลายมือชื่อนิสิต ……..

สาขาวิชา การจัดการทางวิศวกรรม ลายมือชื่ออาจารย์ที่ปรึกษา……..

ปีการศึกษา 2547 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม……..

4671629121 : MAJOR ENGINEERING MANAGEMENT
KEY WORD: PRODUCT DATA MANAGEMENT/SEARCH SYSTEM

CHANAJIT WONGSAENGCHAN : THE DEVELOPMENT OF PRODUCT DATA MANAGEMENT'S SEARCH SYSTEM FOR THE AT BIOPOWER PROJECT. THESIS ADVISOR : ASSOCIATE PROFESSOR DR. MANIT THONGPRASERT, THESIS COADVISOR : CHAIRAT AMATAYAKUL, 164 pp. ISBN 974-17-6593-2.

This research aimed to improve the performance of the Steam Generator and Turbine Engineering Department of Engineering Business Unit of Electricity Generating Authority of Thailand (EGAT) by improving a 'tool' to enhance the workflow; a Search System of Product Data Management system. However, as time and resources were limited, the thesis only focused on the mechanical drawings and technical information of the AT Biopower Project, which is one of major projects in responsibility of the department.

The research methodology consisted of (1) Analysis of a current Product Data Management (PDM) system (found that the main problem was ineffective storage and search system). (2) A survey for users' requirements, expectations and satisfactions with the current PDM system using questionnaire as a data collection tool. (3) Using analyzed data to develop the new storage and search systems to meet the users' requirements. In terms of storage system, the researcher chose to use BVI system code to classify documents and in terms of search system, a new function; Search by Form, was developed to increase the accuracy and ease of use of the system. (4) Testing the system as well as measuring the performance of the search system including its accuracy and speed comparing to the existing system. (5) Preparing user manual/ reference documents for the users. (6) The users tried the new system for 1 week. (7) The survey for users' satisfactions and the performance test of the new system. The data collected at this stage would be analyzed to find the conclusions of the thesis.

The data analysis showed that the majority of the users were relatively satisfied with the improvement of the search system and thought that this study should be taken further either by applying all other projects. However, the main concern with the system was the coding (classification) of documents that should be done by experienced engineer/ IT team to ensure the correctness of document classification and the accuracy of the search system. Regarding to the performance measurement of the new search system, it was found that the accuracy of search system increased by 85.3% and the speed increased by 234.4% which apparently correlated with the satisfactions expressed by the users. Nevertheless, for the best outcome, the document storage system of every project should be developed in the same direction.

The Regional Centre for Manufacturing Systems Engineering Student's signature……..

Field of study Engineering Management Advisor's signature……...

Academic year 2004 Co-advisor's signature……..

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Special thanks to the Co-Advisor, Mr.Chairat Amatayakul for his valuable and helpful suggestion, guidance and time. Many thanks must give to her colleagues in the Steam Generator and Turbine Engineering Department and the others in Information Technology Group, who have been tremendously helpful, corporation and exceptionally patient through the time that this thesis was conducted.

Last but not least, the author wishes to express her deep appreciation and thanks to her beloved parents and her family for being there, supporting, caring, motivating, and understanding throughout the study and her entire life.

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CHAPTER I

Introduction

1.1 Rationale of the Thesis

In the past, Engineering Business Unit typically encounters the problems about using stored information or knowledge as they were kept by various persons in various departments. Often, the staff in various departments of the organization did not share the information and knowledge. Therefore, conflicts in the design and other processes frequently occurred. Apart from the expenses resulted from copying the information for everybody involved in the processes as well as changing and aligning the information, there is also the problem about information searching and resigning/ retirement of experienced staffs.

The aforementioned problems are mainly due to the ineffective knowledge management, therefore, the engineering department has chosen the way to solve these problems by merging technology and management together. This allows the knowledge to be managed with low cost. Also, the knowledge can be built, improved and distributed across the organization far quicker than it used to be.

Starting from introducing 'Product Data Management' (PDM) system, which is capable of storing any kind of electronic documents and is the foundation of Knowledge Management (KM). The valuable electronic documents will be kept with high security but still be easily accessible by authorized persons. In addition, the information regarding technical information and comments can be stored with the documents in this system. The knowledge will then be kept neatly resulting in fast files search and access.

In addition, during the work, the staffs can communicate through e-mail and instant messaging at all time. Then there will be a system that will categorize, store and create relationship between the electronic documents and the concerned user. This provides the 'knowledge map' of the organization that can be easily accessed and

allows the staff to contact the experts in topics of interest. The daily creation of ‘knowledge map’ means fresh knowledge occurred in every project will be transferred to other projects or staffs without delay. This system lets the system’s administrator exactly knows the knowledge or information that the staffs want to know directly, consequently, the exercises and lessons for the staffs can be tailored made to their requests. Therefore, the product data management system seems to be an important tool for the workers in the Engineering Business Unit.

1.2 Statement of Problem

Presently, the Steam Generator and Turbine Engineering Department is responsible for many projects such as DanChang Bio Energy, Phu Kheio Bio Energy, AT Biopower and etc. Product Data Management (PDM) comes to play a vital role for the routine job in the department since it can reduce time to find the data from the hardcopies from various places, improve communication between department, and much more. However, there are some problems exist on the existing PDM’s search system causing dissatisfaction for the users. The main problems are described below.

1. Most of the users spent a lot of time for documents searching which is the biggest obstacle for their routine job. Everyday, there are a plenty of users use PDM system searching for the information or documents they need to study or to check whether the technical specifications from the bidders are conform to the criteria or not. If the search system cannot provide the accurate result, it will affect the time consumption for each project that the department responsible for and conduct to the delay of the submission date of the overall process.

2. Users Interface of the search system for advanced search as shown in Figure 1.1 and Figure 1.2 requires the skill and search engine background from the user to fill in the queries to get to the right information. The beginners or those who rarely use the search engine via the internet will hardly know how to use

the system effectively since the existing system requires a lot of criteria and information from the user.

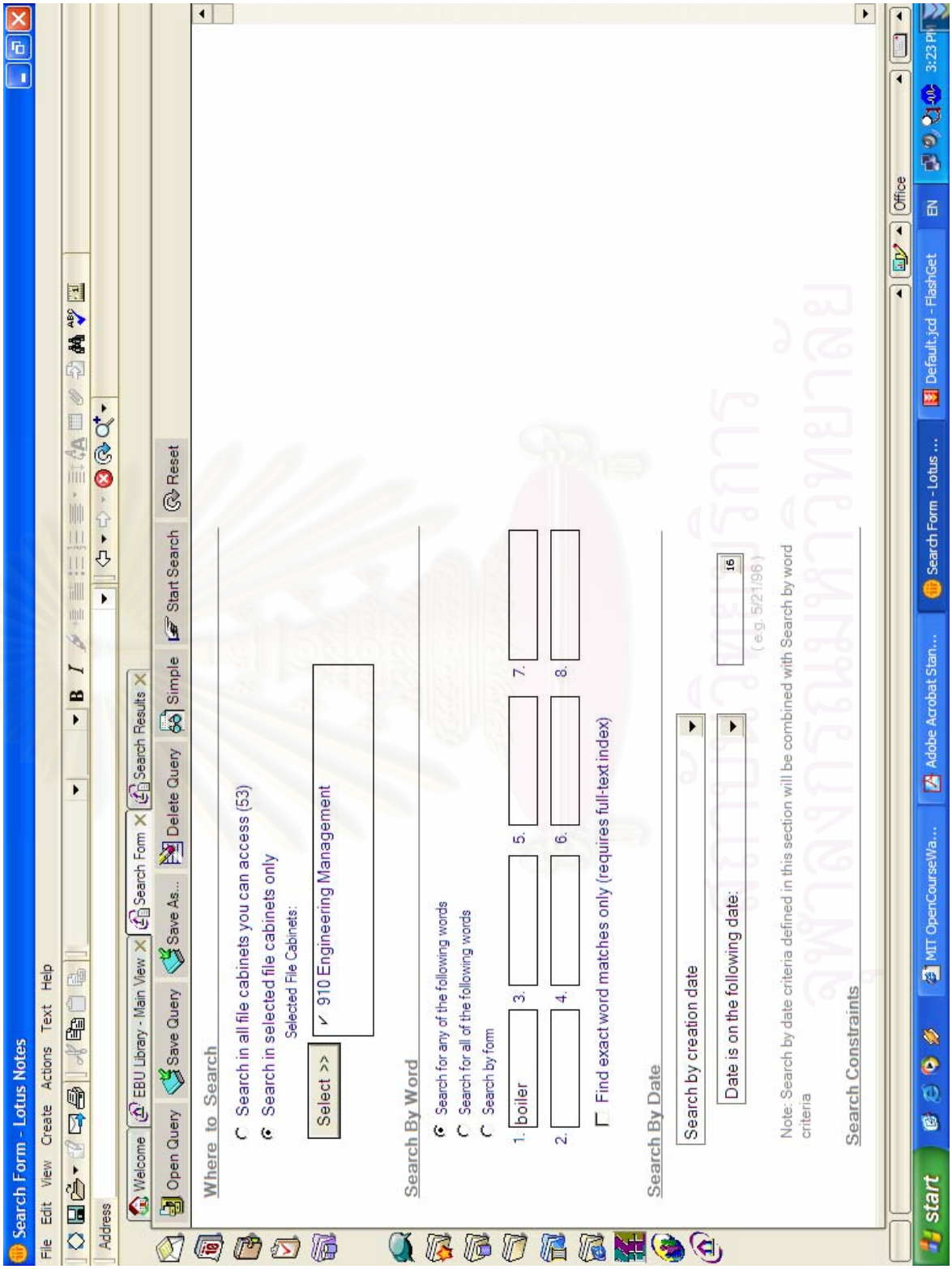

Figure 1.1 Advanced Search's Users Interface of PDM System

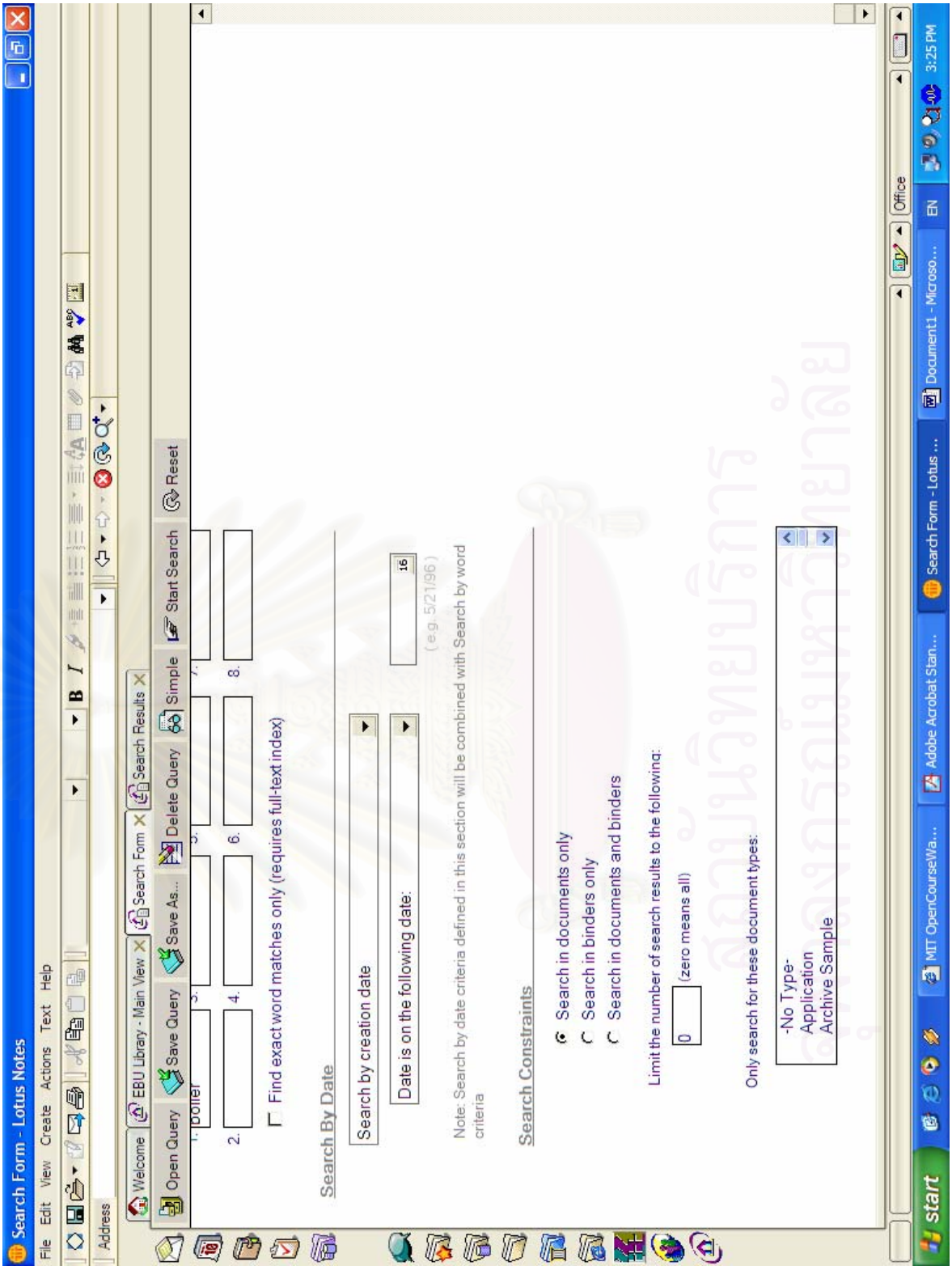

Figure 1.2 Advanced Search's Users Interface of PDM System (Continued)

3. Presently, the PDM's search system is the Full-Text Search which is based on the user entering a search string. The Full-Text Search allows user to search the text of the attached documents as well as the document profile. However, this kind of search will generate a thousand of search results containing the specified search string in any parts of documents (i.e. document profiles, documents' details), which is difficult for the users to know exactly which ones are the documents they need.

1.3 Objectives of the Thesis

1. To improve the effectiveness of search system for the existing product data management.
2. To introduce the new search system model to improve the satisfaction level of the Steam Generator and Turbine Engineering Department's users.

1.4 Scope of the Thesis

The thesis considers on the development of existing product data management of Engineering Business Unit within the scope defined below;

1. The general information, the requirements and suggestions from the users in the Steam Generator and Turbine Engineering Department will be determined by the use of the Pre-Development Questionnaire.
2. The development of the product data management's search system will be conducted for the users in the Steam Generator and Turbine Engineering Department only.
3. The users' satisfaction will be evaluated after the introduction of developed search system using the Post-Development Questionnaire as a data collection tool.
4. The developed search system will be applied only to mechanical drawings and mechanical technical information of the AT Biopower Project.

1.5 Research Schedule

The thesis was scheduled as shown by the table below.

Table 1.1 Thesis Schedule

Activities	2004					2005
	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
1. Requirements Analysis • Study the Related Literatures • Study the Background of the Organization and the Case Study • Analyze the Current PDM's Search System • Analyze the Users' Requirements and Satisfaction from Pre-Development Questionnaire						
2. Development of Product Data Management • Design of Document Storage System • Develop PDM's Search System • Test and Measure the Developed Search System Effectiveness Compared with the the Existing System						
3. Introduce the Developed Search System to the specified users • Implement the Developed Search System						
4. Evaluation of the Developed Search System • Evaluate the Developed Search System and the Users' Satisfaction from Post-Development Questionnaire						
5. Conclusion and Recommendations						
6. Thesis Report Preparation						

1.6 Expected Results

The expected results of the thesis are;

1. To have a better search system for the existing product data management for the Steam Generator and Turbine Engineering Department, this can reduce time consumption when the users need to search for documents and related information in their routine work.
2. The developed search system can process more efficiently than the existing system since it can search the data required by the users more precisely.
3. To be a pilot project for further development for the Engineering Business Unit.

1.7 Expected Benefits

The expected benefits of the thesis are;

1. **The developed search system is more friendly and easy to use especially for the beginners.** Because new system will be very easy to use without many requirements to fill in.
2. **The improvement of the data searching time.** Because the developed search system will provide more precise results to the target users since the new search option will limit the amount of related results more effectively.
3. **The improvement of the work flow.** When the data searching time and the search accuracy are improved, it would also enhance the overall performance of the workflow of the project.
4. **The improvement of the users' satisfaction.** It is certainly that the users' satisfaction will be increased since the developed system provides a lot more precise results with shorter time required and there will be no more users' frustration during using search system.

CHAPTER II

Literature Review

This chapter involved the review of literatures related to the topic being studied, which was about the Product Data Management's search system. The objective of the review was to identify the gab of knowledge, problems, ideas and background information of the interested subjects from available literatures and studies of other researchers as well as to provide the background knowledge for the readers of this thesis. The literatures being reviewed included basic knowledge and published works of other researchers concerning Knowledge Management (KM), Product Data Management (PDM), Lotus Notes/ Domino Document Manager, Searching a Notes Database and Survey Research Methods.

2.1 Knowledge Management (KM)

A simple definition of knowledge management was given by Petrash, G. (1996: cited in Liebowitz, J. 1999) that knowledge management is getting the right knowledge to the right people at the right time so they can make the best decision. In more elaborate terms, Oz, E. (2002), referred knowledge management to as the combination of activities involved in gathering, organizing, sharing, analyzing and disseminating knowledge to improve an organization's performance. In addition to this, Wipawin, N. (2004), claimed that not only knowledge management involves in information management but it is also people management and the implementation of information technology such as intranet system and groupware solutions.

In short, as claimed by Oz, E. (2002, p. 343), knowledge management is an attempt to do the following;

- Transfer individual knowledge into databases
- Filter and separate the most relevant knowledge
- Organize that knowledge in databases that either allows employees to access the knowledge or push specific knowledge to employees based on their needs.

Note that the span of knowledge should not be limited to the knowledge within the organization, the knowledge from outside is equally important as far as it contributes to the growth and wealth of the organization. The component of knowledge management is given in Figure 2.1.

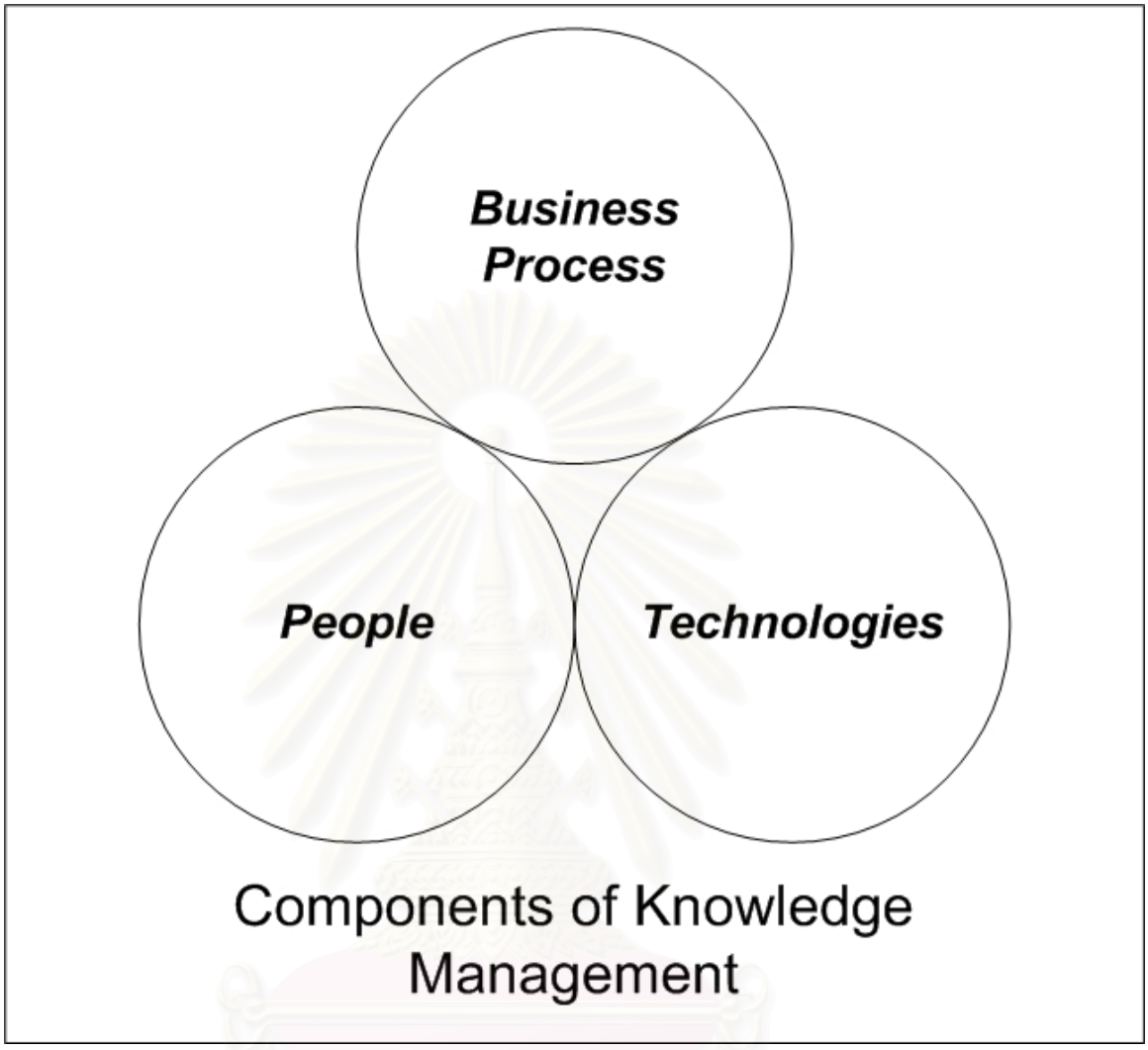

Figure 2.1 Components of Knowledge Management

Source: Wipawin, N. (2004)

According to Dibella, A. & Nevis, E. (1998; cited in Liebowitz, J. 1999) and Wipawin, N. (2004), there are 3 basic steps to be concerned when managing knowledge, including;

1. **Knowledge Acquisition:** Acquiring knowledge from various sources is the first step of developing new knowledge. The acquired information/ knowledge must also be classified properly for effortless accessibility.

2. **Knowledge Sharing:** There are 4 types of knowledge generally being shared within the organization which are knowledge about facts, causes and affects, how to do things, and creative ways to fix the problems. The process of sharing knowledge involves the use of collaborative communication tools such as e-mail or network system.

3. **Knowledge Utilization:** This involves distributing knowledge to the people within the organization so that they can access to the knowledge exist in the organization. Knowledge utilization may including activities such as contributing lists of name and contact information of the experts in various fields in the organization or classifying and storing important news, information and knowledge for later access by the people in the organization.

Note that there are still other perspectives in managing knowledge provided by many authors. Nevertheless, they are quite similar to the aforementioned basic steps. For example, Wiig, K. (1993; cited in Liebowitz, J. 1999) proposed that knowledge management process consist of 4 steps including; *Creation and Sourcing, Compilation and Transformation, Dissemination, Application and Value Realization.* Marquardt, M. (1996; cited in Liebowitz, J. 1999) also proposed 4 steps process including; *Acquisition, Creation, Transfer and Utilization and Storage* while O'Dell, C. (1996; cited in Liebowitz, J. 1999) recommended that knowledge management should consist of 7 steps including; *Identify, Collect, Adapt, Organize, Apply, Share and Create*.

General principles of knowledge management have been developed by Davenport, T. (1996; cited in Liebowitz, J. 1999). These principles include;

1. Knowledge management is expensive (but so is stupidity).
2. Effective management of knowledge requires hybrid solutions involving both people and technology.
3. Knowledge management is highly political.
4. Knowledge management requires knowledge managers.

5. Knowledge management benefits more from maps than models, more from markets than hierarchies.
6. Sharing and using knowledge are often unnatural acts.
7. Knowledge management means improving knowledge work processes.
8. Access to knowledge is only the beginning.
9. Knowledge management never ends.
10. Knowledge management requires a knowledge contract (i.e. intellectual property issues).

Networked computer systems with knowledge management software installed are crucially important in managing knowledge. As Wipawin, N. (2004) indicated, the software mentioned earlier help managing knowledge by collecting all disseminated data/ information and store it in places systematically which results in fast and trouble-free accessibility for the users. Examples of the software are including *MS Office 2000/ XP* from Microsoft Corporation and *Lotus Notes and Domino* by Lotus Development Corporation.

In terms of real-world applications, Sveiby, K.E. (2001) (*www.co-i-l.com*) pointed out that, at the moment, several large companies around the world are realizing the benefits of and paying attention in managing knowledge in their organizations. These companies include 3M, IBM, Analog Devices, Boeing, Ford Motor, Hewlett Packard, Skandia, Xerox, National Technology etc. Some examples of how these companies manage the knowledge within their organizations researched by Sveiby, K.E. (2001) are as followed;

- **Boeing 777** USA. First "paperless" development of aircraft. Included customers in design teams. More than 200 teams with wide range of skills both designed and constructed sub parts, rather than usual organization design team, construction team. Suppliers world-wide used same digital databases as Boeing.

- **3M**, USA. With 60, 000 products of their own innovation process, this company has an organization that balances between creativity and

conservatism. 3M values encourage learning and risk taking, but managers are required to link continuous learning to revenues.

- **Hewlett-Packard**. Famous for its overall culture of collaboration, this encourages knowledge sharing and risk taking on all levels. HP even supports people who try out things that don't work.

- **IBM**, USA and most Japanese large companies. Dual careers. Employees are encouraged to switch between professional and managerial jobs, in order to gain more holistic knowledge about the company.

- **Honda** and others. Japanese companies routinely build "redundancy"; people are given information that goes beyond their immediate operational requirements. This facilitates sharing in responsibilities, creative solutions from unexpected sources and acts a self-control mechanism.

- **Xerox** USA. Provides convenient places where people can get together routinely. Called the "distributed coffee pot" these environments encourage cross-functional links.

2.2 Product Data Management (PDM)

As described by McMahon, C. & Browne, J. (1998), and PDM Information Company (2004), the Product Data Management is a tool that enables engineers and others to manage and control engineering information and the product development process. PDM systems keep track of all product related information- including electronic documents, digital files and database records- required to design and manufacture products. PDM systems provide a structure in which all types of information used to define, manufacture and support products are stored, managed and controlled.

A PDM system has two groups of functions- user functions and utility functions. User functions provide the users interface to the PDM system capabilities- including data vault and document management, process and workflow management, product structure management, data classification and retrieval, and project management. While the utilities functions provide facilities that support the use of the system and support the user's functions-including data communication and notification, data transportation, data translation, image services, and system administration.

The benefits of PDM system have been clearly identified by PDM Information Company (2004). Followings are the summarized benefits of PDM;

- **Reduced Time-to-Market:** Since the PDM system can speed up task by making data instantly available as it is needed and it also supports concurrent task management.
- **Improved Design Productivity:** Since the designer no longer needs to know where to look for released designs or other data, it is all there on demand.
- **Improved Design and Manufacturing Accuracy:** Overlapping or inconsistent design are eliminated-even when people are operating concurrently. It provides more right-the-first-tie designs and, once again, a faster path to the marketplace.

- **Better use of Creative Team Skills:** PDM encourages team problem solving, keeps track of all documents, and reduces the risk of failure by sharing the risk with others.
- **Comfortable to Use:** When the users wish to view information on a PDM system, the application should be loaded automatically.
- **Etc.**

A study involving utilizing PDM system to reduce of design development time of a concerned design office was proposed by Storga, M., Pavlic, D., and Marjanovic, D. (2001). The study has shown that PDM system improved productivity, protected data integrity and effectively reduced design time as expected.

The study started with defining expectations of the PDM system by undertaking interview session with members at the design department office. As a result, the basic requirements of a PDM system were determined. One of the important requirements is the 'Design Process Information Management' which includes activities that create or use product data. The key property is that user needs to be able to 'get at' assemblies and subassemblies data by a variety of routes. User could move up and down through the product tree structure in different ways: pick the path through a product structure; simply call-up data user want by searching for it by name or number, or search for groups of data by specifying an attribute or combination of attributes.

The methodology of the developed PDM system is as follow:

1. Identifying specific company's needs.
2. Analyzing company's existing information flow.
3. Designing the system's architecture.
4. Planning the implementation procedure and implementation.
5. Maintaining the system.

The proposed system supports the product development process on two levels: engineering data management and design data flow coordination.

In the year 2003, Kulpanaves, J.**,** had studied and developed the PDM system for the standard time estimation process in a customized power supply unit manufacturing company. The study methodology was:

1. Study the problems in organization.
2. Literature surveys.
3. Study the requirements of the users.
4. Developing the PDM database (use Microsoft Excel and Microsoft Access.)
5. Developing the PDM functions (table structures, layout user interfaces, link form relations, and program coding.)
6. PDM system evaluation
7. Conclusion and recommendations.

The benefits of this study is the faster component searching time since the users do not need to know where the data documents are actually stored and faster estimation of manufacturing standard time and cost since the repetitive process design is replaced by the electronic one.

2.3 Lotus Notes/ Domino Document Manager

Brown, K. and Brown., K. with Abrahamson, C. and Brown, K. (2000, p.xxxi), described what Lotus Notes as a document database, but "…Notes is not a traditional database. It is more useful to think of Notes as a way of organizing documents and making them accessible to groups of people.…" Notes is more accurately described as a distributed client-server database application that enables groups of people to organize, track, access, and share information over a network.

According to Lynd, D. & Kern, S. (2000), the first Lotus Notes, which ran only under OS/2, was released in 1989 and cost approximately $ 60,000 U.S. Dollars for 10-user installation. Notes had about 1 million users by the time it released version 3 in 1994. 4 years later, the number of users has grown rapidly to over 30 million while the cost of installation has dropped dramatically.

Nowadays, Lotus Notes is available across almost every major platform (operating system) including OS/2, Netware, Windows 95, Windows NT, UNIX, AS/400 and more. Notes server's (now called 'Domino Server' since the release of version 4.5) capability has expanded over years; from supporting 100 users in release 3.x to approximately 27,000 users in release 5.x tested on a single AS/400 platform. It seems clear that Notes and Domino can easily support the information handling of the entire organization provided sufficient system resources (e.g. computers and network systems) are used. In addition, Notes from version 4.6 onwards integrated supports for internet protocols including HTTP, POP3, IMAP, NNTP and more. This make Notes the true applications server for the Internet.

The client, as claimed by the authors, has been split into the Admin client, the Notes client and the Domino Designer; each with different magnitude of authorities and tasks. And while Notes client is available in various operating platform, the user interfaces are very similar. This allows seamless switching from one system to another.

The connectivity of Notes and Domino is probably one of its greatest strengths. The information can be transferred over LAN, WAN, the Internet as well as phone lines.

Domino servers can communicate, transfer, synchronize database with each other. The process of exchanging information in the database is known as ‘replication’. The users use Note clients to connect to the Domino server’s database, with a click of button, to exchange information, receive email and etc.

Basically, there are 2 types of Domino Server; *Hub* and *Spoke* servers (called after its similarity to the vehicle wheel). The hub servers contain all the databases used by the spoke servers. The replication only happens between hub and spoke servers (never between spokes) and can be commenced by either hub or spoke servers. Generally, the users are only attached to the spokes servers. The diagram illustrated the hub-spoke server topology is given in Figure 2.2.

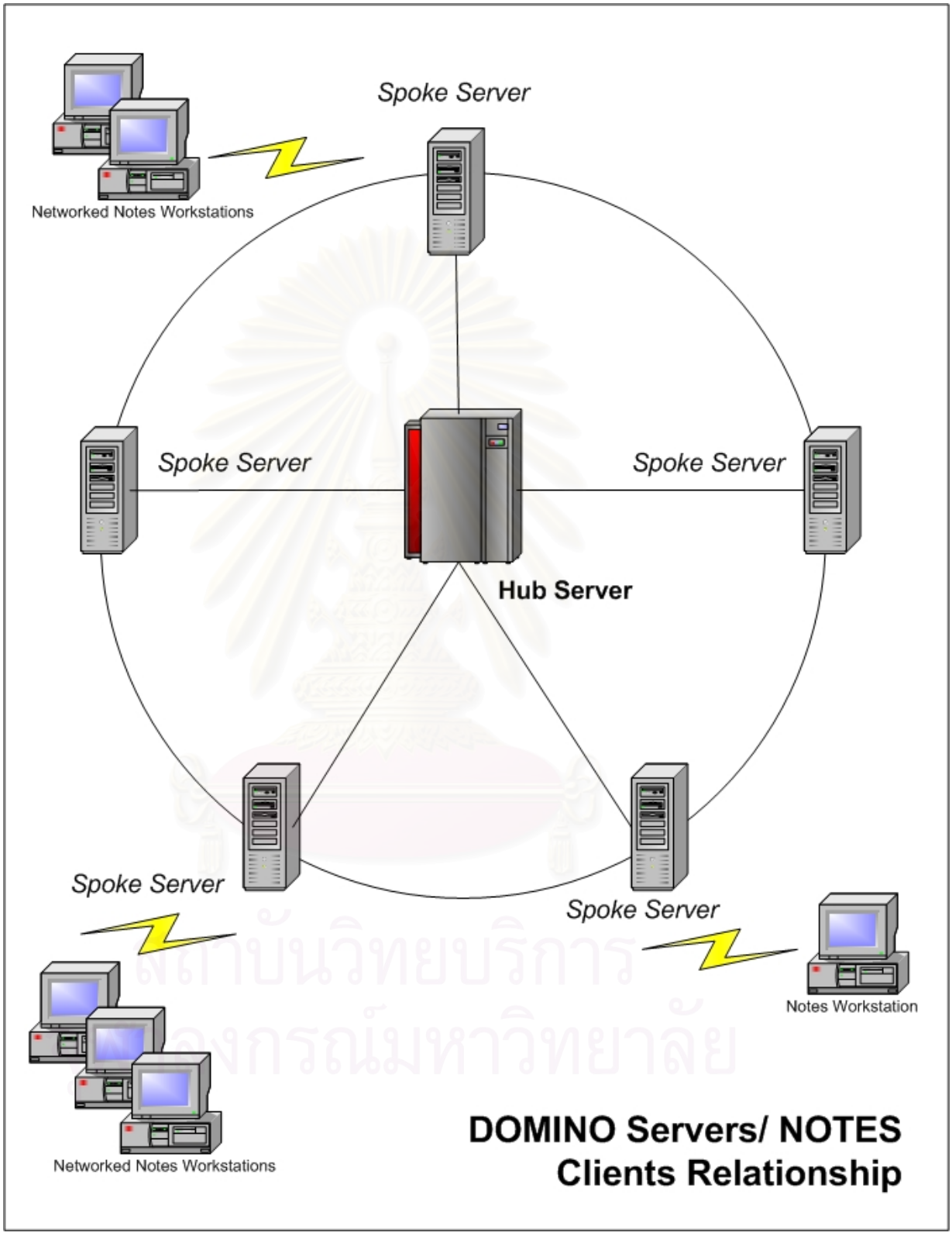

Figure 2.2 Hub-Spoke Topology

Source: Lynd, D. & Kern, S. (2000, p.19, Figure.1.3)

In addition, as Notes and Domino is greatly admired, there are quite large supports from third-party developers for the product. All the flexibilities and functionalities somewhat contribute to the leader position of Notes and Domino in the market. The authors also stressed that Notes and Domino is particularly designed to solve problems coexisting in both send and share models of traditional networking environment by integrating a shared database with an email capability and schedule agents that automatically run and take actions as they are pre-commanded. This potentially proposes what is called a 'workflow' solution. The workflow is comprised of 3 'C's; *communication, collaboration and coordination,* where communication is the send model; collaboration is the share model; coordination is people working together to achieve the same goal. The diagram of 3 Cs of workflow is shown below.

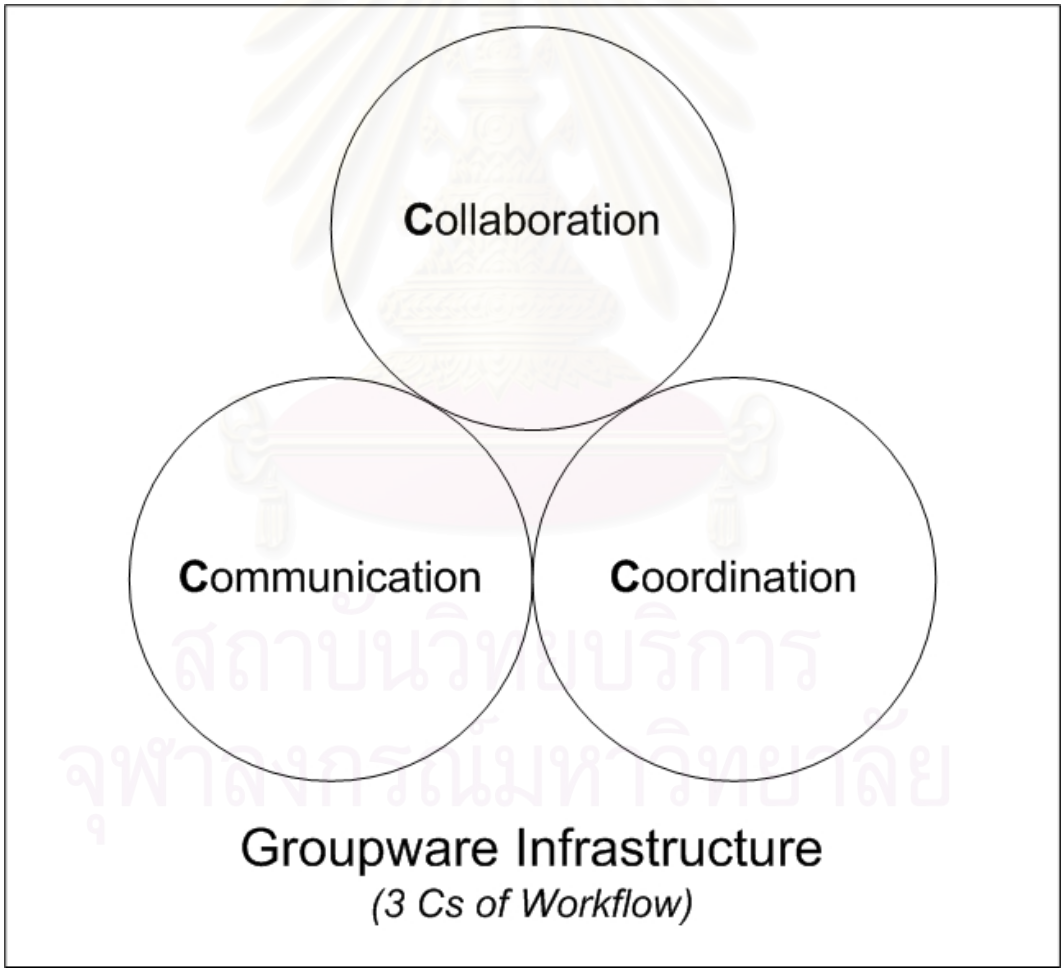

Figure 2.3 3Cs of Workflow Diagram

Source: Lynd, D. & Kern, S. (2000, p.17, Figure1.1)

Some of the major features of Lotus Notes and Domino, as indicated by Lynd, D. & Kern, S. (2000), include the followings;

1. **Notes Clients and Domino Servers:** Notes and Domino is a distributed client/ server application communicating via network protocols such as TCP/IP, Apple talk, NetWare SPX and etc. on LAN, WAN and modems. The essence of Notes and Domino is that Domino application and/or databases can be distributed to more than one client or server through the process called 'replication'.
2. **Domino Databases:** Domino Database is quite unique. The distinction between Domino Database and normal relational database is that the database stores documents or records in unstructured form and does not have fixed data field description. This allows Domino Database to store and link various types of objects.
3. **Replication:** Replication is referred to as a synchronization/ distribution of database from Domino servers to Notes clients and/ or other servers. The users can check *'the replica ID'* to see whether the two databases essentially contain the same information. It is important to note that not all copies of database are in synchronization at all time, however, over time, they will ultimately be.
4. **Security:** The author claims that Notes and Domino utilizes arguably the most secure and advanced encryption scheme – RSA (named after Rivest, Shamir and Adelman) developed in 1997. There are 7 levels of accessibility to the database including No access, Depositor, Reader, Author, Editor, Designer and Manager in respective of the level of accessibility granted (i.e. Manager have all the privileges and also can change the access control list, while reader can read documents but not edit or add, for example).
5. **Integrated E-mail:** Notes e-mail is a great mean to communicate with clients and coworkers. Its supports start range simple text messages, pictures, sounds, file attachments to Internet mail, fax, voice mail messages and etc. Database, document and anchor links embedded within the email are also possible.
6. **Calendaring and Scheduling:** This feature is natively integrated with Notes and Domino. It is possible to access to the calendar and schedule meeting right from Notes clients. With the addition of Group calendar in newer releases

(version 5 and beyond), the group members can share calendars and check each other schedules.

7. **Remote Access:** Remote access via modems and the Internet from both servers and clients are possible. This permits staffs or officers of an organization to be geographically isolated while using the central resource.
8. **Domino Web Server:** Currently, Domino has the ability to extend the company to one of the largest market places – the Internet. The collaboration architecture of Notes and Domino results in always up-to-date information on the web. The security, full-text search capability and many more features for the web are also fully supported.
9. **Internet Protocol:** Notes and Domino from release 5 onwards has been tightly integrated with the internet. It supports most of well-known protocols, for example, NNTP, MIME, HTTP, POP3, IMAP, LDAP and etc.
10. **Personal Web Navigator:** Looks and performs similarly to renowned web navigators such as Netscape Navigator or Microsoft Internet Explorer, however, Notes offers even more features, for instance, web pages storing in database, Web Ahead downloads that link pages to the depth being specified, Page Minder updating web pages on a pre-determined schedule. The access to the Internet using Personal web navigator can be either through a proxy server or a dial-up connection from the workstation.
11. **Components:** Lotus components are some small applets such as spreadsheet, chart, drawing component, file viewer, etc. that are put together in Lotus Notes desktop for the ease of usage. The users can use these components directly and the developers can program and distribute them through the network.

In accordance with Brown, K. and Brown, K. with Abrahamson, C. and Brown, K. (2000), the benefits of Notes include;

1. **The information is kept current:** Because notes documents are centralized, easily accessed and systematically revised, the documents will always be up-to-date. This allows the organization's decisions that based on the precision of the information to be made accurately.

2. **The information is kept secure:** Users of Notes are required to have 'access level' to the database assigned. This effectively protects the database against unauthorized modifications. The users only see the information they are authorized for.
3. **Group work is enabled:** Probably the most important benefit of Notes is that it allows a group of people in an organization to use the same information but in different ways depending on each individual needs and preferences. From version 5 and beyond, Lotus Notes integrates the communication modules and various tools (such as e-mail, scheduling, calendaring, etc.) to expand its capabilities as an efficient knowledge management tool. (For more information, see 'Knowledge Management' part of the literature review).

A study in adoption, implementation and use of Lotus Notes in Singapore by Tung, L.L, Tan, J.H., Er, J.P., Lian, K. and Turban, E. (2000) reports the result of a field study of the abovementioned topic conducted in Singapore. The results provide an insight about the adoption process of Notes, its strategic use of Notes and the benefits realized by organizations. The study attempts to relate different types of organizations classified by their culture and technology levels to the perceived impacts of the introduction of Notes.

The major findings are the medium technology type organizations differ significantly from the high technology organizations with respect to the purpose of using Notes in the areas of distributing and providing information, seeking task information from people, giving and receiving feedback on reports or ideas, learning about events and things that interested them and much more. Meanwhile, there were no significant changes for Mechanistic organizations which use more of Notes to monitor and control the progress of projects.

Notes was found to be most beneficial to organizations with medium level of existing technology rather than high technology. Benefits were reported in productivity, communication and reduction of the time needed to reach a decision.

2.4 Searching a Notes Database

As indicated by Brown, K. and Brown, K. with Abrahamson, C. and Brown, K. (2000), Notes offers full-text search capability that let the users search for words, phrases, numbers and data in a single database or even across multiple ones. It is possible to include search criteria such as *and, or* and other special operators. The search result can be ranked based on the relevancy to the keyword being used and also sorted by date. According to Eurospider Information Technology (2004), the relevancy system outperform the search engine using Boolean operator such as *and*, *or,* etc. in terms of the precision and the recall of the results.

However, there are some limitations to the full-text search of Notes. For example, it is not possible to locate a text that is new or has been updated since the database was last indexed or the text that is not located in any document but appears in a view (such as column headings). Therefore, unless the last full-text index has been deleted and the latest one is re-created, any newer files or information updated after the last full-text index will not be appeared in the search result.

In addition, Notes also offers various search conditions to help target the desired document. These conditions are as followed;

1. Searching by Field
2. Searching by Date
3. Searching by Form
4. Searching by Form used
5. Searching by Folder
6. Searching by Words and Phrases
7. Searching by Author

2.5 Survey Research Methods

According to Adams, G.R. & Schvaneveldt, J.D. (1991), the main characteristic of survey is the data would be gathered from a sample (usually on random basis) or specific population, often by research methods such as questionnaire, interview or telephone survey at a specific point in time. Unlike experiment research design, the researchers basically have no control over independent variables. Another important aspect of survey strategies is that there is an attempt to generalize the findings.

Methods

Two following basic methods for survey are mentioned in a recent Paul Oliver's book, *Research. (*1997, pp. 86-95);

- **Interview** (administered by researcher)
- **Self-completion questionnaire** (distributed by mail or by hand)

The ***face-to-face interview survey*** can be costly and times consuming, however, the researchers are able to put the answers in right categories when the respondents provide answers that are not the ones of the possible coded responses offered.

The interviewers can also clarify the questions if needed. Moreover, with the present of interviewers, the respondents are encouraged participation and involvement.

However, as Robson, C. (1997) pointed out that data collected might be affected by the interactions or interviewers/respondents and characteristics of interviewers such as personality and skill. There may also be the bias caused by the interviewers through verbal or non-verbal indication 'correct' answers. The respondents, in some situations, might feel uncomfortable to express what they actually think.

The survey format that we are probably most familiar with is the use of questionnaire that respondents will have to complete by themselves. Denscombe, M. (2000) indicated that ***postal surveys,*** in essence, involve a large-scale mailing to the target populations. There is no any personal contact between the researchers and respondents and also the respondent would not receive any prior notification of the arrival of the questionnaire. The topic(s) and the length of the questionnaires will have great effect on the response rate. Sensitive subjects are likely to bring the response rate even lower.

Normally, the response rates of postal questionnaires are about 20%. Therefore, very large mailings are used to ensure that a low response will still supply sufficient data.

To ensure the effectiveness of the questionnaire, Oliver, P. (1997) recommended to undertake a 'pilot study' which is the trail run of questionnaire with the respondents that similar to the target population to make sure that they understand the questions or having any difficulty with the instructions. This help the researchers to see and pick up any design faults within the questionnaire and fix the problem.

Besides, Denscombe, M. (2000), mentions that the ***literature survey*** and classic social surveys, ***observations***, are some of the available options. The aim of documents surveys is for the researcher to review and look through as much as possible of the existing sources related to the topic of research. Business and economic forecasts rely heavily on document-based data (such as company reports and financial records). In terms of observations, the author make a point that surveys are not only asking people what they do but can also *observe* at what they actually do.

Another way of doing survey is to use e-mail. Rowland, R. (2000) claimed that even if the ***e-mail interview*** cannot substitute in-person or telephone contact, it is often useful to employ when pre-interview of a source that will be meet in person later is expected. Once contacting people via e-mails for a couple of times, it becomes easier to contact them by telephone. This effectively defeats unwillingness and

rejections from a person to the one he/she does not know (often called ‘cold call barrier’).

Advantages

Denscombe, M. (2000, pp. 27-28) claimed that survey approach has advantages and disadvantages as followed;

- *Empirical data are provided.* This is due to the nature of survey research that tends to focus on data more than theory.
- *Wide and inclusive coverage.* This also means that the findings on good survey research can be generalized easier than the results from other approaches.
- *Surveys produce quantitative data.* Surveys are very helpful in doing qualitative research as the data can be subject to statistical analysis.
- *Produce a huge pile of data.* Surveys can be done with fairly low cost and produce a huge pile of data in a short time.

Disadvantages

- *Detail or depth of the data.* This is a drawback of must be realized by researchers. Often, the survey researches are in large-scale, it is not possible to get much detail for the data. If detail or depth of the study is required, then ‘case study’ is what to select.
- *Accuracy and honesty of responses.* Researchers are unlikely to know that the respondents tell them what they really feel.

In addition to this, the design of survey, if not carefully prepared, will cause researcher some problems about validity as Robson, C. (1997, pp.125-8) pointed out that if the questions are incomprehensible or ambiguous, the exercise is obviously a waste of time. This is the problem of *internal validity* where are not obtaining valid information about the respondents and what they are thinking, or how they are feeling.

If the sampling is faulty, this produces an *external validity* problem such that we can't generalize our findings.

Another point that the author mentioned is that the data collected by survey will be affected by the respondents' characteristics (such as personality, memory, motivation etc.). In case of telephone interview, even it shares many advantages with face-to-face interview, but lacking of visual contact can lead to misinterpretation of data.

2.6 Bias, Reliability, Validity and Ethical Issues

Bias

Bias, as said by Bennett, L. (2004), is an unknown or unacknowledged error created during the design, measurement, sampling, procedure, or choice of problem studied. Some examples of bias in research may be that people tend to give socially desirable answer, which sometimes is not what they really have in mind (and this often beyond the researcher's control) or the way the question was asked by the research leads to certain result, etc. In addition, he pointed out the difference between quantitative and qualitative research in terms of bias that in qualitative design, the researchers explicitly acknowledge bias while in quantitative design, and the researchers attempt to eliminate it.

In terms of writing a research project, Schoolcraft College Writing Fellow (2004) (www.schoolcraft.edu) stressed that bias in writing the project is often created when the researcher only consults one side of an issue regardless of the credibility and honesty of the sources used. Therefore, proper research writing should consist of various sources from various perspectives. Noted that the word used in writing might also creates bias. For example, words like manpower or mankind may make a sentence sexually bias, etc.

Reliability

Oliver, P. **(**1997) claimed that when doing research, if the result can be repeatedly found using the same structured approaches, that means the research is reliable, hence the reliability of the result. It is, although, very hard to obtain the consistency or reliability of the results even if in laboratories. It is certainly much harder in social-science context, involving human being studied. Methods such as observation or interview tends to give low level or reliability because of the differences in a way each research observe, 'observer effect' and the influences the interviewers might have over the interviewee (respectively).

Litwin, M. (1995) stated that the reliability of the survey instrument can be assessed in the following forms;

1. **Test-retest:** measure the stability of response over times, in the same group of respondents.
2. **Alternate form:** use differently worded questions to obtain the same information about a specific topic.
3. **Internal consistency:** measure how well several items in a scale vary together in a sample.

Questionnaire seems to provide most reliable data, however, that depends largely on the way the questions are structured; close-questions lean to have more reliability than the open-question in which respondents have to write down a paragraph of answers.

Validity

Litwin, M. (1995), Oliver, P. (1997) and Black, T.R. (1999) are all agree that the research is valid because it has measured what it was intended to measure. To secure the validity of research project, the author recommended that the researcher measures an event using a number of ways and see if the results are the same.

Litwin, M. (1995, p. 33-45) indicated that there are 4 types of validity as followed;

1. **Face:** casual review by colleagues, for example, of how good an item or group of items appear
2. **Content:** formal expert review of how good an item or group of items appear
3. **Criterion:** measures how well one instrument stacks up against another instrument.
4. **Construct:** theoretical measure of how meaningful a survey instrument is.

According to Oliver, P (1997), Validity check, same as checking the reliability, is very difficult especially when it comes to measure humans as their attitudes or believes are always changed or developed each day. The environment might have been changed at the time of re-checking the validity. The key point here is if the method of data collection used is normal in respondents' life, there are prone to be less effects caused by that process of data collection.

Ethical Issues

As Farr, J. & Seaver, B. (1975; cited in Adams, G.R. & Schvaneveldt, J.D. 1991, p. 32) stressed, sometimes research procedures can cause invasion of privacy, physical and psychological discomfort to the people involved. For example, asking the users to comment upon the search system designed by the administrator whom they are familiar with may result inaccurate responses possibly caused by sympathy when people commenting someone they know in person. Therefore, great care should be taken, if the reliability and accuracy of the data is expected.

CHAPTER III

Background of the Organization and the Case Study

In the previous chapter, the considered theories such as Knowledge Management, Product Data Management, Lotus Domino Document Manager, Lotus Notes, and Satisfaction Measurement with their related literatures were discussed. There are many advantages and much benefits of deploying the Product Data Management in an organization which can be a strong foundation of Knowledge Management. In this chapter, the background of the organization and the AT Biopower Project were discussed.

3.1 Background of the Organization

Electricity Generating Authority of Thailand (EGAT) was formed on May 1, 1969, by the merging of three former regional electricity authorities-Yanhee Electricity Authority (YEA), Lignite Authority (LA) and Northeastern Electricity Authority (NEA). EGAT is presently Thailand's state owned enterprise.

EGAT Vision

- To be the ASEAN Power Grid center and the region's leading company in energy and related businesses.

EGAT Mission

- To generate, acquire, transmit electric energy to the Metropolitan Electricity Authority (MEA), the Provincial Electricity (PEA), other electric energy consumers under the law thereon and neighboring countries.
- To undertake various activities concerning electric energy. Energy sources deriving from natural resource for the production of electric energy and other activities which will promote the purposes of EGAT.
- To undertake businesses concerning electric energy and other businesses concerning with the activities of EGAT, or collaborate with other persons for the said activities.
- To produce and sell lignite, or collaborate with other persons for the said activities.

EGAT Business

1. Generation

EGAT presently builds, owns and operates several types and sizes of power plants across the country with a combined installed capacity of 15,000 MW, accounting for about 59 percent of the country's 25,602.8 MW generating capacity.

EGAT also purchases electric power from private power companies and neighboring countries.

2. Transmission 

EGAT develops, owns and operates the national transmission network which boasts one among the most reliable and efficient network in the region. Its grid system which covers the entire country mainly operates at 500 kV, 230 kV and 115 kV voltages; EGAT's power system operation is divided into five geographical areas: metropolitan, central, northeastern, southern and northern regions.

3. Energy Sales

EGAT is obliged to supply and sell virtually all of the energy output from its own generation facilities and from private power sources to two distributing authorities, namely the metropolitan Electricity Authority (about 35% of the total supply) and the Provincial Electricity Authority (about 63%) which then deliver electricity to the users across the country.

4. Other Service Businesses

EGAT has been striving to create added value from its decades of expertise and existing resources. In addition to its mission of providing the quality power supply service countrywide, EGAT has now been offering a variety of energy related services to industrial and business sectors. Its scope of service ranges from engineering, operation and maintenance, construction, survey, testing, chemical to information technology services.

Source of Information: (www.egat.co.th)

EGAT has continuously been undertaking accelerated organizational development and improvement, and is fully prepared to step forward as the Thai leading organization in the energy business, supporting the Government policy which

envisions Thailand to be the energy hub of the region, and enhancing energy security of the country and of the region. EGAT is also determined to develop and streamline its overall operations and optimize the utilization of its resources to provide the high quality energy service by international standards at a competitive price.

To show the direction of the country's future energy development, the electricity supply industry (ESI) must be reformed. EGAT has continuously prepared itself to be more streamlined and readily adapt to its future role and the changing industry. Presently, EGAT is divided into 11 units: six Business Units (BUs) and five Operative Units (OUs). Six business units comprise with Transmission System Business, Generation Business I and II, Maintenance Business. Engineering Business and Fuel Business. Five operative units comprise with Policy and Planning, Account and Finance, Administration, Construction, and Hydro Plant. The EGAT organization chart is shown in Figure 3.1.

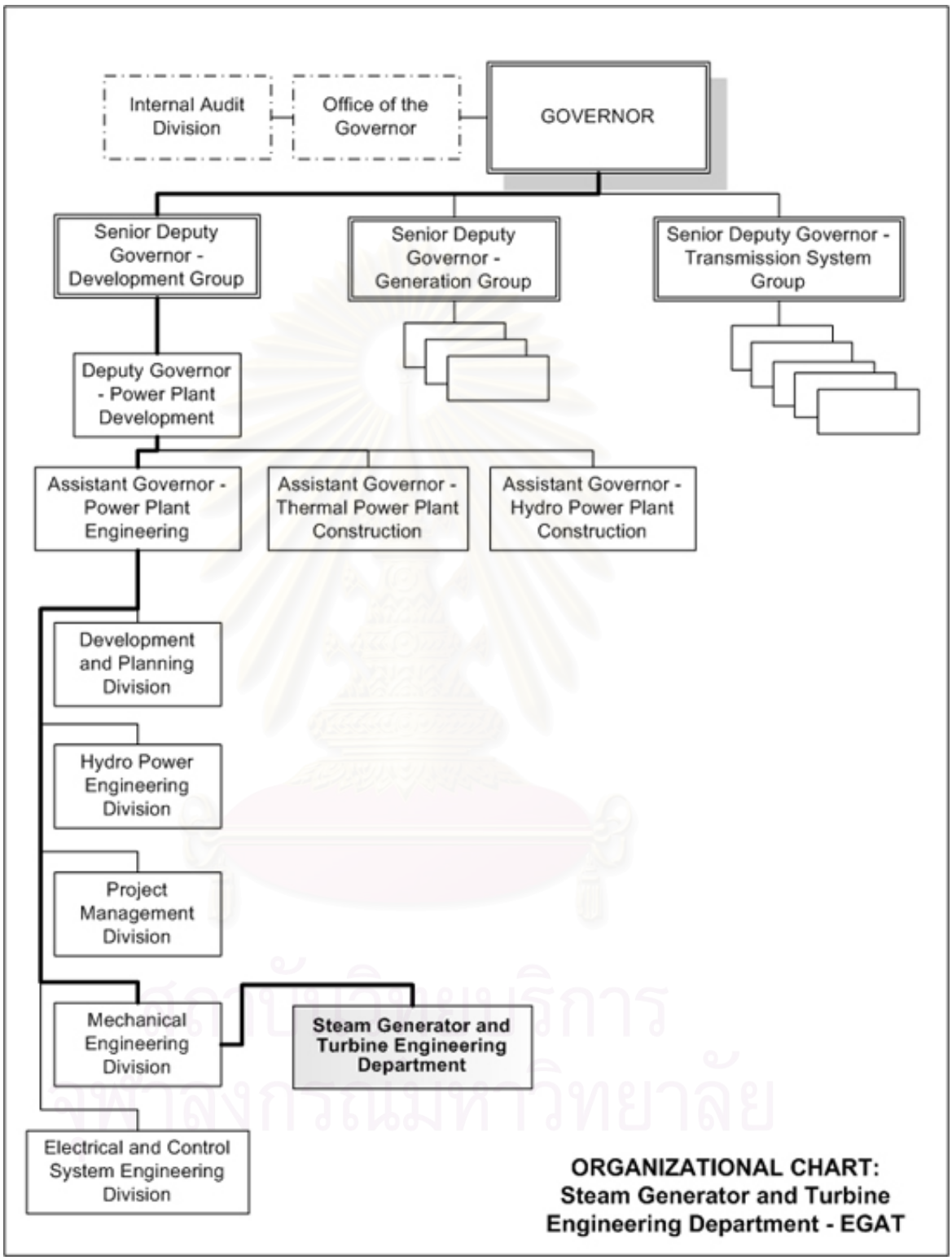

Figure 3.1 EGAT Organizational Chart

3.1.1 Mechanical Engineering Division

Mechanical Engineering Division (ME) is a division under Engineering Business Unit. The main responsibility of ME Division is to be responsible for the project proceeding of mechanical engineering, chemical engineering and pollution control, and nuclear power engineering from the very beginning including the preliminary study, technical feasibility study, preparation of technical specification, cost estimation, bids tendering, bidders' technical specifications evaluation, negotiation and contraction, design, engineering design consideration, and commissioning and performance tests. The goals of ME Division are;

- Controlling the management and operational cost to be financially effective.
- Improving the quality of mechanical engineering projects and controlling the projects to be conformed to the international standard and to be finished on time.
- Developing data for mechanical design analysis.
- Procuring and developing the technology which is best suited for each project.
- Increasing or maintaining the customer satisfaction level of the customers to be in good position.

Mechanical Engineering Division is divided into 4 departments which are Steam Generator and Turbine Engineering Department, Nuclear Power Engineering Department, Chemical Engineering and Pollution Control Department, and Mechanical Equipment Engineering Department.

3.1.2 Steam Generator and Turbine Engineering Department

Steam Generator and Turbine Engineering Department is a part of the Mechanical Engineering Division. The responsibilities of the department cover the overall operational activities in mechanical engineering, steam generating system, steam turbine & gas turbine and auxiliary system, and other related equipments. The responsibilities include;

- The technical feasibility study and technical analysis of various equipment of the power plant.
- Preparation of the bidding documentation.
- Providing the technical advice on technical specifications, standard specification and much more for internal and external customers.
- The evaluation on the bidding documents before the transfer to the next related department.
- Manage and control the budget and expenses to be financially effective and fully utilized.
- The effective management on the responsibilities and also the conduction of the appropriate technology which be able to help the operations of the department.

There are 23 employees working in Steam Generator and Turbine Engineering Department. The Figure 3.2 shows the amount of employees classified by branch of knowledge.

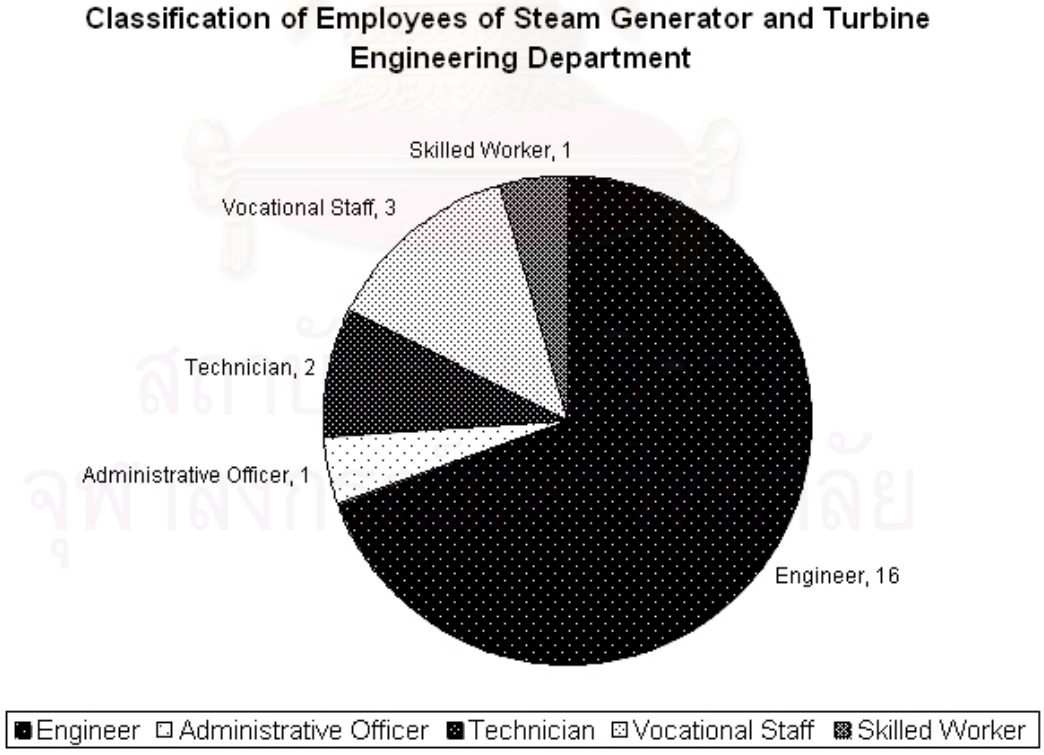

Figure 3.2 Classification of Employees of Steam Generator and Turbine Engineering Department

3.2 Background of the Case Study (The AT Biopower Project)

According to the huge impact of increased oil price in the countries worldwide has been increased and the increased demand of energy power, Ministry of Energy of Thailand decided to promote the utilization of renewable energy and the Bio-fuel production in the country. There are good responses from private companies and state enterprises to follow the government plan.

AT Biopower (ATB) is a Thai company developing power plants fueled by rice husk, the by-product of Thailand's largest agricultural industry. The ATB Company intends to construct a rice-husk fired electric energy generating plant in Pichit, Thailand. With a power production capacity of approximately 22 MWe (gross), the Generating Unit shall comprise one power block consisting of one biomass fired boiler, a single condensing steam turbine and a generator, and all necessary auxiliary equipment associated with this type of plant. The primary fuel will be rice husk, which will be supplied by the ATB Company, and electric power will be sold to the Electricity Generating Authority of Thailand (EGAT) under EGAT's Small Power Producer (SPP) Program.

The Figure 3.3 shows the model of the standard ATB rice husk fueled power plant. The actual power plan is the cluster of buildings in the center. In the back are stockpiles of rice husk.

Figure 3.3 Model of the Standard ATB Rice Husk Fueled Power Plant

Source: www.atbiopower.co.th (2004)

The scope of work of EGAT to AT Biopower consists of Engineering and Field Service only. Steam Generator and Turbine Engineering Department is responsible for checking the drawings and technical information documents received from the contractor of AT Biopower (ELECTROWATT-EKONO Co. Ltd.). The contract between EGAT and ATB was signed on 4 March 2004. More details of the AT Biopower Project are shown in Table 3.1.

Table 3.1 AT Biopower General Information

Location:	Central Thailand
Project description:	To build, own and operate thermal power plants fueled by rice husk
Plant technology:	Steam boilers specially modified to burn rice husk, based on technically mature and commercially proven technology
Fuel:	Rice husk
Transmission:	Through a 115 kV Provincial Electricity Authority (PEA) line connected to the national grid
Sales of electricity:	Through long-term Power Purchase Agreements (PPAs) with the Electricity Generating Authority of Thailand (EGAT) under the Small Power Producer (SPP) program
Sales of steam:	For paddy drying
Project company:	AT Biopower Co. Ltd.
Project sponsors:	Al Tayyar Energy Ltd., Private Energy Market Fund L.P., Finnish Fund for Industrial Cooperation Ltd., Flagship Asia Corp., Rolls-Royce Power Ventures Ltd.

The objectives of purchasing electricity from SPPs are

1. To encourage participation by SPPs in electricity generation
2. To promote the use of indigenous by-product energy sources and renewable energy for electricity generation.
3. To promote more efficient use of primary energy.
4. To reduce the financial burden of government investment in electricity generation and distribution.

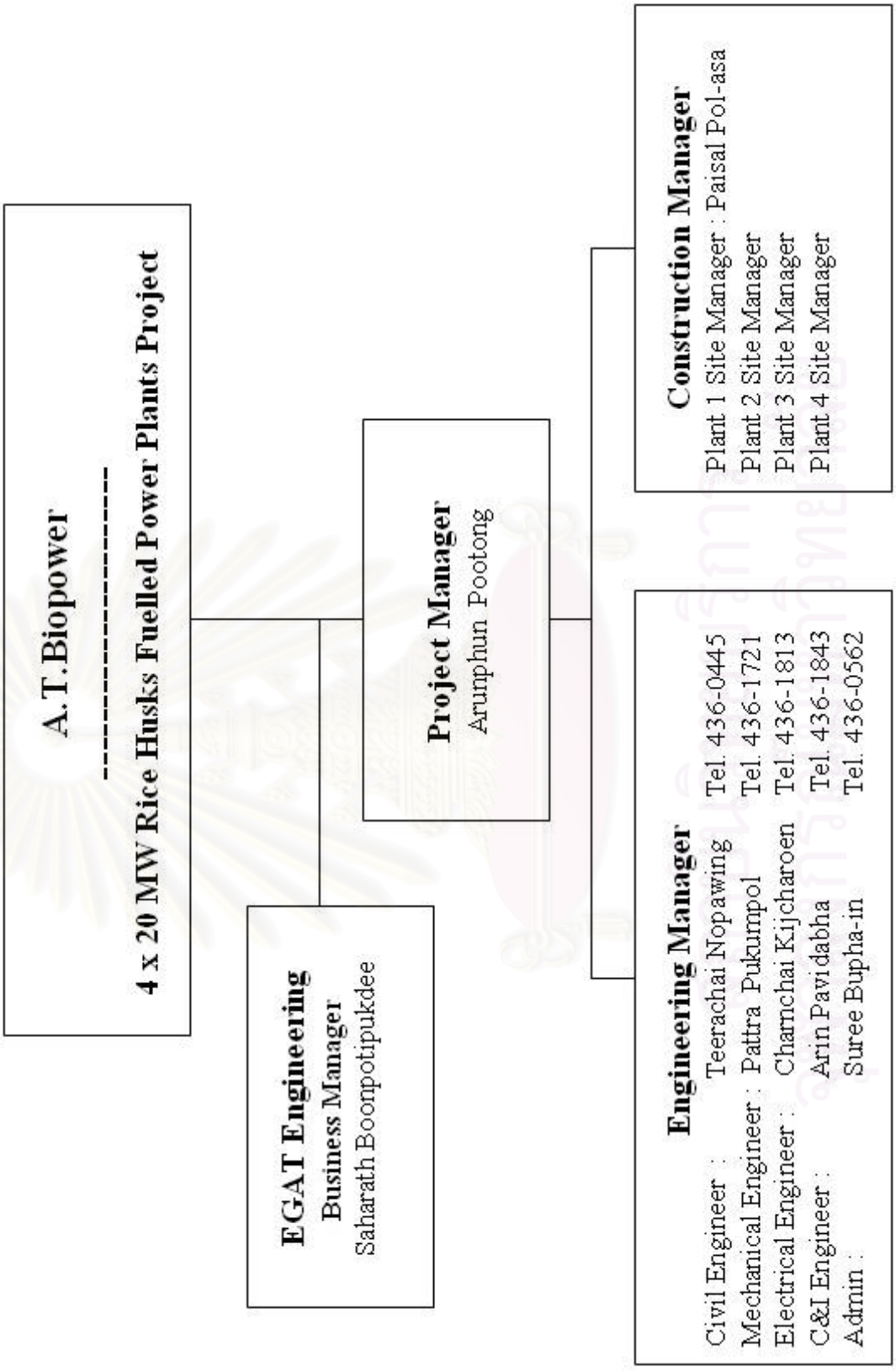

Figure 3.4 Project Organization Chart

4 x 20 MW Rice Husks Fired Power Plants Project: Owner Engineering Services

3.3 Current Product Data Management (PDM) System

In the past, Engineering Business Unit of EGAT typically encounters the problems about using stored information or knowledge as they were kept by various persons in various departments.

Engineering Business Unit has applied the concept of 'Product Data Management' (PDM) throughout the projects as it is capable of storing any kind of electronic documents and is the foundation of Knowledge Management (KM). The PDM system is used as the Engineering Document Management (EDM) in Engineering Business Unit. The system was developed under the Domino Document Manager Program as a *Central Server* and Lotus Notes Release 6.5 as a *Client* to manage the documents related to engineering works of several projects such as correspondence, electronic mail (e-mail), drawing, technical information, contract, minute of meeting, and etc.

The advantages of PDM system described above are as follows;

- The amount of documents in form of hardcopy can be reduced since all documents are stored in the server in form of electronic files instead.
- All documents are stored in the central server (Data Vault) which its hard disk can operate in RAID (Redundant Array of Independent Disks) mode. RAID system may contain several hard disk units working in conjunction with hardware controller and software. The benefits of RAID system are the increased speed and high reliability of document storage and retrieval. Normally, RAID system is capable of repairing failed hard disk automatically without interrupting main activity.
- Users can search for the documents from various projects easier.
- The duplication of document storage can be eliminated.
- The documents are more secured because all electronic documents were controlled by the Data Encryption process.

The table below can demonstrate the flow of the document received from the contractor to EGAT until the document is sent back to the contractor.

Table 3.2 Flow of Document Used in the Project

Item	Process	Contractor	Project Admin.	Discipline	IT Group
1.	Send E-Mail with attached documents				
2.	Storing E-mail and attached documents in EBU Library				
3.	Submit for reviewer				
4.	Detach the document for reviewing or editing.				
5.	Complete review				
6.	Change the document's profile				
7.	Scan the document at size A0		Scan A0	Yes	
8.	Scan the document at normal size (A4)		No		
9.	Storing the document and outgoing E-mail in EBU Library				
10.	Sending E-Mail with attached document back to contractor				

Whenever the Project Administrator (can be one person or a team) receives the electronic mail together with its attached documents such as technical specification, commercial contract, drawings, and so on from the contractor, the Project Administrator will classify the documents regarding to the 'Title' of the document and the 'Project Numbering System' submitted by the contractor that used to help the Project Administrator to store the document in PDM's database more accurately. Then the Project Administrator will store the electronic mail and attached document into the EBU Library and then the electronic mail and documents will be sent to the involved engineering group (Project Management Group, Mechanical Engineering Group, Electrical Engineering Group and Control & Instrument Engineering Group) so that they can review or edit those documents.

However, during the reviewing or editing process, the system will send the 'warning e-mail' to the one who has not submitted the reviewed/edited documents in time. After receiving the warning e-mail, the related engineering group must complete reviewing and editing process and must immediately submit the documents to the Project Administration in order to set the documents' profile and then scan all documents (in case of hardcopies) before sending the documents back to the contractor with outgoing e-mail. All incoming and outgoing e-mails, the attached documents from the contractor and the revised documents from engineering group will be stored into the database of Product Data Management System in EBU Library. The users can search for all stored documents which are already classified into proper project names and document types. More details of document storage will be discussed in next chapter.

CHAPTER IV

Product Data Management's Search System Analysis

In previous chapter, the background of the organization and the case study was studied. The existing Product Data Management of the Engineering Business Unit also was explained. There are a lot of benefits found from the Product Data Management. However, as mentioned earlier, there are some problems occurred in storage system and search system which cause the delay of the routine work and loss of the project.

In this Chapter, the document storage system and the PDM's search system were analyzed thoroughly. The current problems of both systems were also determined.

4.1 Current Document Storage System

Currently, there are two main procedures to store the engineering documents used in the overall projects.

1. For old projects, all the original engineering documents are mostly in the form of hardcopies. To save/store them into the PDM's server, all documents have to be scanned and saved in form of "PDF File" into EBU Library. The documents are classified into type of the document and field of the engineering to make it easier for users to find out.

2. For new projects, all engineering documents from the contractors are mostly in the form of electronic files. Due to new EGAT's regulation, the contractor shall submit all project documents in the form of electronic files instead of papers. Whenever the contractor sends the document via electronic mail, the document needs to have its own specific code (project numbering system). Project numbering system document generated by the contractor must be submitted to the project administrator before the contractor sends the first document. Project numbering system will help the project administrator to grouping the coded documents.

The current document storage system is shown by Figure 4.1.

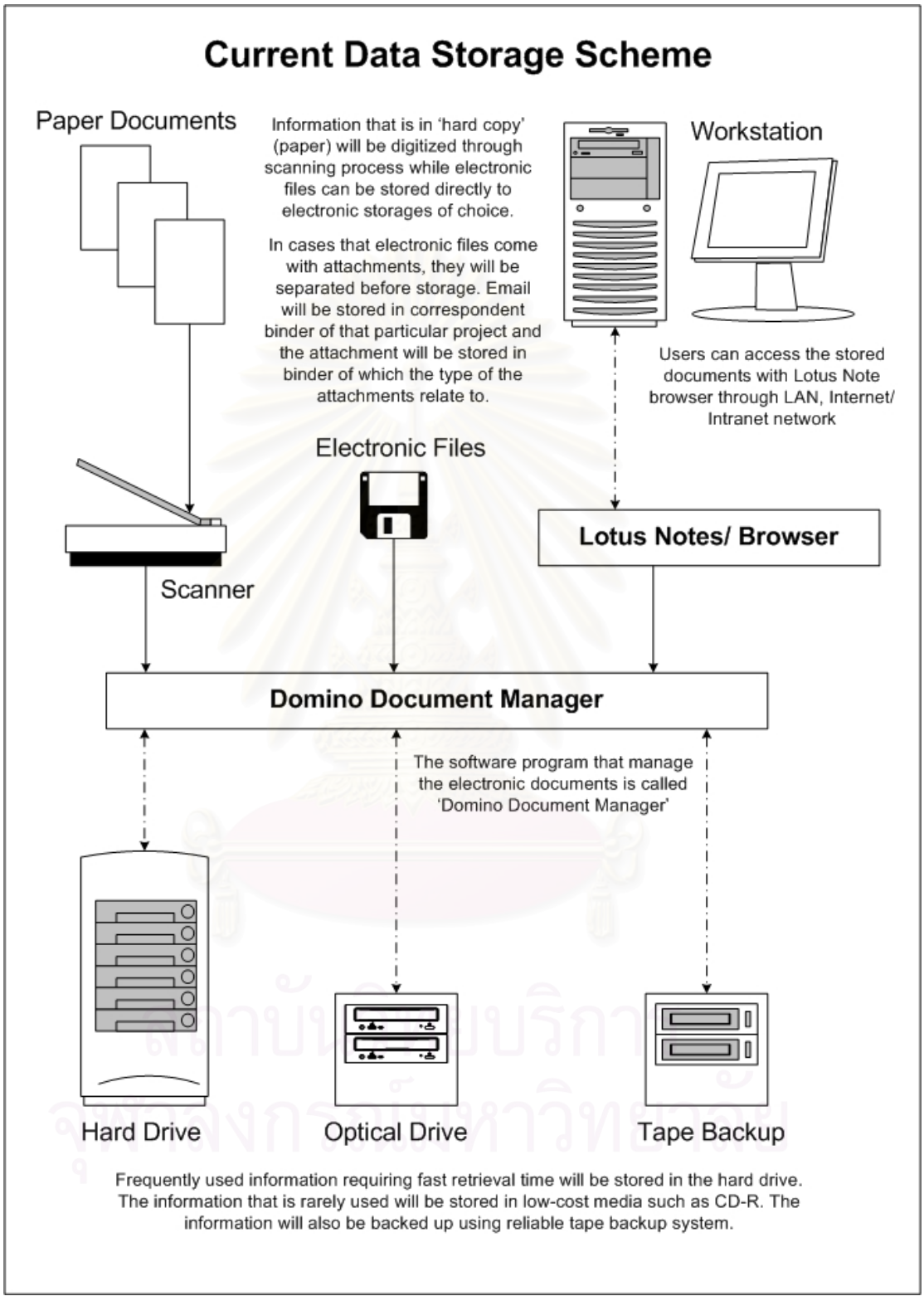

Figure 4.1 Current PDM's Document Storage System

However, the project administrators of each project are not from the Engineering Division but from the Project Management Division of Engineering Business Unit. Normally, the position of the project administrator is selected from the expertise of the English Language of an individual rather than the engineering background. Without engineering background, therefore, the management of document storage cannot be done effectively. Many problems found in many projects related to the ineffective storage system. The major problems of the PDM's document storage system are listed as follows;

- Some documents were not stored in the right place. (i.e. Mechanical Drawing is saved in ME/ Technical Specification binder).
- The details of the document inside are not match to the Title and Description of its document's profile.
- The latest version of document is not updated instantly and is not saved in the same binder of previous version. This causes a big problem when the user needs to use the latest version.

To store the documents from several projects, there must be a standard format of the document storage process. Presently, the Domino Document Manager is built on the familiar storage metaphor of a library or multiple libraries that are comprised of file rooms, file cabinets, binders, and documents. The library structure for the AT Biopower Project is illustrated in the following diagram. In this case, the AT Biopower Project is named as **'L77 Rice Husks Fired Power Plant'**.

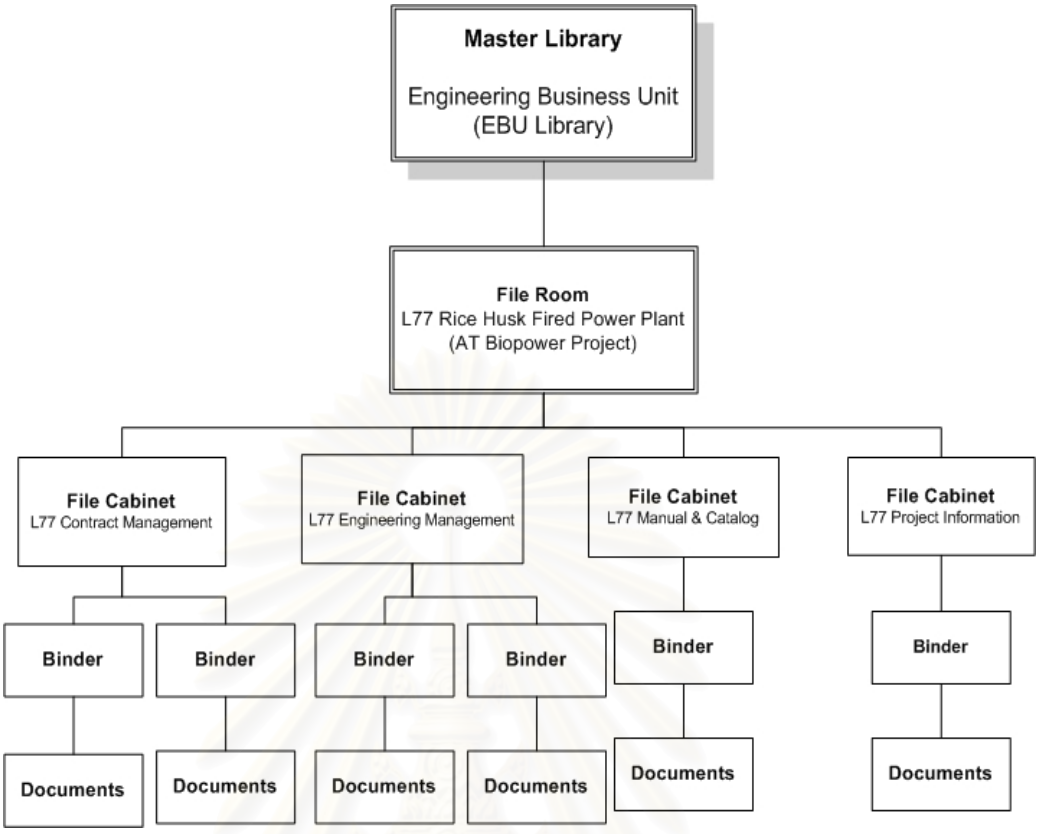

Figure 4.2 Library Chart for the AT Biopower Project

The documents of the AT Biopower Project have been classified into five main file cabinets (as shown in Figure 4.3) which are;

- **Nakornpatom Site**: Storage of documents for Nakornpatom Site
- **Contract Management**: Storage of contract documents.
- **Engineering Management**: Storage of engineering document such as correspondence, drawing, minute of meeting, technical information.
- **Manual & Catalog**: Storage of manual and standard catalog.
- **Project Information**: Storage of general documents about the project.

Figure 4.3 The Structure of AT Biopower File Cabinets

It is very important for the Project Administrators and users to understand the definition of PDM's document storage metaphor. Project Administrators needs to know where the right place to save each document is. Users must also understand the storage structure and its functions which can help the users to find the documents they need more precisely.

- **Library:** The Library is the entry point into Domino Document Manager. There can be multiple libraries within one domain. The library is the main view or home page, from which users can navigate the storage system, perform searches, list and override checked-out documents, and etc.
- **File Room:** File room provides a way to logically group individual file cabinets to facilitate navigation. All file cabinets are contained in a file room. In this case, file rooms are used for categorized documents.
- **File Cabinet:** File cabinets provide a way to logically organize and manage binders and documents.
- **Binder:** A Binder is a container within a file cabinet that logically groups related documents together. The binder points to a particular document database within the file cabinet and uses a view to show a listing of its associated documents. Profile data is associated with every binder to facilitate organization and retrieval of its associated documents. This type of data includes: Title, Description, Reference, Type, Issued Date, Returned Date, Revision, Status, and etc. However, profile data can be different for different binder.
- **Document:** A document is a container for the information that Domino Document Manager manages. The information stored can be a MS-Office file,

PDF file, AutoCAD file, and etc. Each document also has profile data that facilitates document organization and retrieval. Profile for different type of document can be different.

Currently, the documents of each project were stored into binders of each file cabinet. For example, the Engineering Management File Cabinet consists of 6 binders which are correspondence, drawing, minute of meeting, miscellaneous, technical information and not categorized as shown in Figure 4.4. In each binder, the documents are categorized by engineering discipline such as, C&I (control and instrument engineering), CE (civil engineering), EE (electrical engineering) and ME (mechanical engineering).

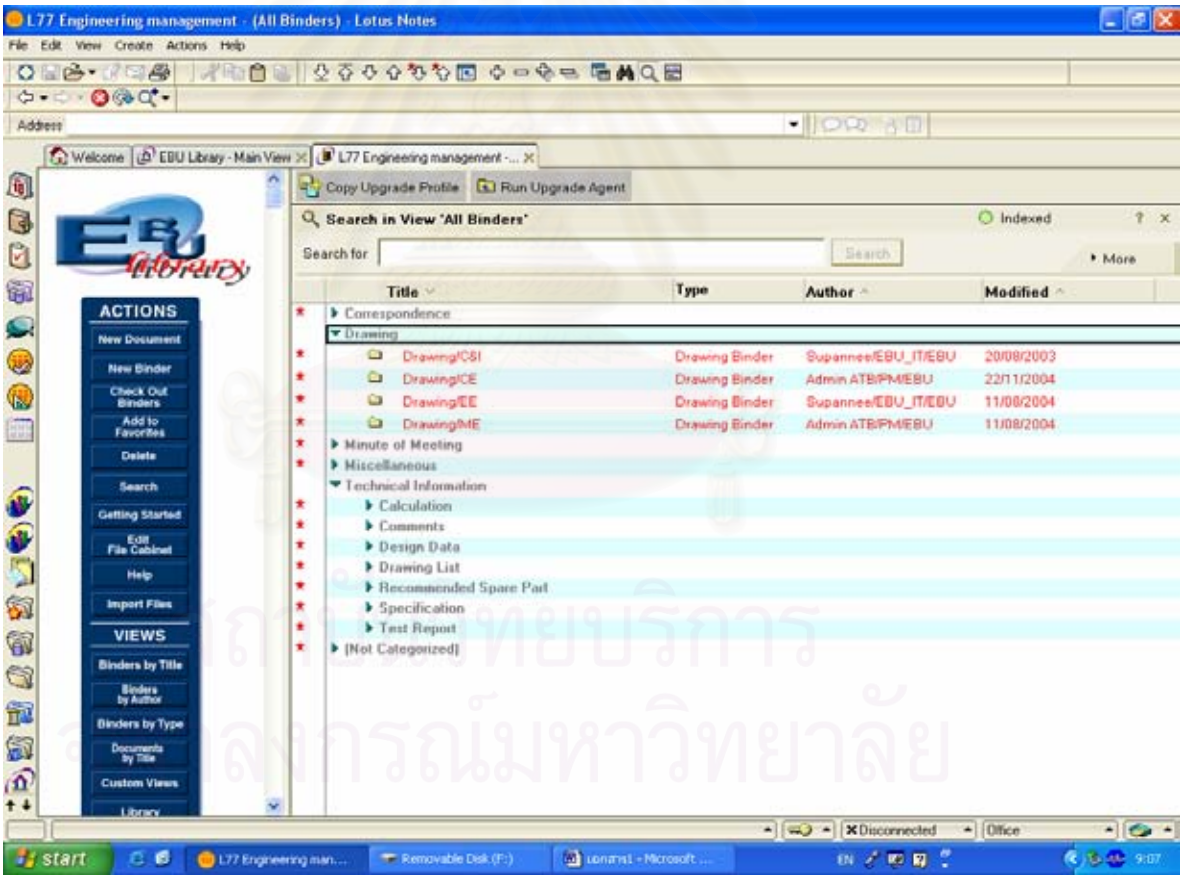

Figure 4.4 Document Binders of Engineering Management File Cabinet

However, this thesis will consider only the documents stored in Drawing/ME Binder and Technical Information Binders (Calculation/ME, Comments/ME, Design Data/ME, Recommended Spare Part/ME, Specification/ME, and Test Report/ME) of the AT Biopower Project as already proposed in the scope of the thesis.

4.2 Current Product Data Management's Search System

Presently, there are 3 different modes available for users to perform search which are simple search, advanced search and search by keyword. Simple search and advanced search are the "Full-Text Search". Search by keyword, the user performs search manually by selecting the interested file room (project), file cabinet, binder, and then search for the documents. The functions of those three search methods are suitable for different type of users. However, the search system must work efficiently in any kind of situation.

According to Domino Document Manager Users' Guide (1999), full-text searching allows users to search the text of the document attachment (provided it is text-based) as well as the document profile. On the other hand, the user can search only the words written in the binder profile only such as title, description, issued date, and so on. Therefore, the search results from the full-text search are a lot more than a search by keyword. To narrow the field of results, the advanced search must be developed by increasing a new search option.

Before moving to the problems of the PDM's search system, the background and the functions of 3 search system of the PDM should be described.

4.2.1 Simple Search (Full-Text Search)

In a simple search, user provides a text string, or words, to search for the documents. To perform a simple search, user must select a "Search" button at the left-handed menu bar. If the user does not select the file room (project name) in library's main view, the system will ask the user to select the project. Users can search across multiple file cabinets they can access within the library and receive a single view of the results or they can select the project they are interested in. After select the file cabinets, users can perform a simple search by specify words or a text string. Every documents in the selected file cabinets whose detailed data, document profiles, binder profiles compose of the provided words will be shown in the search results. It can be

sure that the target documents specified by the user will be definitely found in the search results. Unfortunately, the amount of search results from simple search is normally large. Therefore, the functions of the simple search are not suitable for the users who have a limited time. It might be useful for a new user or beginner who does not know where to search and the one who would like to search for the project he/she is not directly responsible for.

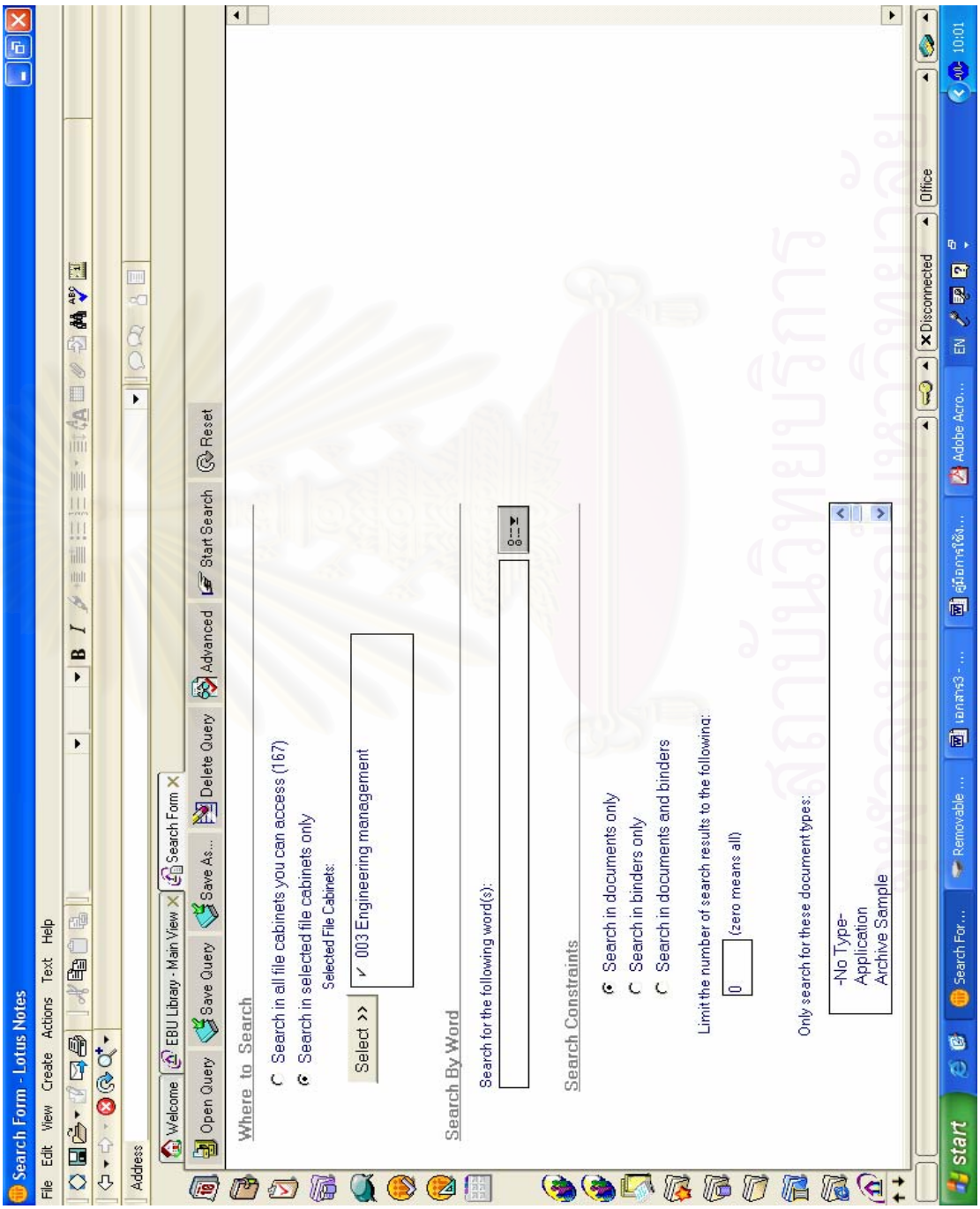

Figure 4.5 Simple Search Users Interface

4.2.2 Advanced Search (Full-Text Search)

By using Advanced Search, user can reduce the number of hits by creating a very customized search string or words to narrow the field, as well as limiting the search to selected file cabinets. The method to select the file cabinet is similar to simple search. Users can select all file cabinets they can access or select only the interesting file cabinet.

Advanced search allows users to refine their search by specifying a list of words and a specific date for the document they are trying to locate. However, the Users Interface of advanced search is not friendly for the users. The system requires a good search background from the users. The beginner or new user cannot perform a search since they do not know how to start and where to start. Therefore, current advanced search are not popular among users. Advanced search is suitable for the one who has a good background of search engine or the one who already passed the training system of the PDM system.

When the search is completed, users are presented with a list of the documents that met the criteria. Users can then select any of those documents to work on – open, edit, check out, delete, move, and so on. The amount of search results of the advanced search is quite less than of the simple search. However, the amount of the results is still large (over a hundred). This is because of full-text search (search throughout the details in every document) and the constraints of the search (only search by word and search by date). The user cannot specify the type of the document that will help to locate the document more precisely and also help to narrow the field. This can point out that the advanced search system needs the improvement.

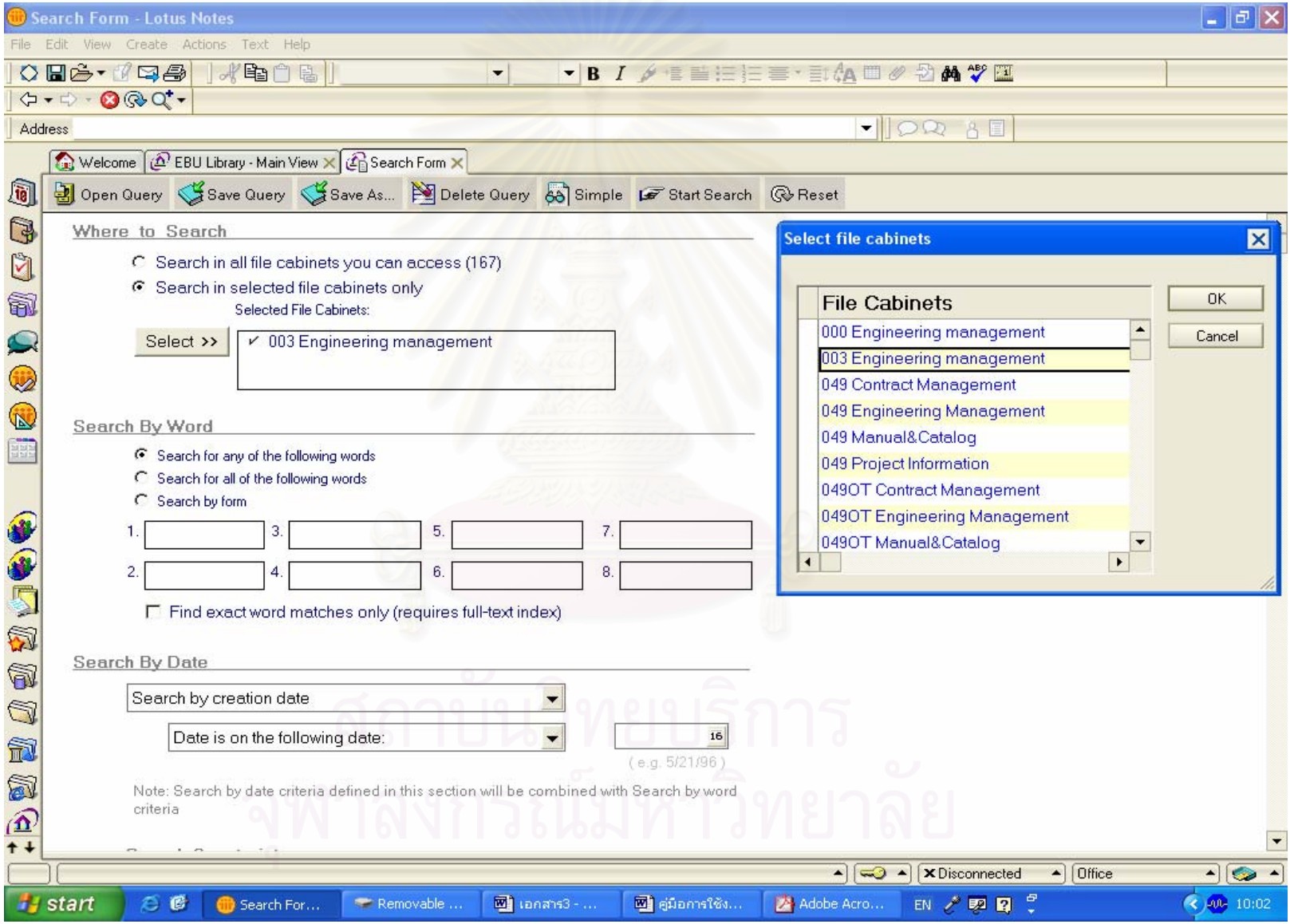

Figure 4.6 Advanced Search Users Interface

4.2.3 Search by Keyword

The last method is the search by keyword. This kind of search is quite easy to perform for anyone who knows well about the documents structure inside the project such as the engineer who directly works with that project or the user who is the project discipline. Users can select the file cabinet from the main view of the EBU library and then locate the binder where the document is belonged to. Users can provide a specific word, or words, or text string to specify the search results in "Search For" dialogue box. Then click "Search" button to start search.

Even though this kind of search seems so easy for the users, the users have to be sure about the location of the document they need to search for. Search by keyword cannot search inside the document details. It only searches on the document profiles. The search results will show the documents which met the criteria in the selected binder. The problem of this kind of search is that the document's description dose not contain the keyword that user provided. For example, user would like to search for the documents about "Boiler", the boiler document whose description does not contain 'Boiler' text will not be retrieved and shown in the search results. This problem leads to the inaccurate of the search system.

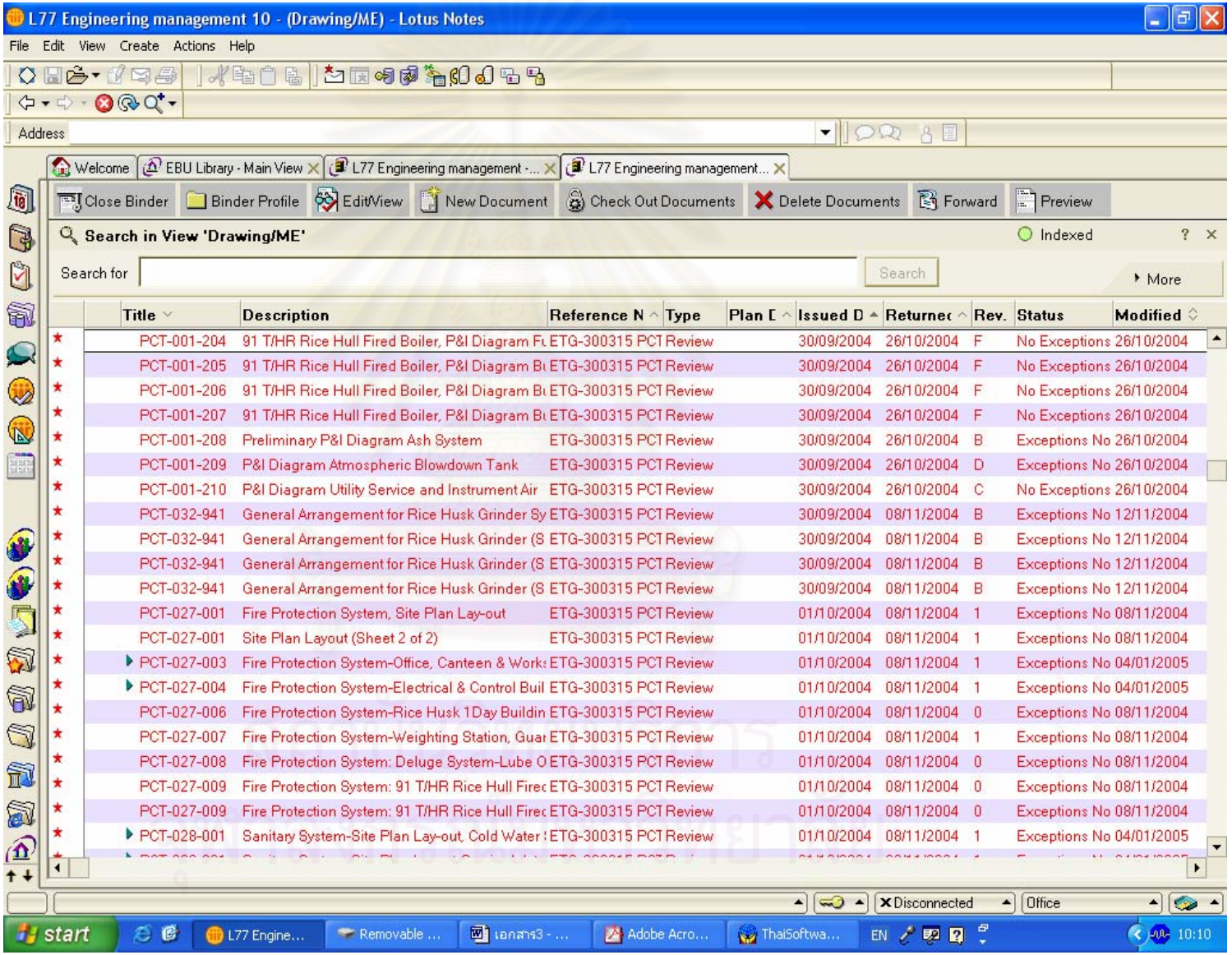

Figure 4.7 Search by Keyword Users Interface

4.3 Current Problems of Product Data Management's Search System

Having analyzed the Document Storage System and the current Product Data Management' search system, the problems of the PDM's search system then can be summarized as follows:

1. There is no standard for document storage system since the documents are classified by using only the project numbering system provided by the contractors.
2. The project administrators, who are responsible for storing the documents received from the contractor at the first stage, have no engineering background.
3. Some documents are stored in the wrong place and some are defined in the wrong document type which causes the misunderstanding of the users and the reduction of the effectiveness of the PDM's search system.
4. The training course for the PDM's users is not efficiently enough.
5. The search user interface is not user-friendly.
6. There is no search constrain for user to specify the document type to limit the results in advanced search.
7. Search by keyword is good to use to limit the search results but the results are quite inaccurate.

There are also many other factors related to the problem of the inefficient search system of the Product Data Management for Engineering Business Unit which can be demonstrated by the Ishikawa Diagram (Fishbone diagram).

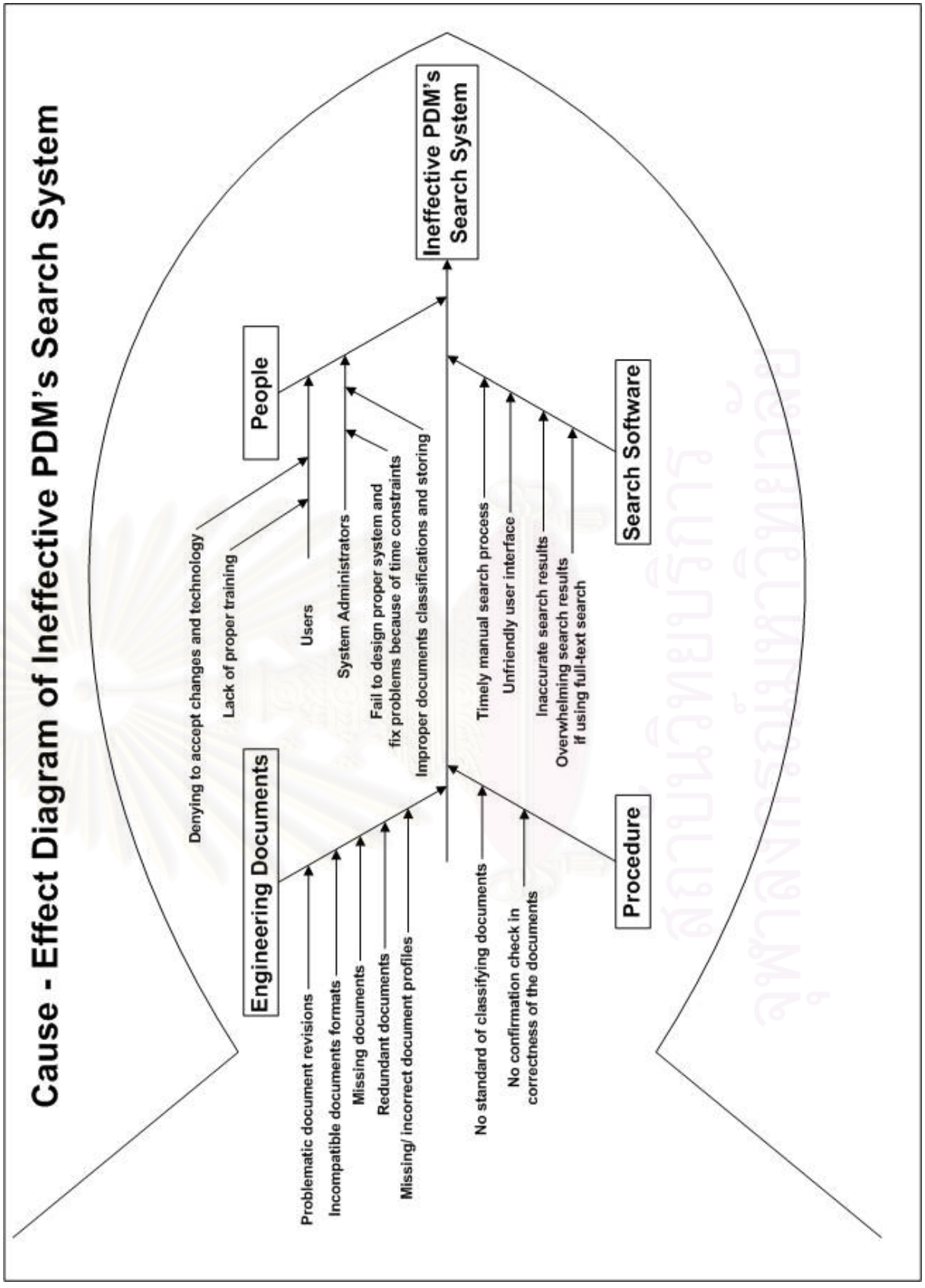

Figure 4.8 Cause and Effect Diagram Revealing Current Problems on PDM's Search System

To develop the PDM's search system for Engineering Business Unit, however, the requirement of the users of the unit must be determined. The users' problems must also be determined. In next chapter, the preparation of the questionnaires both pre-development questionnaire and post-development questionnaire will be discussed. The proposal of the solution to develop PDM's search system will be done after knowing the requirements, the problems and the satisfaction of the users. According to the scope of the thesis, the target users are the employees who work in the Steam Generator and Turbine Engineering Department only.

CHAPTER V

Users' Requirement and Satisfaction Analysis

In order to discover exactly what the target users of the PDM's search system concern, the survey instrument (Pre-Development Questionnaire) was prepared and administered to the target users of the search system. The outcome of the survey was then analyzed and the results of the analysis were used to develop a new search system and to complete the Post-Development Questionnaire, which was designed to test for the users' satisfaction after trying the new search system.

5.1 Survey Instrument Preparation

The survey instruments were prepared in two separate forms with different objectives. The first one, Pre-Development Questionnaire, was designed with the aim to identify the users' requirement of the search system as well as their satisfaction with the existing system. The latter, which is the Post-Development Questionnaire, was prepared for administration the users have tried the new search system for a week. This was to see if the solution proposed could actually fix the problems and finally satisfy the users.

The design of the questionnaire was actually an assimilation of quantitative and qualitative research design. That is; some questions in the questionnaire are closed-question while some others are open-ended depending on the depth of data required in that particular topic.

5.1.1 Pre-Development Questionnaire

The questions resided within the Pre-Development Questionnaire were ones regarding;

1. Personal information (for example, position and responsibility for the projects)
2. Awareness of PDM system
3. Frequency of use of various PDM's system functions
4. Experiences with PDM system's search function
5. Users' satisfaction of existing PDM system's search function
6. Frequency of specified types of document being searched
7. Possible improvement upon search system
8. etc.

For more information on how each question was worded and organized, please see the actual questionnaire in **APPENDIX 1**

At the time of constructing the Pre-Development Questionnaire, the contents of the Post version had, to some extent, already been assumed. However, the actual Post-Development Questionnaire was completed after the information regarding users' satisfactions, requirements and probably expectations were provided and the questionnaire was tailored to accurately test them. The questions in the Post-Development Questionnaire will be discussed shortly after determining the users' requirements and satisfactions from the Pre-Development Questionnaire.

5.1.2 Bias, Reliability, Validity and Ethical issues

Bias

The researcher had attempted to avoid various forms of bias previously discussed in Chapter 2 (Literature Review) by carefully selecting research procedure, studying in the way to create proper, unbiased and politically-correct questions and also having the questionnaire piloted once before the actual administration. However, there may be some unacknowledged bias existing in the revised versions of the Pre/ Post-Development Questionnaire.

Reliability

To obtain the maximum reliability, all of the reliability tests including *Test-retest, Alternate form and Internal consistency* should be performed. However, this is quite difficult to achieve in practice unless time, budget and other necessary resources are allowed for.

In this research, *Test-retest reliability* was not measured as the questionnaire would be administered once. However, this could be possible if some other researchers decide to take this research further: administering the questionnaire to the same of very similar group of respondents. *Alternate form reliability*, which the type and/ or wording of questions are different but still have the same meaning, was not measured either because of the limitation of time undertaking the research project. On the other hand, according to Black, T.R. (1999), *Internal consistency reliability* could

be easily measured using various methods, for example, Spearman-Brown Split-half, Cronbach or Kuder-Richardson KR20, 21, however, as there was only a single question per subject, it was impossible to carry out any type of Internal consistency reliability measurement, which requires at least 2 questions per the single subject.

As a result, there was no guarantee whatsoever in the reliability of questionnaire. Even though the researcher and the expert were subjectively agreed upon the appropriateness of the questions, they might not objectively measure the expected concept.

Validity

While the questionnaire has successfully passed the test for *Face validity* (i.e. close friends of the researcher all reported that the questionnaire look fine to them) and *Content validity* (i.e. the expert (IT manager/ programmer agreed upon the appropriateness and correctness of the questionnaire.), *Criterion validity* and *Construct validity* were fairly problematic. This was because the lack of access to the 'Gold Standard' survey instrument for assessing search system's user requirements and satisfaction (used for measuring *Criterion validity*) as well as the access to experienced investigators (who are able to assess the questionnaire's *Construct validity*).

Ethical Issues

Steps had been taken to ensure minimum ethical issues in this research project. For instance, the users had been properly informed about the research project, questions were asked based on the necessity, not the luxuriousness, an inclusion 'neutral' response in the questions indicating that this particular choice is essentially acceptable. And even if some user's personal information is required, it will only be used for educational purposes and kept cautiously.

5.2 Determine Users' Requirement and Satisfaction from Pre-Development Questionnaire

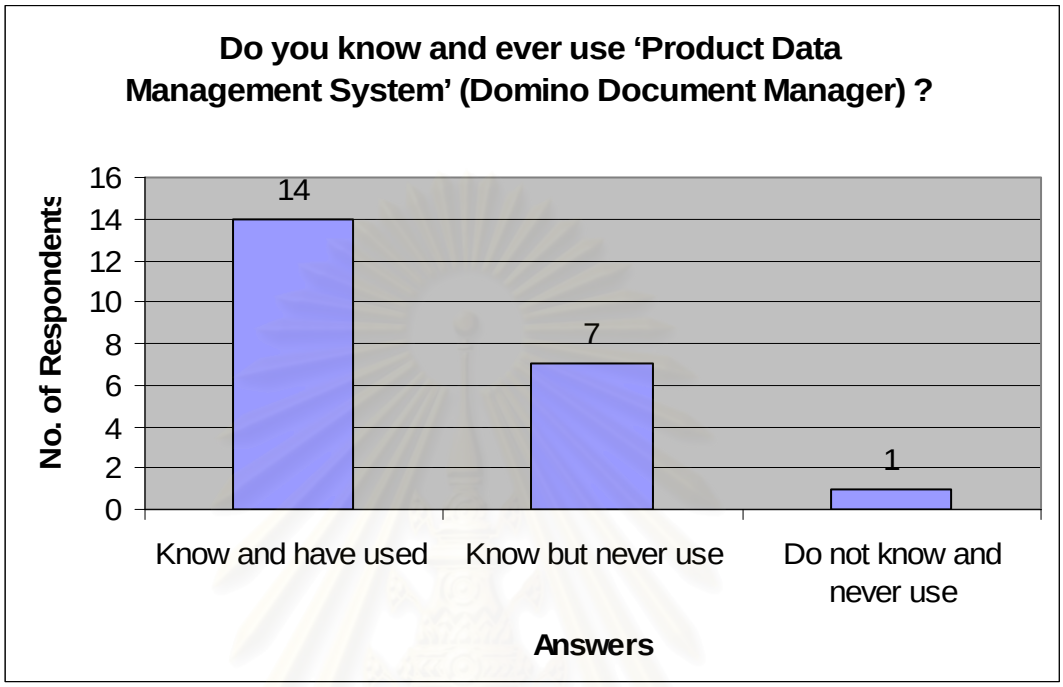

Figure 5.1 The Responses of the Users to the First Question - Do you know and ever use 'Product Data Management System' (Domino Document Manager)?

The first question on the first survey was asked to see the ratio of the persons who knew and have used the PDM system before to those who did know but never use as well as those who did not know and apparently never use the system. According to Figure 5.1, the results were that about two third of the target users (14 out of 22) did know the PDM system and have used it before. Only one person was not aware of and never used the search system.

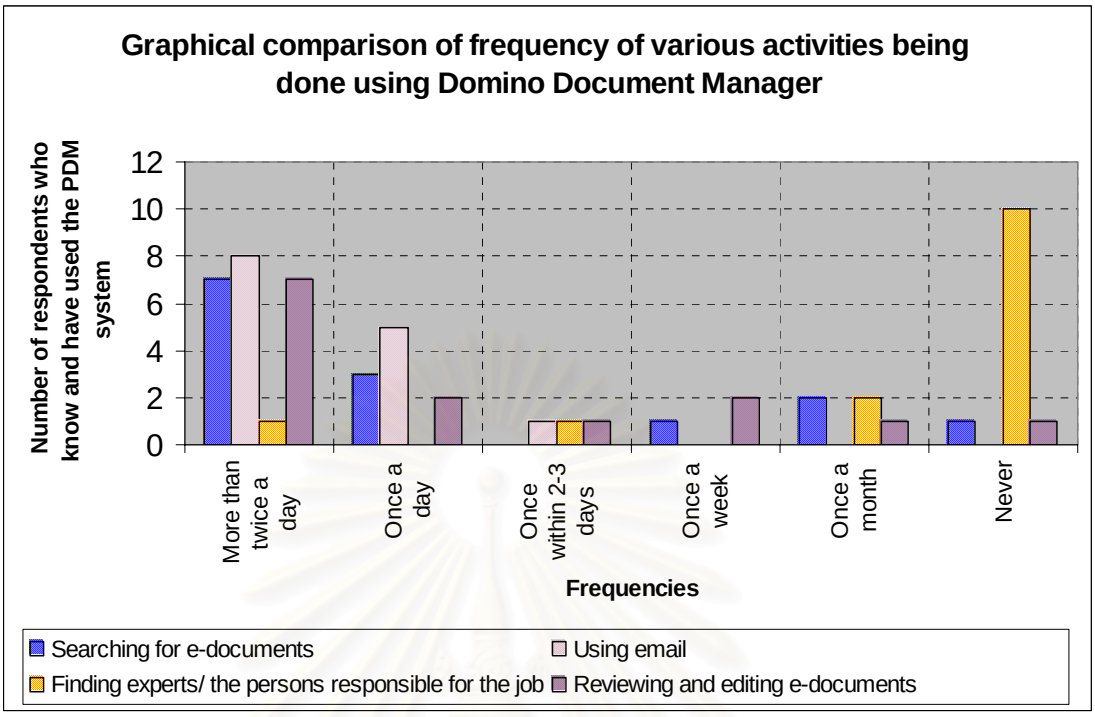

Figure 5.2 The Responses of the Users to the Second Question - If you do know and have used 'Product Data Management System' (Domino Document Manager), how often do you do the following activities?

The second question asked that if the users know and have used 'Product Data Management System' (Domino Document Manager), how often they do the following activities and specified ones if they were not included. The activities included in this question were;

1. Searching for electronic documents
2. Sending electronic documents through e-mail
3. Finding experts or persons who are responsible for the job
4. Reviewing and editing electronic documents
5. Others (specified by the users)

As shown in Figure 5.2, it appeared that searching for documents, e-mailing and reviewing and editing documents were the most frequently done activities with votes from more than half of the respondents who knew and have used PDM system. Note that the reason that e-mailing was the most frequently done activity may be that

it was used in both personal and business affairs (from the observations made by the researcher and some qualitative data from the users). And while the frequencies of searching and reviewing/ editing were equal, the higher weighting somewhat goes into searching activity because to search for the documents is the main routine jobs of the users who use the PDM system. It relates to the quality of the engineering works.

According to the feedback from the users in this question, the activity that was rarely done was finding experts or persons who are responsible for the job. This was probably because majority of the population being surveyed are not in high profile positions such as project manager, division manager, etc., which this activity may be more important to them than employees with the lower positions. In addition, one user specified that some other activities that had been done were calendaring and checking project costs and man-hours calculation.

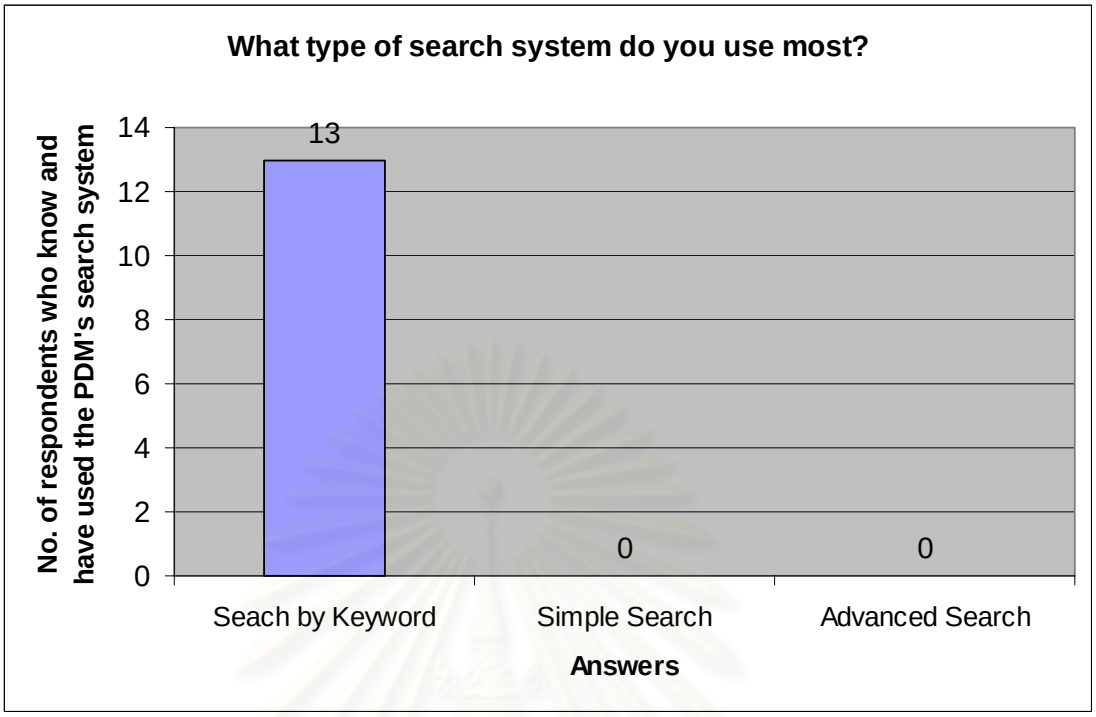

Figure 5.3 The Responses of the Users to the Third Question - If you have used 'Search' function of Product Data Management System (Domino Document Manager), which type of 'Search', have you use most often?

The third question was about the most frequently used type of search system. Noted here that this question only applied to 13 respondents who have used the PDM's search system as shown in Figure 5.2. According to Figure 5.3, the result was that all of 13 respondents used "Search by Keyword". This means that they basically search manually through file cabinets and binders until reaching the desired binder, then use 'Search by Keyword' function. It is undeniably that the time taken using this method can be less than using proper full-text search system if the users do know exactly where the documents are stored. However, the reverse is likely true; it can take much more time searching when the exact destination of file is unknown by using manual, try-and-error searching through binders and folders.

An informal interview with some of the users revealed that the reason that all of the respondents who know and have used the PDM's search system typically manually search for the intended documents was that either they knew exactly where

to find them (hence taking less time than using search system) or do not know exactly how to properly use search system.

Considering the responses from the second question in conjunction with the responses from this question, it can be noticed that while the users frequently search for the documents, they generally did that by manually searching through file cabinets and binders and used “Search by Keyword” function. Having mentioned earlier, the effectiveness of searching by this method depends largely whether the users know where to find what they want.

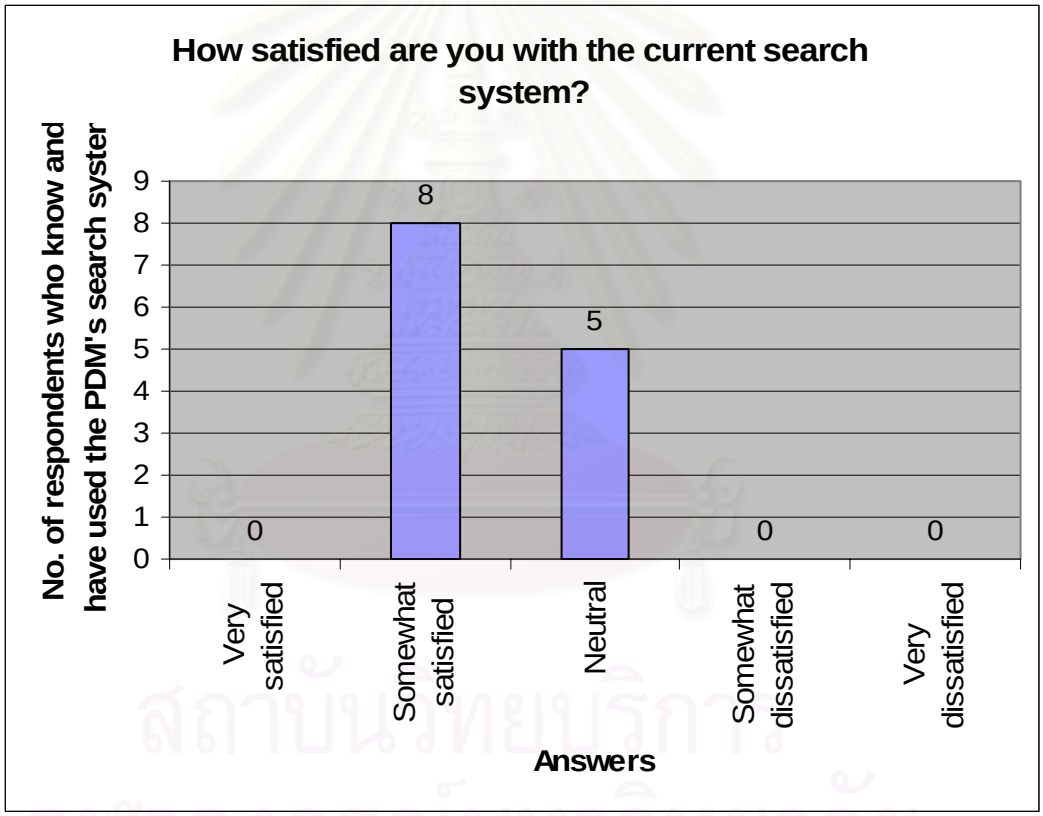

Figure 5.4 The Responses of the Users to the Fourth Question - If you have used ‘Search’ function of Product Data Management System (Domino Document Manager), how satisfied do you feel?

Questions 4 and 5 are continuous ones. The fourth question examines the users’ satisfaction upon the current search system and the fifth question asks the reason behind the answer of the fourth question.

In terms of the fourth question, the findings were that more than half of the respondents who know and have used the PDM's search system are somewhat satisfied, while 5 from 13 have "neutral" feelings for the search function.

From the third question, all 13 respondents indicated that they most often manually search for desired documents. However, in the fourth question, according to Figure 5.4, more than half of them (8 persons) noted that they were somewhat satisfied with the current search function. This reflects that probably unless the documents can be found faster and more convenient by search system than manually searching in file cabinets and binders, there may still be no use of the PDM's search system at the end.

The results from the fifth question varied with attitude and experience of the respondents. The summarized answers from them are listed as followed;

For those who were somewhat satisfied with the system.

1. The existing system is not too hard to search for documents.
2. Advanced search is time consuming.
3. Simple search is very easy to use but it generates a thousand of search results.
4. Easy and convenient to use.

For those who were neither satisfied and nor dissatisfied (neutral).

1. Some works regarding, document storing and organizing must be improved first before smoother and easier search can be achieved.
2. The data storage structure is complex and makes manual search a difficult task.
3. Sometimes, the document cannot be found.
4. The existence of search system does not result in any improvement on daily work.

The reasons behind the satisfaction/dissatisfaction of the search system clearly stress the fact that when the exact destination of the desired documents is unknown, manual search can be quite a difficult task. Also, the respondents pointed out the current search system still need some improvement to be practically useable.

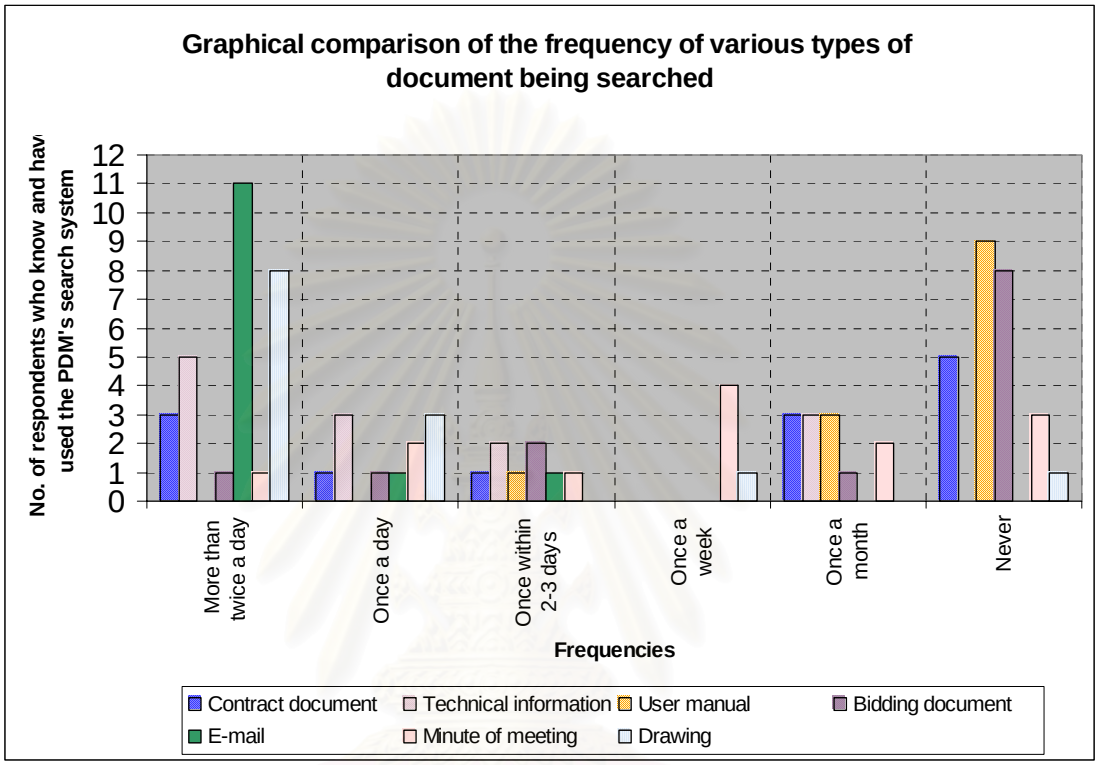

Figure 5.5 The Responses of the Users to the Sixth Question - Normally, how often do you search for the following documents?

The sixth question was designed to determine the types of document that the users often search for. There were 7 types of document specified in the question including;

1. Contract document
2. Technical information
3. User manual
4. Bidding document
5. E-mail

6. Minute of meeting
7. Drawing

As indicated in Figure 5.5, e-mail, drawing and technical information were the most frequently searched for documents, while user manual, bidding and contract document were rarely or never get searched.

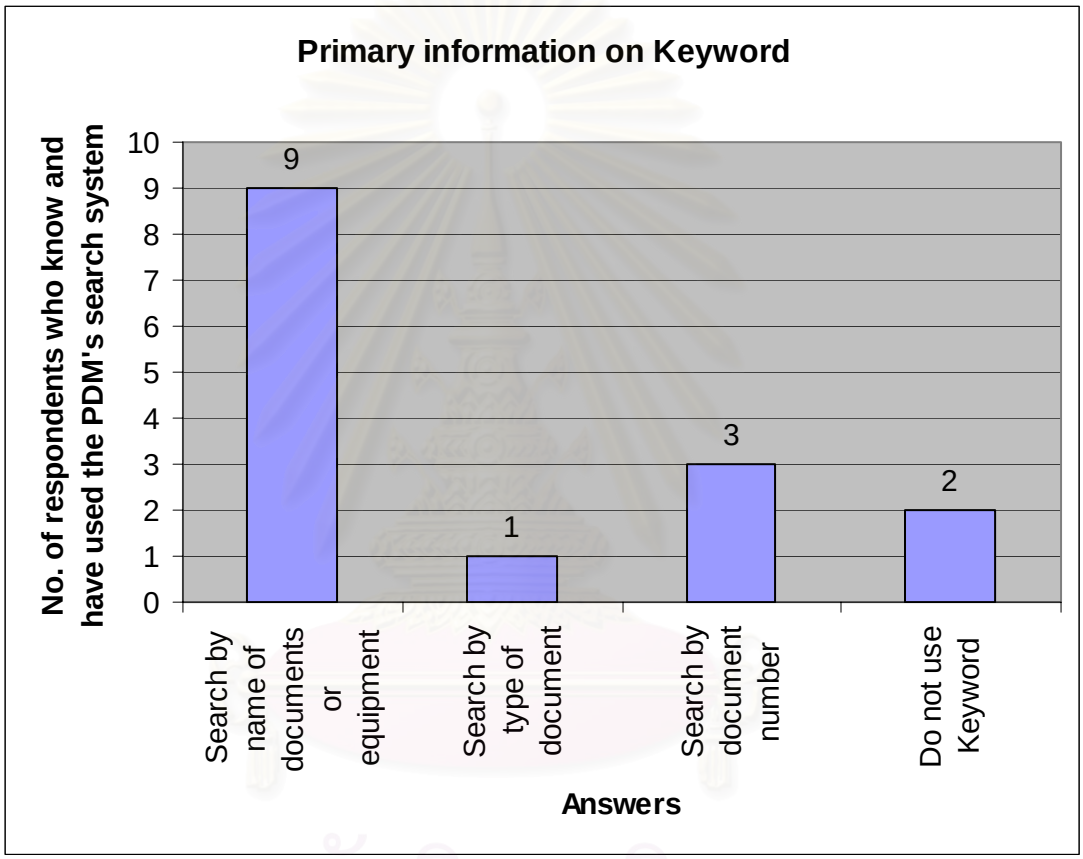

Figure 5.6 The Responses of the Users to the Seventh Question - Primary information regarding the respondent's use of keyword

The seventh question, which was open-ended, asked about the keywords the respondents use when searching for the desired documents. The outcomes, as illustrated in Figure 5.6, were that the majority of the respondents would use the name of document or equipment as a keyword. For example, Boiler, Turbine and Pump. However, for those who knows the document reference numbers, they would use them for the enhancement in precision of the search results. Sometimes, as reported

by one user, a type of document can be used as a keyword. However, this often results in large, overwhelming amount of search results. In addition, some respondents did not use any keywords. This was probably because either they did not use search function as often as others or they knew exactly where the desired documents located in the database.

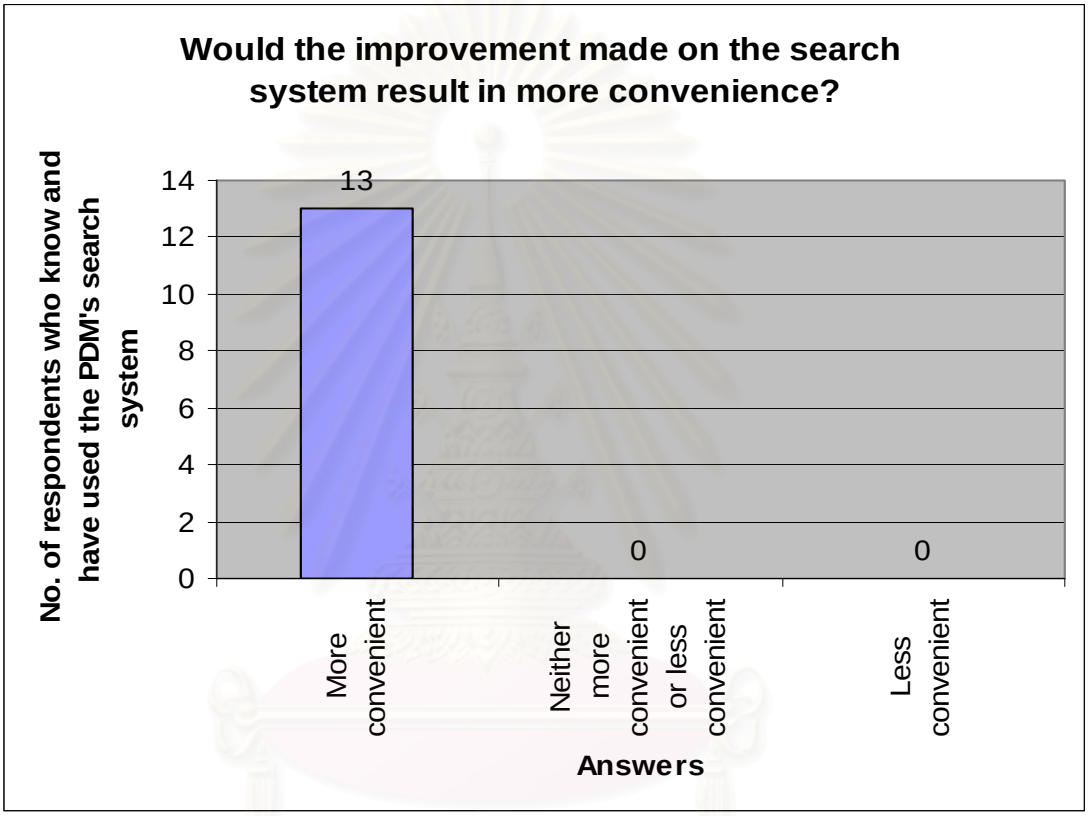

Figure 5.7 The Responses of the Users to the Eighth Question – Do you think that such improvements in the system will lead to any more convenience in using the system and why?

The eighth question asked if there are improvements made to the search system by providing lists of project names and document names, types of document as well as definition of each document in detail and the user can still use the old system to search for required document, would this result in any more convenience for the users. A brief reason for the answer selected was also required for this particular question.

From Figure 5.7, it seems clear that all of the users agreed that improving the search system in such way would bring more convenience into the workflow, however, the reasons of the agreement may vary depending on their attitudes and experiences with the system.

The reasons by the respondents are listed as followed;

- More convenient, as the span/ amount of information being searched through is limited.
- More convenient, as the documents are properly categorized and this should reduce time searching for the documents.
- More convenient, although not much, as the users often know the documents' codes and where to find them.
- More convenient, as the accessibility to information is improved
- More convenient, as it is unnecessary to specify the binder before searching for documents like before.

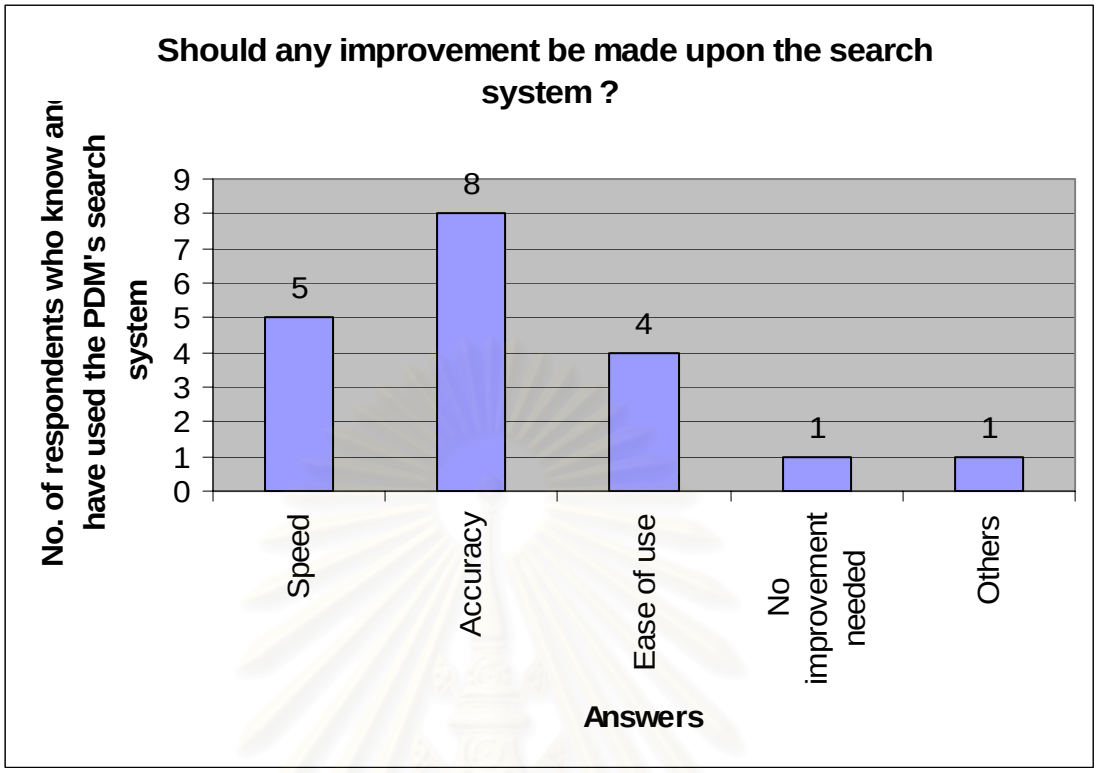

Figure 5.8 The Responses of the Users to the Ninth Question – Overall, do you think in which areas the 'Search' functions of Product Data Management (Domino Document Manager) should be improved?

The last question (the ninth one) asked the respondents if any improvement can be made to the search system given choices of answers including speed, accuracy, ease of use, no need for improvement and others (specified by the users).

According to figure 5.8, accuracy of the search system was a point to be improved agreed by more than half of the respondents followed by speed and ease of use respectively. One of the respondents felt quite satisfied with the existing system and commented that improvement was not necessary while the other user stressed on more specific problems regarding the speed of advanced search, the flexibility of the search function as well as the updating process of the documents.

In conclusion, approximately 2/3 of targeted users know and have used the PDM system before (14 out of 22). The functions of the PDM system that have been mostly used were emailing, searching, reviewing and editing documents. While the users specified that they frequently searched for documents, they searched manually. This means the users have to know where to find that particular document first, then went through File Cabinets and Binders and typed in Keyword to search for document within the desired Binder. Therefore, unless the rough destination of the documents were known, it could take several minutes or even hours trying to locate the desired documents.

In addition, according to the results from the questionnaire, the users usually type in name of the equipment or title of documents when performing search. And while many of the users were quite satisfied with the performance of search system (manual search), every single user still wanted a superior search system. Besides, they suggested that the accuracy, speed and ease of use should be the main areas for improvement.

5.3 Post-Development Questionnaire – Survey Instrument Design

After the prepared Post-Development Questionnaire was modified with the feedback from the first survey in consideration, the selected questions for the post-test include questions regarding;

1. Users' satisfaction regarding the convenience, accuracy and speed of search system
2. Essence and benefits of system code
3. Benefits of program orientation and user manual
4. Possible problems
5. Possible improvement upon search system
6. Suggestions from users

The Post-Development questionnaire was administered to the target users for a week after the introduction of the improved search system to them. During that week, the users were encouraged to use the search system as often as they can to increase the accuracy of the answers and feedback from the users as much as possible.

Findings from the Post-Development questionnaire would be discussed in Chapter 7. The actual Post-Development Questionnaire can be found in **APPENDIX 2**.

5.4 Proposal of Solution

Having analyzed the current PDM's search system, the documents storage system, the problems in current situation in Chapter 4, and the users' requirements in this Chapter, it is proposed that,

1. The storage of mechanical drawings and technical information documents of the AT Biopower Project (as the thesis's scope) should be improved by increasing the accuracy during the document classification or grouping process to standardize the document storage system. This method, the appropriate system code will be used to group the equipment type for the specified documents. **(The design of the document storage system will be discussed in Chapter 6)**

2. The development of the search system which can provide the function that the users can specify the type of the document and the group of the document to narrow the amount of the search results with high accuracy. This function can be called **"Search by Form"** function. This type of search is more feasible than developing the list of keyword (as questioned in question 8). Because the users normally know the basic keyword to search. To provide a hundred lists of keyword would increase work-load and time to the users. **(The development of PDM's search system (Search by Form) will be discussed in Chapter 6)**

3. The development of the search users interface to be friendly for all type of users' search background. **(Further Detail in Chapter 6)**

4. The measurement of the performance/effectiveness (accuracy and speed) of the developed search system would be carried out once after the researcher finished developing the new search system to see if the goals/ objectives of this thesis were well accomplished. **(Further Detail in Chapter 6)**

5. Questionnaire would be used to measure the users' satisfaction after they have tried the developed search system for a week.
   (Further Detail in Chapter 7)

6. The development of developed search system manual for the target users to ensure that the users can use the developed search system more correctly and more efficiently. **(Further Detail in Chapter 7)**

By doing so, the specified users can improve their search efficiency and can reduce time spent during using the system which leads to the reduction of the overall project delay. The developed search system and its developed users interface are more friendly and easy to use for all type of users without regarding to the level of users' search background and the level of authority of the users. Moreover, the satisfaction of the users will be increased due to the increased search's accuracy, speed and convenience.

CHAPTER VI

Development of Product Data Management's Search System

According to the existing problems found in the document storage system, the Product Data Management's search system, and the problems and requirements of the Steam Generator and Turbine Engineering Department's users, the proper document storage system and the PDM's search system must be developed to reduce such problems and enhance the efficiency of the system itself.

In this chapter, the document storage system was developed by using the most appropriate system code as a standard classification system to group the document. The overall mechanical drawings and technical information documents were re-classified during this process. Next, the PDM's search system was designed to fulfill the users' needs and to increase its capability and its efficiency. The users interface of the new search option would be designed to be friendlier for the users. The old and new search results would also be compared in this Chapter.

6.1 Design of Document Storage System

According to the problems of the PDM's document storage system analyzed in previous Chapter, the document storage system requires a system that is capable to specify the group of the document more accurately. Apart from the document classification by the document type (i.e. drawing, correspondence, contract, and etc.), the documents must be classified by the power plant systems or the items of equipments. From the results of users' requirement and satisfaction analysis by using Pre-Development Questionnaire, almost all of the users use the name of the equipment as a keyword such as Boiler, Turbine, Pump, etc. Therefore, to develop the document storage system to locate the document by providing its group name would be helpful. These group names will be used as a **"Drawing Reference"** for drawing document and as a **"Document Reference"** for technical information documents both in the documents' profile and in the developed search users' interface.

Normally, the documents received from the contractors are mostly identified by **"Project Code"** or **"Project Numbering System"**. The format of numbering system for different type of documents is different. For drawings and technical information document types, the documents are identified by **"System Code"**. Being able to know and memorize the System Code is the best way to perform a search efficiently but it is very difficult to do. Moreover, the system code is different from project to project which definitely increases load and confusion to the users. Therefore, the most suitable system code must be selected to use as a standard system code for all projects.

In this thesis, three different system codes are taken into account for the classification of mechanical drawings and technical information documents of the AT Biopower Project. These codes consist of;

1. Original system code of AT Biopower Project developed by ELECTROWATT-EKONO Company.
2. System code developed by KKS (Kraftwerk-Kennzeichensystem)
3. System code developed by BVI (Black & Veatch International Company)

The reason that the researcher selected only those three systems is because presently, EGAT requires the contractors to supply all documents by using only either KKS or BVI Project Numbering System Code to use in the power plant project. However, for small projects such as biomass power plant project, to force the contractor (normally is small and medium company) to use international system or to upgrade the original system code to KKS or BVI system is very difficult and costly. Therefore, any system code is acceptable for biomass power plant project.

All of the three system codes mentioned earlier will be discussed in more details in the next section. The most appropriate system code will be selected to use to classify the documents into appropriate group which increases the efficiency of the document storage system and search system.

6.1.1 Selection of the System Code

6.1.1.1 Original System Code of the AT Biopower Project Developed by ELECTROWATT-EKONO Company.

After signing the contract between EGAT and the AT Biopower Co, Ltd. ("Owner"), the owner's contractors (ELECTROWATT-EKONO Company) shall submit the "Project Numbering System" as information to EGAT in order to know the documentation system. Drawing Numbering Format and Technical Information Numbering Format are the same as the followings;

Drawing/Technical Information Numbering Format

A – BC – D.dwg

A	=	Site locations (PCT = Pichit)
B	**=**	**Two digit account number**
C	**=**	**One digit system number**
D	=	Sequential number (3 digits)
dwg	=	Standard Code Extension

In this thesis, the code that can represent the document group or document classification of the numbering system is taken into consideration only. In this case there are two codes (account number and system number) represent how the drawing and technical information can be classified.

Two Digits Account Number (B) is described as follows;

Account	00	Process
Account	01	Civil
Account	02	Structural and buildings
Account	03	Boiler plant
Account	04	Turbine plant
Account	05	Vessels / Tanks
Account	06	Fuel handling system
Account	07	Piping
Account	08	Water treatment system
Account	09	Cooling water systems
Account	10	Electrical
Account	11	Instrumentation & Control systems
Account	12	Other equipment
Account	13	Erection works
Account	14	Painting and Insulation
Account	15	Start-up and commissioning
Account	16	Freight forwarding
Account	17	General

According to the results from Pre-Development Questionnaire, the users mainly search by using the name of equipment or system as a keyword, the ‘Two Digits Account Number (B)’ is not appropriate to be a standard system code for PDM’s document storage system because the account number can be classified the documents into main equipments only. For “One Digit” System Number (C)’, this system is also not appropriate to use as a standard system code. The system number only divides the main equipment into main engineering disciplines such as electrical, mechanical, civil which is difficult for the users to specify the document more accurately by using this system number.

The problems of Original System Code of the AT Biopower Project which is not proper to be used as a standard system code that going to be used for the development of existing document storage system are summarized as follows;

1. The classification of the equipments/systems of the power plants is too broad.
2. Using digits to code the documents make the process cumbersome as the digits are difficult to memorize and are not literally related to the types of document.
3. The system code is specific to ATB project only; cannot be used with any other projects.

6.1.1.2 System Code Developed by KKS (Kraftwerk-Kennzeichensystem)

According to the Kraftwerk – Kennzeichensystem (1995, p.6), the Identification System for Power Stations “KKS” serves to identify plants, sections of plants and items of equipment in any type of power station according to task, type and location. It is to be used by all engineering disciplines for planning, licensing, construction, operation and maintenance.

Since 1991, there are three sections of the Identification System for Power Stations containing the keys for functions, equipment units, and components have been issued as a PC program as well as in printed form. In this thesis, only the system of the 4th edition (1995) will be discussed.

KKS standard code consists of types of code and breakdown levels such as process-related code, point of installation code, and location code. In this case, only the system code which is the second level code of the process-related code will be discussed. Because the equipment unit code and component code just classify the system into engineering disciplines (e.g. mechanical, electrical).

To make it more understandable, the titles of the breakdown levels of the three types of code are shown as follows:

Table 6.1 Breakdown Levels of the Three Types of KKS Code

Serial no. of breakdown level	0	1	2	3
Process-related identification	Total plant	System Code	Equipment unit code	Component code
Point of installation identification	Total plant	Installation unit code	Installation Space code	
Location identification	Total plant	Structure code	Room code	

The system code of KKS comprises of the designation of data character and type of data character as shown in Figure 6.1.

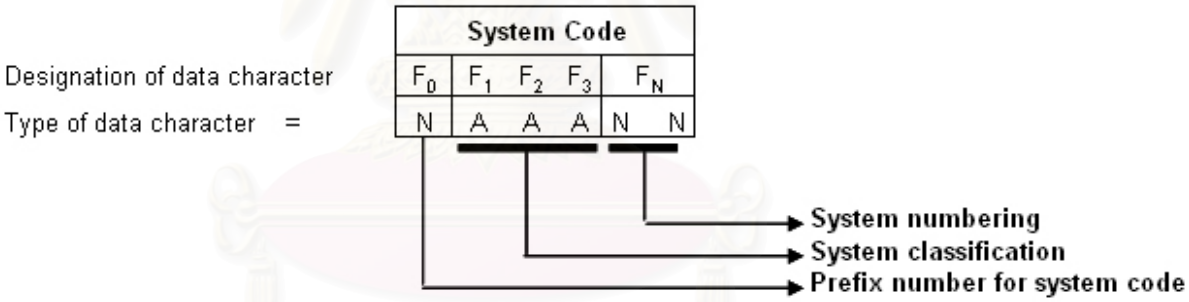

Figure 6.1 KKS System Code

- **Prefix number for system code**

Within the parts of a power station identified on breakdown level 0 the prefix number applies only to the system or plant which is classified in the subsequent alpha data characters.

- **System classification**

Coding letters and designations of the main groups F_1 as given in the Function Key:

A Grid and distribution system

B Power transmission and auxiliary power supply

C Instrumentation and control equipment

D Instrumentation and control equipment

E Conventional fuel supply and residues disposal

F Handling of nuclear equipment

G Water supply and disposal

H Conventional heat generation

Etc.

The subdivisions in F_2 and F_3 are given in the applicable Function Key.

- **System numbering**

Numbering starts anew when one of the preceding code element changes. The F_N code element has no generally – applicable classification.

Having described the breakdown level of Identification System for Power Stations “KKS” and its system code, KKS serves to unambiguously identified plants, sections of plants, and items of equipment. It is also applicable for all engineering discipline which can be used for planning, construction, and maintenance. However, the system code of the KKS standard may be inappropriate to use as a standard system code for the development of document storage system for the AT Biopower Project. The concerned points are listed below:

1. The breakdown level of KKS system code is too complex to use as a system code for document storage system and for searching process.
2. The system classification of the KKS system code is not classified into the equipments or items of the power plant which does not conform to the normal search operation of the users. (Users are normally search by name of the equipments rather than their functions).

6.1.1.3 System Code Developed by BVI (Black & Veatch International Company)

According to the **"Equipment Numbering Procedure"** Document prepared by STONE & WEBSTER (THAILAND) LIMITED, BANGKOK, THAILAND (1997) which was quoted from the BVI Equipment Numbering Procedure Document, the methodology used in establishing component identification numbers assigned to equipment and devices for unique identification on drawings, equipment lists, labels, and other documents. The following is a representation of the identification numbering system. Groups (1), (2), and (3) collectively define the unique component identification number for each item:

(1)		(2)		(3)
XAAA	-	YYYY	-	ZZZZ

Where,

X – Unit Designation

AAA – System Code

YYYY – Component Function Code

ZZZZ – Component Sequence Number

As mention earlier, only the system code will be discussed. The system code identifies the system to which the equipment or device belongs. The BVI system codes are not to be confused with equipment names or their abbreviations, e.g., boiler feed pump (BFP). The list of the examples of System Codes and/or System Definitions for the power plant project is as follows.

System Description	System Code
Circulating Water	HRC
Boiler Feed	FWA
Condensate	FWC
Steam Generator	SGA
Boiler Vents and Drains	SGF
Turbine System	TGA
Generator and Excitation	TGB
Chemical Waste Collection and Treatment	WWA
Service Water	WSC
Fire Protection Water Supply and Storage	WSE

The BVI Equipment Numbering System has been used in many projects of EGAT such as Ratchaburi Power Plant Project, District Cooling System and Power Plant Project for Suvarnabhumi Airport, and much more for several years, therefore, most of engineers who work with engineering documents are well familiar with these system codes. From the discussion with the Information Technology Group Manager and Engineers of Steam Generator and Turbine Engineering Department, the BVI Equipment Numbering System or Project Numbering System is the appropriate choice to use as a standard system code to locate the group of engineering documents (e.g. mechanical drawings and technical information). However, there are some problems found in the BVI system.

1. The list of the BVI system shown in the BVI Equipment Numbering Procedure Document is a basic list of systems related to the reference design for coal generating plants and combustion turbine/combined cycle plants. Therefore, the present system codes cannot cover the overall systems in the biomass power plant like the AT Biopower Project.
2. The main system code starts with two alphabets (e.g. Steam Generation; SG-) and its sub-system consists of three alphabets (e.g. SG*X*). The first two alphabets of the sub-system identify the main system, therefore, the sub-system cannot exceed 26 systems because the third code runs from A to Z.

This can cause a problem when the main system consists of more than 26 sub-systems.

Having analyzed the available three system codes and their problems, the most appropriate system code which can be used as a standard system code for document storage system, document grouping that enhance the efficiency of search system is the BVI system. The BVI system provides system code that is more close to the users' requirement than the others. Moreover, BVI system codes are easy to memorize which is an advantage to the users to specify into the search process.

For the first problem of the BVI system, the author proposes that any systems which are not required for the AT Biopower Project design can be deleted (e.g. Coal Handling System). Additional systems required for a specific system may be added. For the second problem, this problem may not occur in this situation because the biomass power plant system is very small compared to coal plant system. In next section, the example of grouping the documents by using the BVI system code will be shown.

6.1.2 Example of Grouping the Documents by Using the Selected System Code

After selecting the appropriate international system code which is the BVI system to use to group documents, the mechanical drawings and mechanical information documents of the AT Biopower Projects must be grouped. However, there are some systems which are not required for this project listed in the **"System Code Handbook"** because the author would like to develop a handbook that can cover the equipments in various types of power plant. The developed System Code Handbook is shown in **APPENDIX 3**. There are two systems were added into the original system which are,

- Fuel Handling System (FHA), and
- Raw Water System (WSA).

For mechanical drawings, the system code will be used as a drawing reference. In this case, the drawing reference field is needed to be added into the current drawing document profile. Document classification of mechanical drawings by using the system code can be done by opening each drawing and check out the document to edit its profile. During the editing process, the appropriate system code will be filled into the drawing reference field of that drawing document. Figure 6.2 is illustrated the document profile of mechanical drawing.

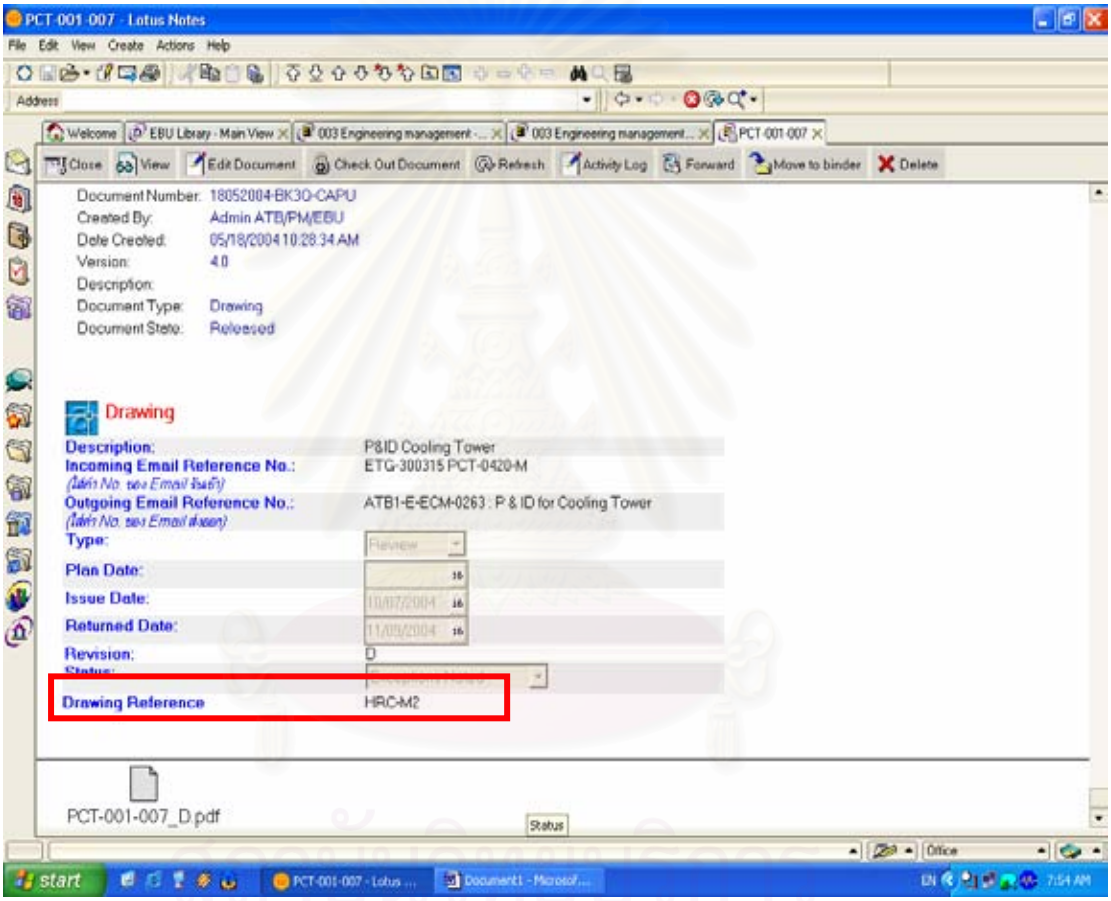

Figure 6.2 Mechanical Drawing's Developed Document Profile.

The drawing reference field **(Drawing Ref.)** is also added into the existing drawing binder profile. The binder profile will show the overall drawing document profiles. Table 6.2 shows the binder profile of drawing document. The overall mechanical drawings will be shown in this "View".

Table 6.2 Mechanical Drawing Document's Profile

Title	Description	Reference No.	Type	Plan Date	Issued Date	Returned Date	Rev.	Status	Drawing Ref.	Modified

The next table shows the example of the mechanical drawings which are already classified into its system group.

Table 6.3 Example of Mechanical Drawings Grouping by using System Code

Description	Drawing Ref.
Process- Rice Husk Storage Capacity	FHA
Foundation-Cooling Tower Foundation Plan	HRC
Fire Protection System-Schematic Diagram	FPA
Sanitary System-Cole Water & Sewage System	WWB
Rice Hull Fired Boiler, General Arrangement	SGA
Rice Hull Storage Bin-General Arrangement	FHA
General Arrangement Drawing for Induced Draft Fan	CCE
General Arrangement Steam Turbine Generator	TGB

The overall mechanical drawings have to be checked to ensure that the attached documents (if presented) are conformed to document's description and the system code used must also correctly identify the documents. There are 440 documents in mechanical drawing binder required for grouping as illustrated in Figure 6.3.

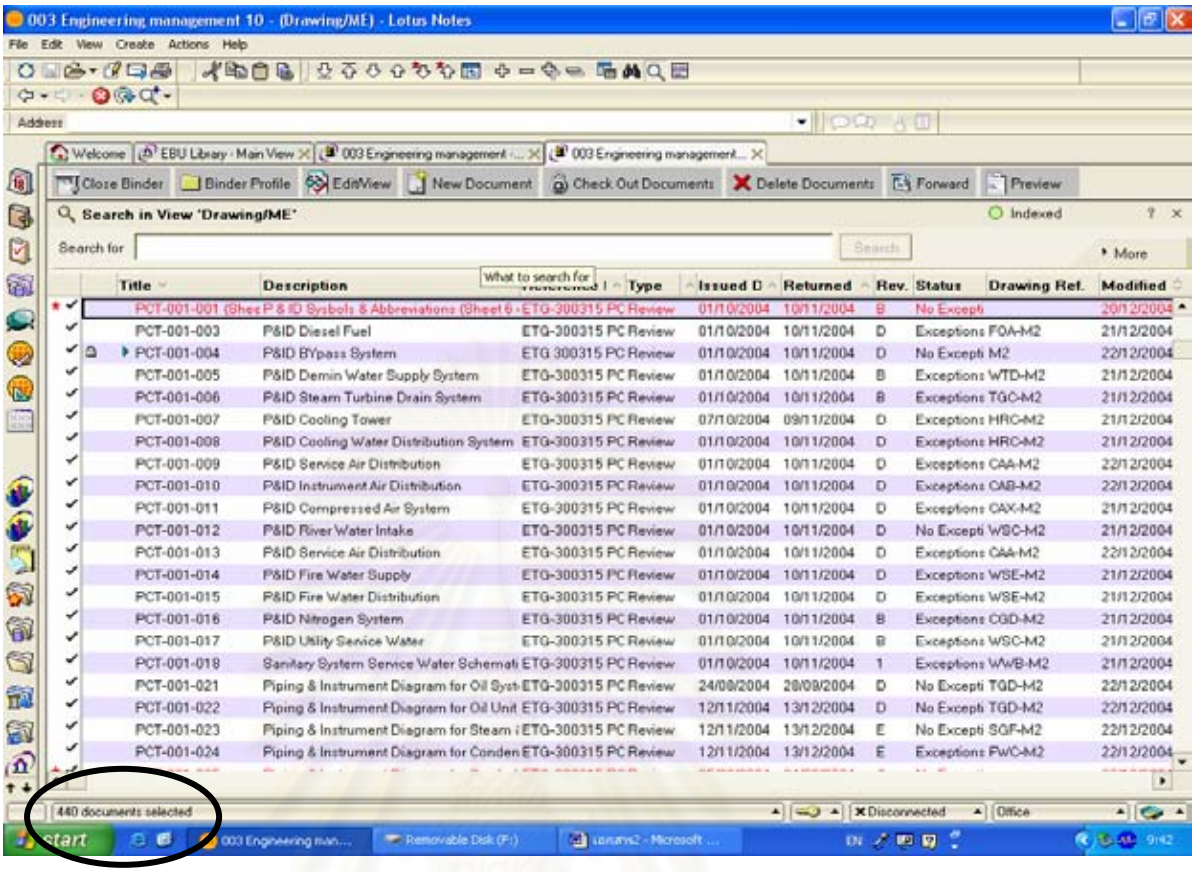

Figure 6.3 View of Mechanical Drawing Binder

For technical information, the system code will be used as a document reference. In this case, the document reference field is needed to be added into the current technical information document profile. Document classification of technical documents by using the system code can be done by opening each technical document and check out the document to edit its profile. During the editing process, the appropriate system code will be put into the document reference field of that technical document. Figure 6.4 shows the document profile of technical information.

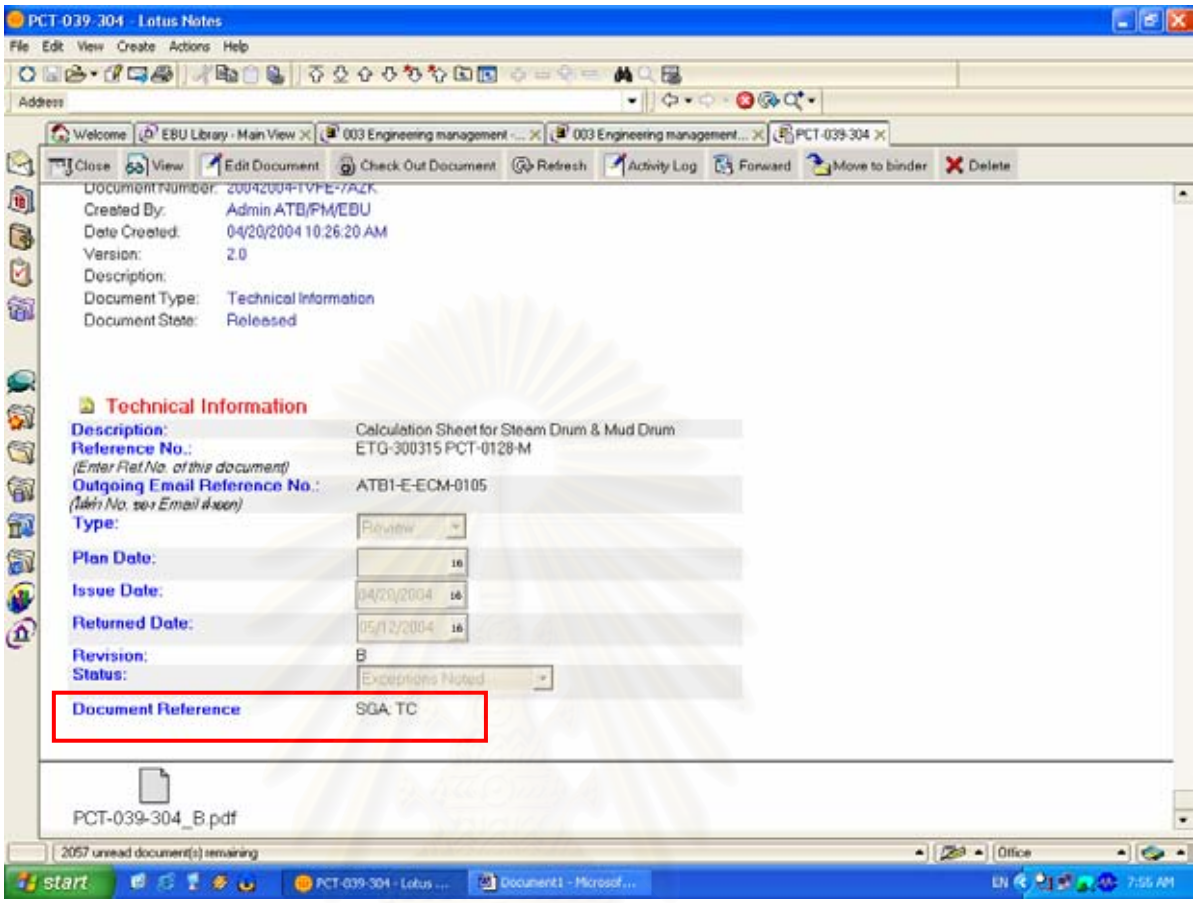

Figure 6.4 Mechanical Calculation's Developed Document Profile

The document reference **(Document Ref.)** is also added into the existing technical information profile. The next table shows the binder profile of technical information. The overall documents of the selected technical information binder will be shown in this "View".

Table 6.4 Technical Information Document's Profile

Title	Description	Reference No.	Type	Plan Date	Issued Date	Returned Date	Rev.	Status	Document Ref.	Modified

However, the technical information is classified into 6 binders which are:

1. Calculations (54 documents)
2. Comments (3 documents)
3. Design Data (30 documents)
4. Recommended Spare Part (2 documents)
5. Specification (73 documents)
6. Test Report (18 documents)

Only the mechanical technical information documents are considered in this thesis. To group the technical information is very similar to grouping the mechanical drawings. All documents of the technical information in mechanical field have to be grouped using the system code. All documents also have to be checked whether the attached documents are stored into the right document profile.

As mentioned above, the technical information binder consists of 6 sub-binders. To avoid confusion and to increase the search accuracy, technical information document should be grouped by document type. The abbreviation of the document type will be used as a document code as shown in Table 6.5.

Table 6.5 Document Code of Technical Information Documents

Document Type	Code
Technical Information	**T**
Calculations	TC
Comments	TO
Design Data	TD
Recommendation	TR
Specification	TS
Test Report	TT

These codes will be added into the document's system code. The users can specify the document reference by typing the system code (XXX) with comma (,) and follow with the required document type (XX). The examples of the technical specification documents with their document codes are shown below.

Table 6.6 Example of Mechanical Specification Grouping by using System Code

Description	Document Ref.
Economizer Performance Data	SGA, TS
Test & Inspection Procedure for Steam Turbine	TGA, TS
Painting Procedure at Shop for Surface Condenser	HRC, TS
Water Treatment System Specification for Water Pumps	WTD, TS

Now, the document storage system of the PDM system has been developed. Both mechanical drawings and technical information documents were grouped into their equipment system group using the BVI's system code as a standard. In next section, the PDM's search system will be developed to increase the search accuracy and users' satisfaction.

6.2 Development of Product Data Management's Search System (Search by Form)

After the development of PDM's document storage system, the PDM's search system which must work aligning to the storage system will be developed. It means that the developed search system must be able to search everything stored in the document storage system including the group of the document. In this case, the development will be done only on the Advanced Search System because it is not necessary to develop in Simple Search System to be more complicated than it used to be.

Since the users interface of the advanced search system is not friendly enough to the users and the search results are overwhelming because of the full-text search which was already mentioned in Chapter 4, the users interface of the advanced search should be developed as well. It would be better to add a new option for advanced search rather than improve the existing one. This is because there may be someone is familiar with the old system and do not want to try a new system, someone who does not like to change.

Search by Form is a search option provided by the Domino Document Manager for the designer to customize the template to include SearchByForm as a custom subform. The users can choose the "Search by Form" option to select the appropriate form. More details of "Search by Form" will be described in next section.

6.2.1 Advanced Search (Search by Form: Drawing Form)

Advanced search allows users to refine their search by specifying a list of words and a specific date for the document they are trying to locate. To perform an advanced search, the user can click search and then advanced search from the Domino Document Manager Library. The following figure shows the search options which allow user to specify the file cabinets to search (Where to search). After selecting the file cabinet, the user must choose one option from the Search by Word. Search by form is a new option developed in this thesis to satisfy the users and to increase the efficiency of the search system. In this section, the drawing form will be considered only. In Search by Form option, the users can not only specify the type of the document but the users can also select the filed (description, revision, drawing reference, etc.) to perform search.

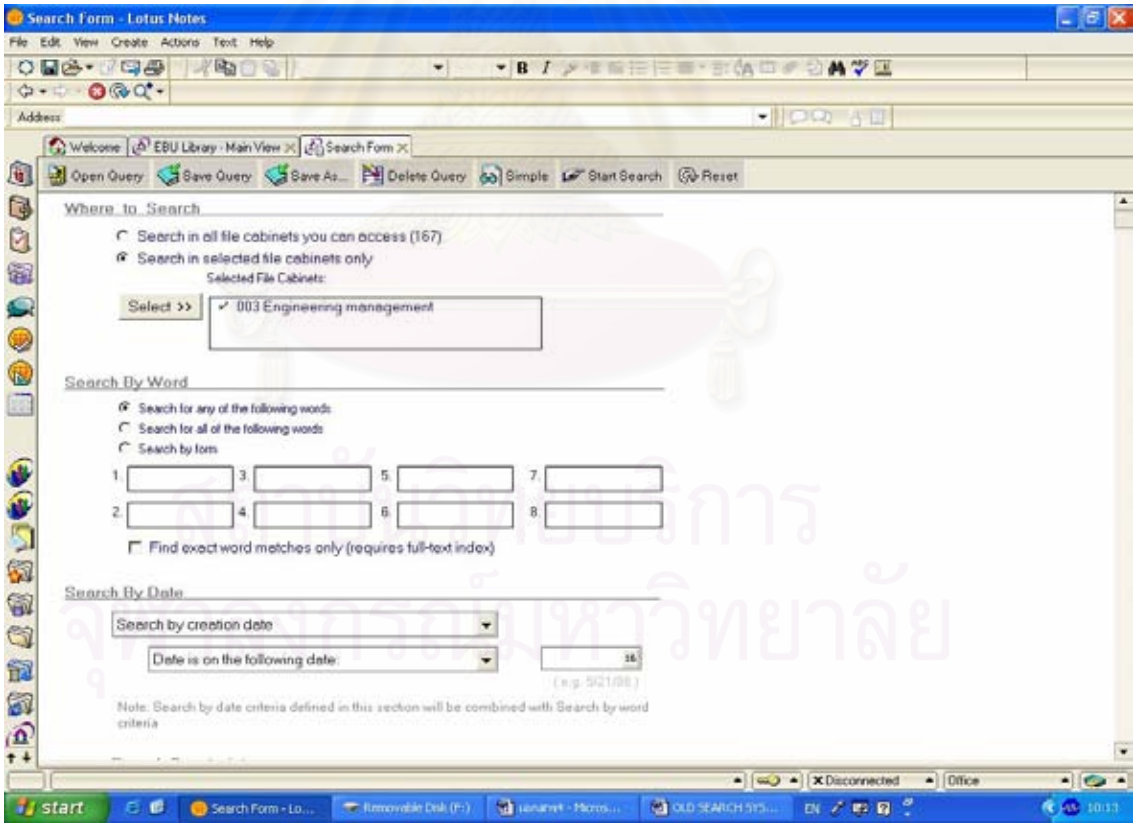

Figure 6.5 View of Advanced Search

The different document forms are listed and shown up when the user select the Search by Form option. Not only the drawing and technical information forms were prepared in this list, there are other important forms were listed for the future use such as, commercial, contract, and etc as illustrated in Figure 6.6. However, there are only drawing and technical information forms that were designed to use as a pilot project in this case.

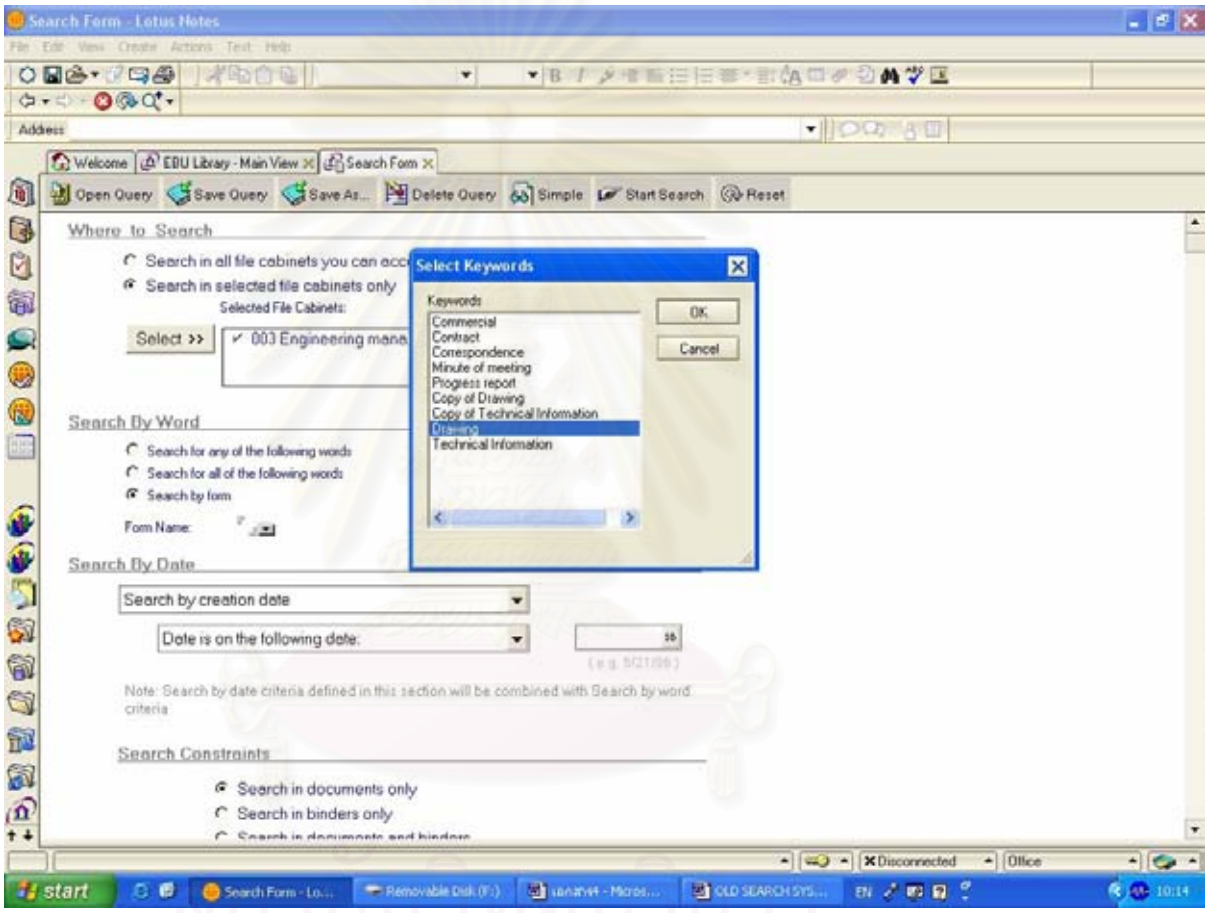

Figure 6.6 Forms Name of Search by Form

According to Frakes (1992, p.1), the queries are the formal statements of information needs – to document stored in a database. Therefore, the query used in the new search option should be formal and easy for users to proceed. The next figure shows the drawing form queries which are quite similar to the drawing document profile because the users are almost familiar with the document profile and the document profile is the most general information to represent the attached document.

The more the queries are filled in, the more the accurate search results are displayed. As mentioned earlier, the users can search in any field they need to locate the required document.

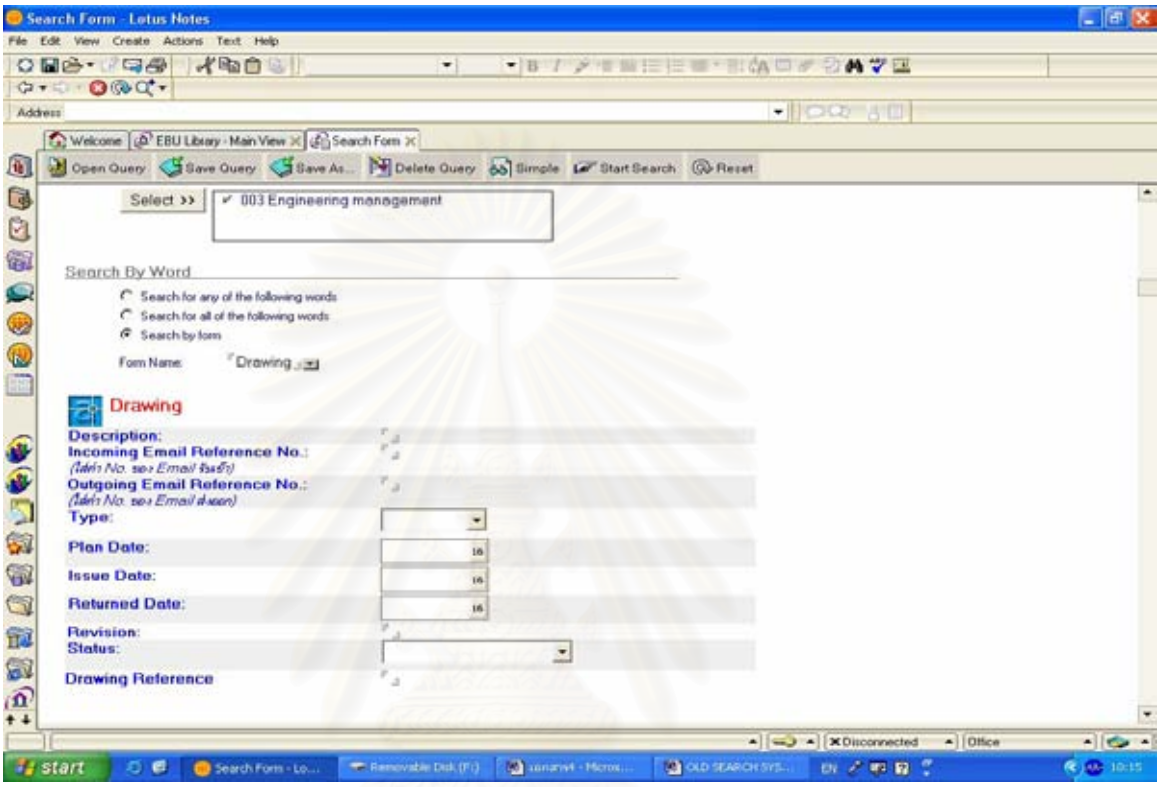

Figure 6.7 Search by Drawing Form's Users Interface

And the example of the search results view display is shown in Figure 6.8.

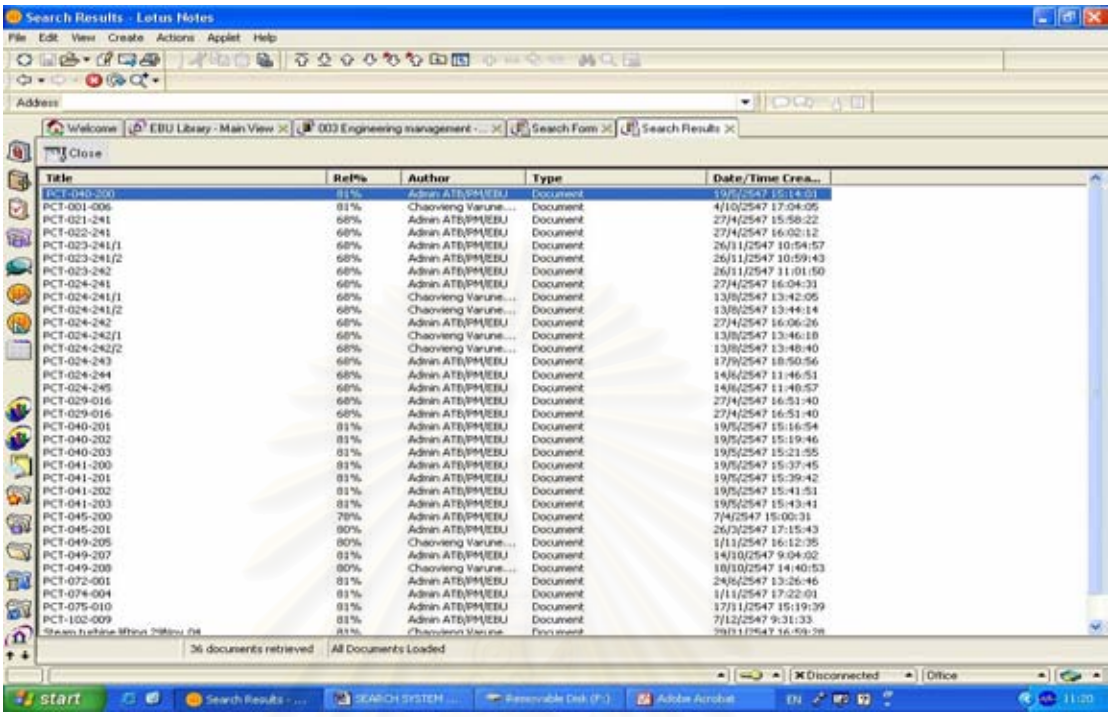

Figure 6.8 View Display of Search Results when use Search By Drawing Form

Table 6.7 shows the search results comparison between not searching by system code and using system code to search. When the user performs search by specify only the keyword “Steam Turbine”, as a full-text search the system will retrieve the drawing documents whose document’s description contains “Steam Turbine” text, as a result, the amount of documents retrieved are abundant. But when the user performs search by specify the keyword and the system group of that keyword (System Code) as known as “Drawing Reference”, the system will search only the documents that contains “Steam Turbine” in their description and their drawing references must be in the group of “TGA- Turbine System”. By doing so, the amount of documents retrieved is reduced dramatically. If the user specify in much details, the search results are more accurate.

Table 6.7 Search Results Comparison between Non-Using and Using System Code of Search by Drawing Form

Description	Revision	Drawing Reference	Amount of Documents Retrieved
Steam Turbine	-	-	36
Steam Turbine	-	TGA	3
Steam Turbine	A	TGA	1

6.2.2 Advanced Search (Search by Form: Technical Information Form)

The process of search by technical information form is similar to the drawing form. The users can choose the file cabinets before choose the search by form option. To search the technical information, the users must select “Technical Information” from the search by form list. Figure 6.9 illustrates the technical information form queries which are quite similar to the technical information document profile. It is very convenience for the users who know the document information. However, the use can limit the search results and perform search effectively by specifying the group of the equipment system.

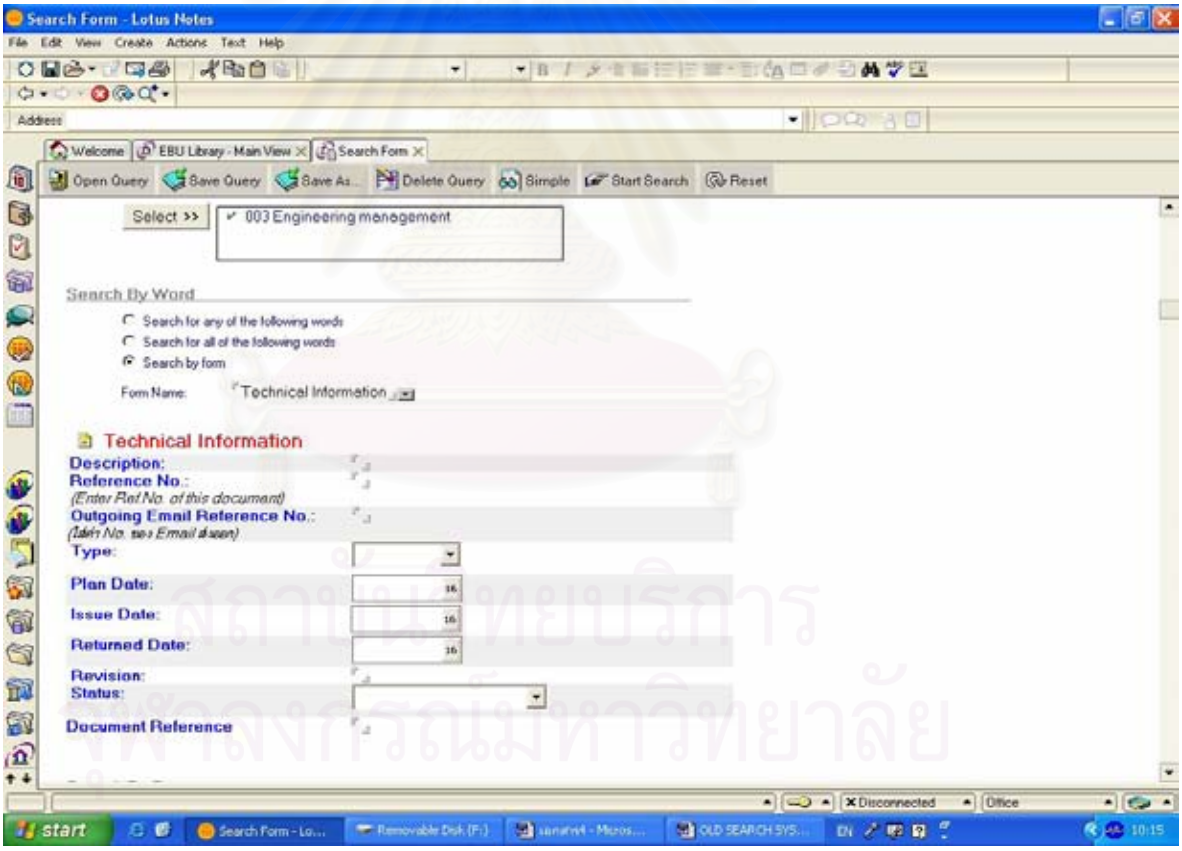

Figure 6.9 Search by Technical Information Form’s Users Interface

Search results comparison between not searching by system code and using system code to search is shown in Table 6.8.

Table 6.8 Search Results Comparison between Non-Using and Using System Code of Search by Technical Information Form

Description	Revision	Drawing Reference	Amount of Documents Retrieved
Steam Turbine	-	-	40
Steam Turbine	-	TGA; TS	5
Steam Turbine	0	TGA; TS	1

From table above, the user can find the required document by specifying only description, revision and drawing reference. To ensure that the document found is right to the requirement, Figure 6.10 shows the attached document of the document retrieved. This document is the mechanical specification which is about the test & inspection procedure for steam turbine, zero revision. This can enhance the reliability and accuracy of the new search system to the users.

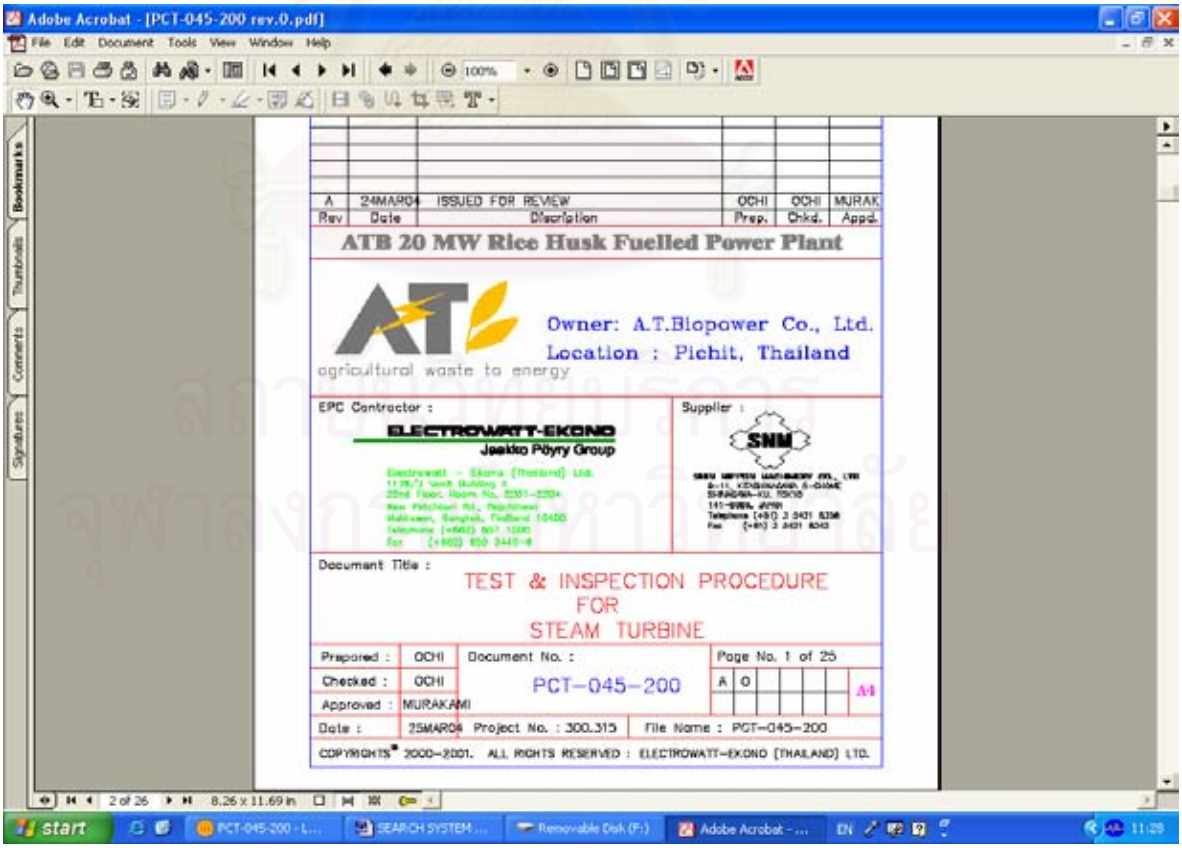

Figure 6.10 Document Retrieved by Developed Search System

6.2.3 Search by Keyword

As mentioned earlier in Chapter 4 that Search by Keyword is not a Full-Text Search. Search by Keyword, the system will search the keyword requested by the users only in the document profile. This kind of search cannot search the keyword inside the attached document's details. To increase the effectiveness, the users can add the system code of the required system into the search dialogue box.

To start searching by keyword, the users must choose the file cabinet (003 Engineering Management), and specify the binder (e.g. Drawing/ME) as shown by the figure below.

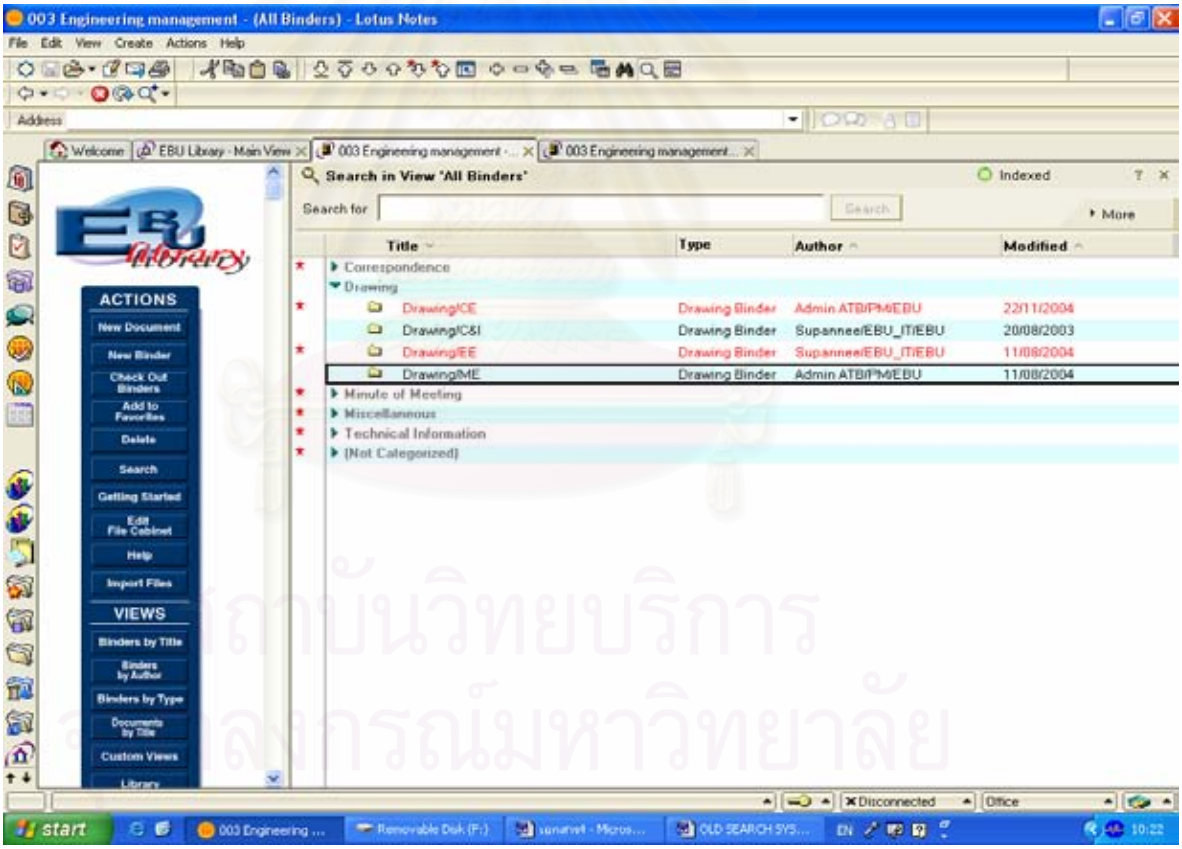

Figure 6.11 All Binders in 003 Engineering Management Profile

When the users have already specified the location to search, the view of the search will be shown in Figure 6.12. All document profiles are listed in this page.

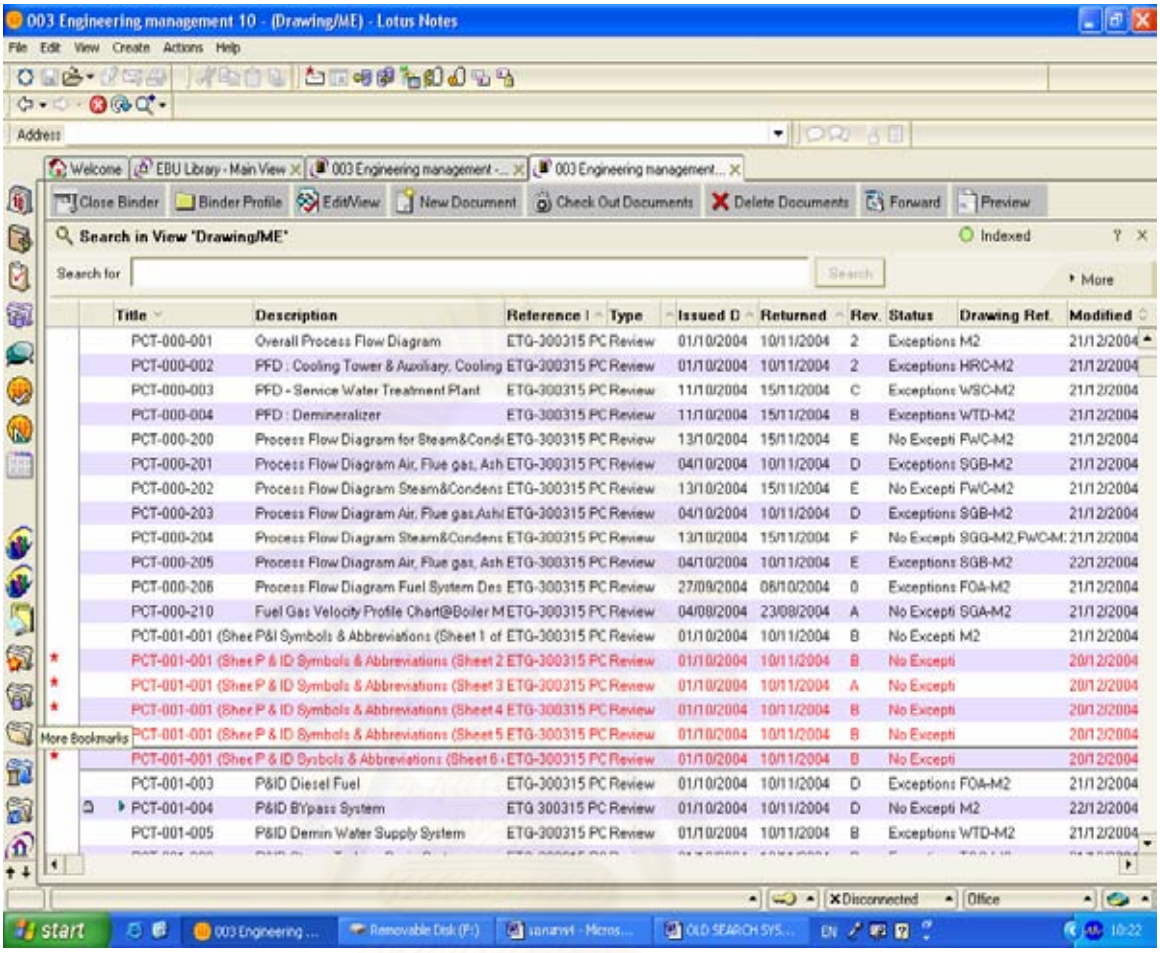

Figure 6.12 All Documents in Drawing/ME Binder
of 003 Engineering Management Profile

The users can perform search by filling in the keywords into the “Search for” dialogue box. The keyword can be anything that the users think that they would be appeared in the document profile of the required document. Moreover, the users can enter a query consisting of a set of keywords connected by Boolean operators (are not (!), and (&), accrue (,), and or (|)). The query is parsed into its constituent term and Boolean operators. The user can use either the keyword or symbol.

Even though, the search by keyword are not developed, the user can specify the system group of the required by document by using the system code. This is because the system code (Drawing Reference, Document Reference) of each

document has been added into all drawing document profile and technical information document profile already. Therefore, the user can limit their search results by using system code in “Search by Keyword” as well.

As illustrated in Figure 6.13, the searched results by using “Search by Keyword” in Drawing/ME binder of 003 Engineering Management Profile.

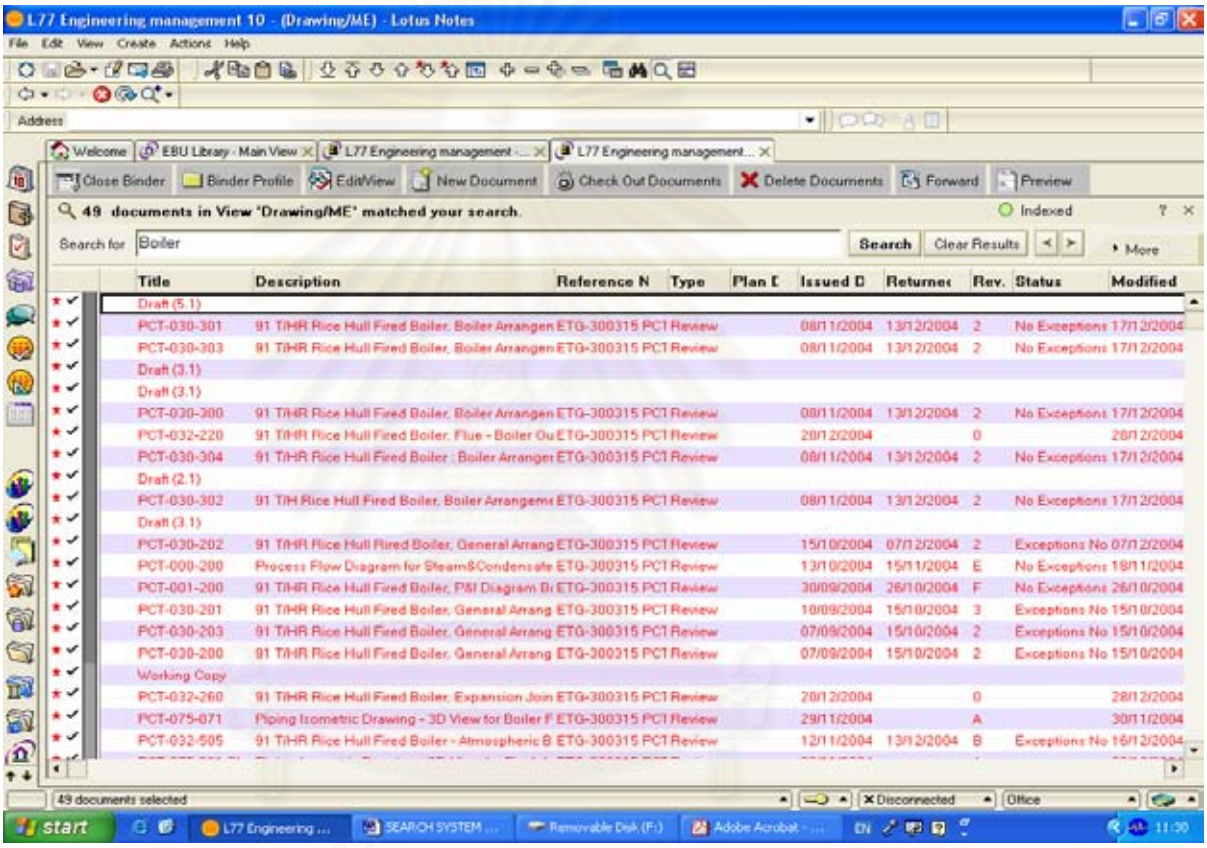

Figure 6.13 View of Searched Results by using Search by Keyword

Search results comparison between not searching by system code and using system code to search is shown in Table 6.9.

Table 6.9 Search Results Comparison between Non-Using and Using System Code of Search by Keyword

Search Comparison (Drawing/ME)

Search For	Amount of Documents Retrieved
Boiler	49
Boiler & SGA	21
Boiler | SGA	50
Raw Water	9
Raw Water & WSA	3
Raw Water | WSA	15

Search Comparison (Technical Information: Calculations/ME)

Search For	Amount of Documents Retrieved
Steam Drum	10
Steam Drum & SGA	8

In summary, the overall mechanical drawings and technical information documents of the AT Biopower Project have been already classified into several groups by using the BVI's System Code developed by the Black & Veatch International Company. Some system codes were deleted because those systems are not required in the AT Biopower Project and some systems were added to cover the overall systems in the AT Biopower Project. However, as shown in APPENDIX 3, all system codes are listed because the author would like to use this handbook in every project.

The overall document profiles of both mechanical drawings and technical information documents have been designed to support the system code by adding drawing reference field into drawing profile and adding document reference field into technical information profile.

The PDM's search system also was developed by increase one search option which is "Search by Form" option into the Search by Keyword. Search by form, the users can choose the document form they would like to find. The data queries of drawing form search are similar to drawing document profile and the data queries of technical information form search are similar to technical information profile since the information of the profile is the basic requirement of document and the users are also familiar with the profile structure.

The search results comparison from three different search option can shows the increasing of the search performance and the accuracy of the search by specifying the system code into the search queries. However, this is just an example done by the author only. To determine the developed search system performance, this new system must be implemented to the target users (Steam Generator and Turbine Engineering Department's users). The post-development questionnaire also should be used to determine the users' satisfaction and the developed system's efficiency.

6.3 Effectiveness/Performance Test

There were 2 parameters of effectiveness/performance of search system being measured, which were accuracy and speed. Since some of the users were quite busy with their routine works, there were only two persons volunteered for the test. The method was that the researcher specified keywords and search criteria and let these two users performed search by using the new search system (Advanced Search: Search by Form function) and the existing search system (Advanced Search: Search all of following words) in comparison. The search results from both users would then be averaged and compared. In terms of accuracy measurement, the researcher compared the usable results (results that actually related to the keywords) with all the results found using both existing and new search system in percentage. The outcomes of the test were shown in the table below.

Table 6.10 Result of Search System Accuracy Measurement

Keywords and Criteria	*Existing system* (usable results: all results - Averaged)	*New system* (usable results: all results - Averaged)	**A** *Existing system* (usable results: all results) in percentage	**B** *New system* (usable results: all results) in percentage	**C** Percentage of improvement **= (B-A)**
File protection system, mechanical, drawing	4:14	10:10	28.6%	100%	71.4%
Rice hull fired boiler, mechanical, drawing	1:14	16:16	7.1%	100%	92.9%
Turbine, mechanical, specification	3:32	5:5	9.4%	100%	90.6%
Steam drum, mechanical, calculation	0:5	10:10	0%	100%	100%
Boiler feed water, mechanical, design data	1:7	6:7	14.3%	85.7%	71.4%
Average			11.9%	97.1%	85.3%

As indicated in Table 6.10, the average accuracy of the developed search system (Search by Form) was significantly better than that of the existing system (Advanced Search: Full-Text Search) with 85.3% of improved accuracy. It should also be noted that the new search system was quite reliable; getting the results the users needed almost every time. Partly, this was probably because the researcher monitored and ensured each the keyword was typed correctly. Meanwhile, the existing search system performed quite disappointing by displaying too many unrelated results, hence having only 11.9 % of accuracy of the searched results.

Another measurement taken was the speed of search system. This was done similarly to the aforementioned accuracy measurement; the researcher specified keywords and search criteria and measured the time spent before the users can find what they needed. The time spent by the two users were then averaged and compared to see if there was any improvement. The outcomes of the speed test were listed below in Table 6.11.

Table 6.11 Result of Search System Speed Measurement

Keywords and Criteria	**A** *Existing system* (Time spent in seconds - Averaged)	**B** *New system* (Time spent in seconds - Averaged)	**C** Percentage of improvement **= ((A/B)-1) x 100%**
Sanitary system, mechanical, drawing, revision 0	50	25	100%
Cooling tower, mechanical, drawing, revision 3	90	15	500%
Steam drum, mechanical, calculation, revision B	73	25	192%
Fire pump, mechanical, specification, revision A	40	14	185%
Compressed air, mechanical, calculation, revision C	62	21	195%
Average			234.4%

According to Table 6.11, the speed of the new search system was approximately two times faster than the existing system. In other words, the users would have to spend only about 50 % of the time they used to do when searching for documents using the existing search system. This was probably due to the outstanding accuracy of the new search system that helped reduce the number of results shown for users as well as the proper infrastructure and co-operation of search and BVI coded storage systems.

In summary, the developed search system (Search by Form) had proven its effectiveness or its performance in terms of accuracy and speed by being 85.3% more accurate and 234.4 % faster than the existing search system. It was expected that such improvements would help the workflow of routine jobs and the projects and finally satisfied the users. However, it must be pointed out that, these improvements are not the improvements of the whole PDM's search system. The developed search system can be operated effectively whenever it is used to search the developed documents specified in the thesis's scope only. Therefore, to improve the PDM's search system effectiveness thoroughly, the overall documents stored in the database must be re-classified and store into the right location.

CHAPTER VII

Implementation and Evaluation

This chapter involves implementation process and evaluation of the user's feedback after trying the new option of the PDM's search system for a specific period of time. Implementation processes can be divided into several sub-processes, which will be explained in detail later. However, before the implementation processes can start, there must also be some preparation steps to ensure that the system was ready for the trial.

Evaluation took users' responses to the improved search system into consideration. The feedbacks from users were critically analyzed and summarized in graphical representations and this would lead to the findings of this thesis.

7.1 Implementation Process

There were 11 steps of implementation process as followed;

1. **Development of the document storage system:** Before the documents could be searched, they must be stored in a way that they would be found easily. BVI's System Codes were used to classify various types of documents into proper categories. Noted that, in this thesis, the coding and classification only applied for drawings and technical information documents of the AT Biopower Project.

2. **Development of the PDM's search system:** "Search by Form" option was added to advanced search mode allowing the coded documents to be found effortlessly. Using Search by Form option, user can search the document in specific type of document form and the data queries of this option are similar to the document profile. This developed system is suitable for the users who know some of the information of document profile they would like to find and for the users who do not know the information but they can increase accuracy by specifying the system code.

3. **Test and compare results with existing search system:** The newly completed search system was test against the existing search system to see if the performance of the new one was better. All problems were fixed before the next step was taken.

4. **Preparation of the user manual and attached documents:** After testing the new search system and feeling confident that it would outperform the existing system, the researcher started to prepare user manual and attached documents (System Code Handbook, for example).

5. **Allow the targeted users to test the system:** At the phase the system, as Notes/ Domino software environment was much secured, accessibility without

permission was impossible. Administrator would have to permit the targeted users to access the system before the process could continue.

6. **Briefly explain the users about search and storage systems:** The users were briefly explained about the search and storage systems so that they had basic knowledge and understanding of how these two systems cooperated.

7. **Briefly explain the users about system codes:** The users were briefly explained about the BVI's System Code so that they had basic knowledge and understanding of how the documents were classified and how that affected the search process.

8. **Begin training and give the users the user manuals:** The training was begun after all users received user manual and system code handbook and had basic knowledge and understanding about how the system came and worked together.

9. **Check for comprehension of the users:** During the training, the researcher asked questions, established conversations and allowed the users to ask questions to check if all users understood the subject in the same way and had no problem using the new search system.

10. **Allow the users to try the system for 1 week:** The researcher allowed 1 week for the search system to be tested by the users. During this 1 week, questions and any problems occurred would be directed to the researcher through phone call and/ or email.

11. **Check for the users' satisfaction and efficiency of the system:** After the completion of test period, the researcher administered the Post-Development Questionnaire to the users who have tried the new search system. The Post-Development Questionnaire was designed to collect information regarding users' satisfaction after using the new search system as well as the performance of the system itself.

Illustrated in the below is Figure 7.1 The Implementation Process.

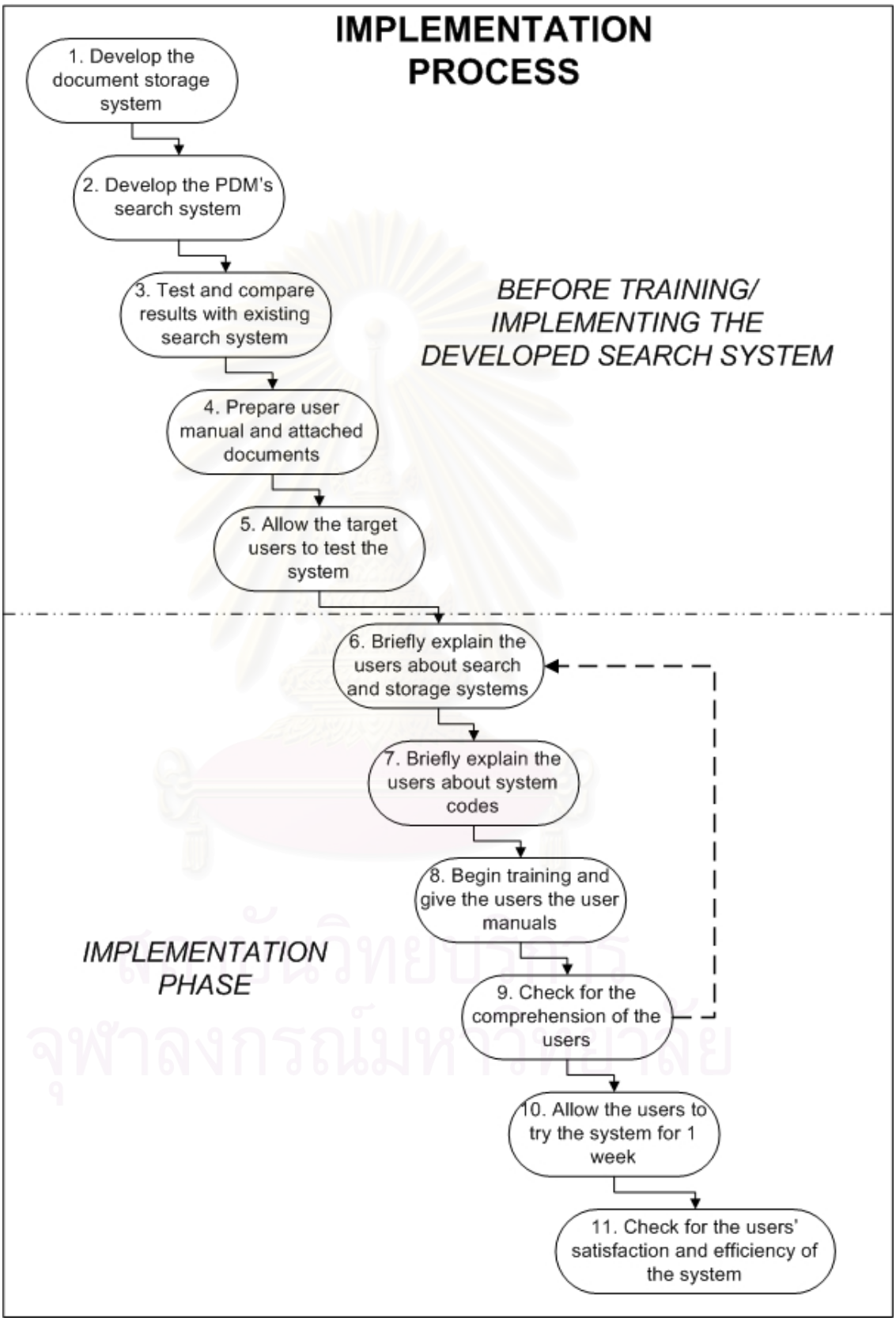

Figure 7.1 The Implementation Process

7.2 Survey Instrument Preparation

At the time of constructing the Pre-Development Questionnaire, the Post-Development version was also prepared to some extent. After the data collected by Pre-Development Questionnaires was analyzed thoroughly, the information regarding users' satisfactions, requirements and probably expectations were used to develop the search system and to create the additional questions to complete the Post-Development Questionnaire.

7.2.1 Post-Development Questionnaire

The questions reside within the Post-Development Questionnaire include questions regarding;

1. Users' satisfaction in terms of convenience, accuracy and speed of the improved search system.
2. Users' opinions about system code
3. Users' opinions about the benefits of 'Search by Form' function
4. Users' opinions about the researcher's implementation method.
5. Problems found by users
6. User's opinions in the appropriateness of taking this research project further.
7. Users' suggestions upon the improved search system.

For more information on how each question was worded and organized, please see the actual questionnaire in **APPENDIX 2**

7.2.2 Bias, Reliability, Validity and Ethical Issues

Bias, reliability, validity and ethical issues were managed exactly like ones in the Pre-Development Questionnaire (the first survey). For more information, please see **Section 5.1.2**.

7.3 Survey for Users' Satisfaction and Opinion upon the Developed Search System

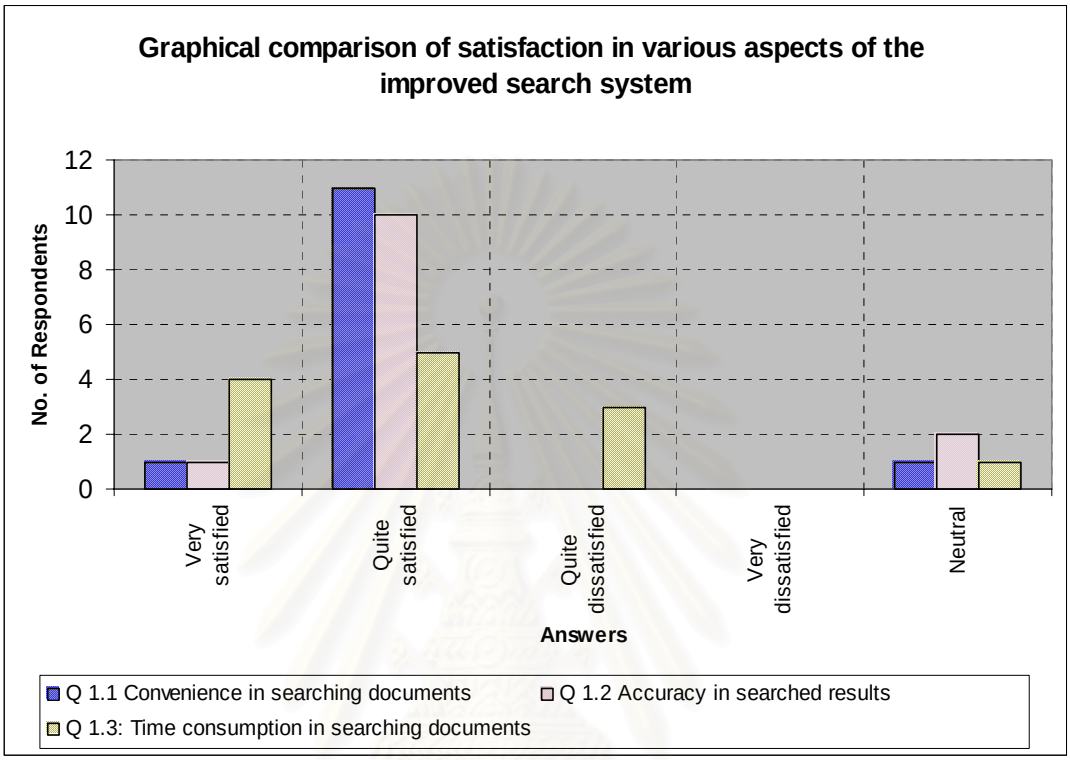

Figure 7.2 The Responses of the Users to the First Question – After you have tried the improved version of search system which has the improved storage system (utilizing system code) and the 'Search by Form' function, are you satisfied with the system in terms of convenience, accuracy and time consumption comparing with the existing system?

The first question (with 3 sub-questions) on the survey was asked to see if the users were satisfied with the following areas in the improved search system featuring "Search by Form" and the use of system code.

1. Convenience in searching for documents
2. Accuracy in searching for documents
3. Time spent searching for documents

As seen in Figure 7.2, the results were that almost every user filling this questionnaire was quite satisfied with the convenience when using the new search system (comparing to the existing one) and found that the accuracy of the search results were better than the existing system.

One third of the respondents were very satisfied with time consumption in searching document which was significantly improved (reduced) while one fourth of the respondents conversely felt that the new system is somewhat slower than the existing one. However, as mentioned earlier in Effectiveness/Performance Test section, the speed of the new search system was much faster than the existing system, therefore, the reason that some of the respondents felt the new system was slower was probably because the they were still new to the developed search system. By the way, a couple of users felt that there was neither improvement nor degradation made to the new search system in terms of accuracy of the search results.

Noted that the reasons that some users were not quite satisfied with the new search system could be that these users had not use the system much during the test time, therefore they were not very familiar with the system. More accurate results may be expected providing more time to test the system is available as well as assigning some document search homework to the users. However, most of the time, the latter was not very practical choice as the users were usually busy with their own work.

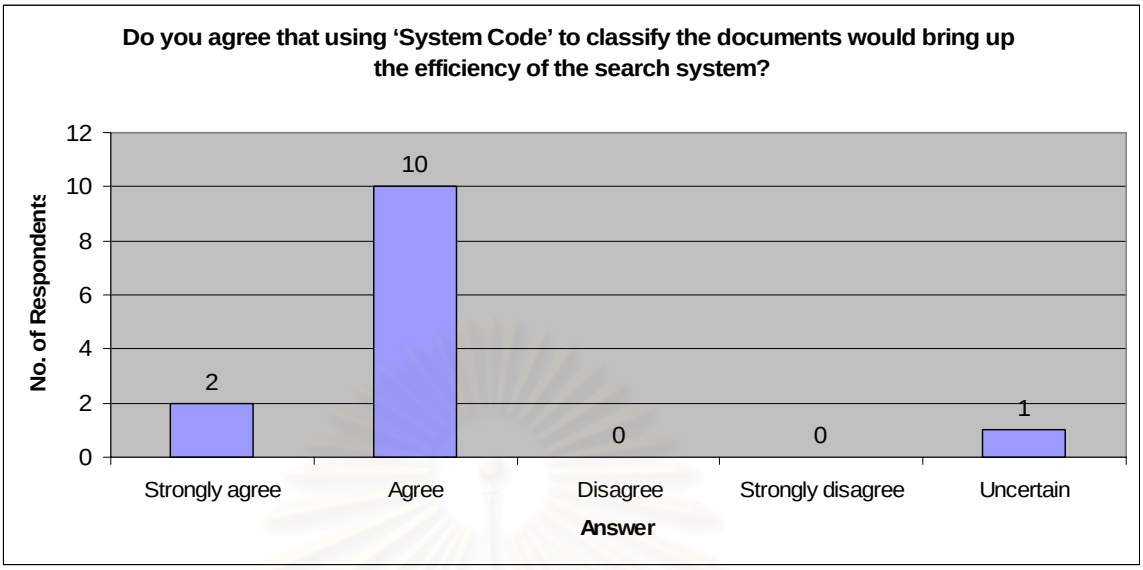

Figure 7.3 The Responses of the Users to the Second Question - Do you agree that using 'System Code' to classify the documents would bring up the efficiency of the search system?

The second question asked that whether or not the users agree that the use of system code make the search system more effective and the reasons behind their answers. The results, according to Figure 7.3, appeared that almost every user agreed that using system code would make the search system more effective to varying. There was only one user that thought using system code would make no attribution to the performance of the search system. The reasons given by the users who agreed of using system code included;

1. System code would allow technical documents and drawing to be classified and therefore reduce the amount of unrelated documents.
2. System code allows the area of search to be limited. Therefore, the documents can be found easier and more precisely.
3. System code enhances convenience and speed of the search system.
4. Using system code to classify documents would result in more accurate search result. Sometimes some documents are not in text format (i.e. PDF files) and they cannot be found by search system.
5. etc.

However, according to the response from the only one user that had uncertain feeling about enhancing the search system with system code, since system code would need someone with expertise in both programming and engineering in every concerned field to fill in information to ensure correct documents classification. At this moment, the problem was being that EGAT was unable to fill in codes for every single document kept digitally in the storage system. In addition, as contractor would not likely be familiar with system code used by EGAT, it was impossible for them to fill in correct system code.

Noted that it may be true that it is impossible to coding all existing documents EGAT has now because of the lack of human resources and knowledge. However, the future documents stored in the system should not be a problem. By the way, as may be noticed that the objective and scope of this research was actually to make improvement on the storage and search system of the future documents, left the existing documents intact.

In addition, it should be pointed out here that the System Code used by EGAT has nothing to do with the document code/ reference of the contractors as concerned by one of the users. The contractors can code the documents any way they see appropriated and the administrative staffs who look after the use of System Code would find a proper code for each type of document supplied by the contractors.

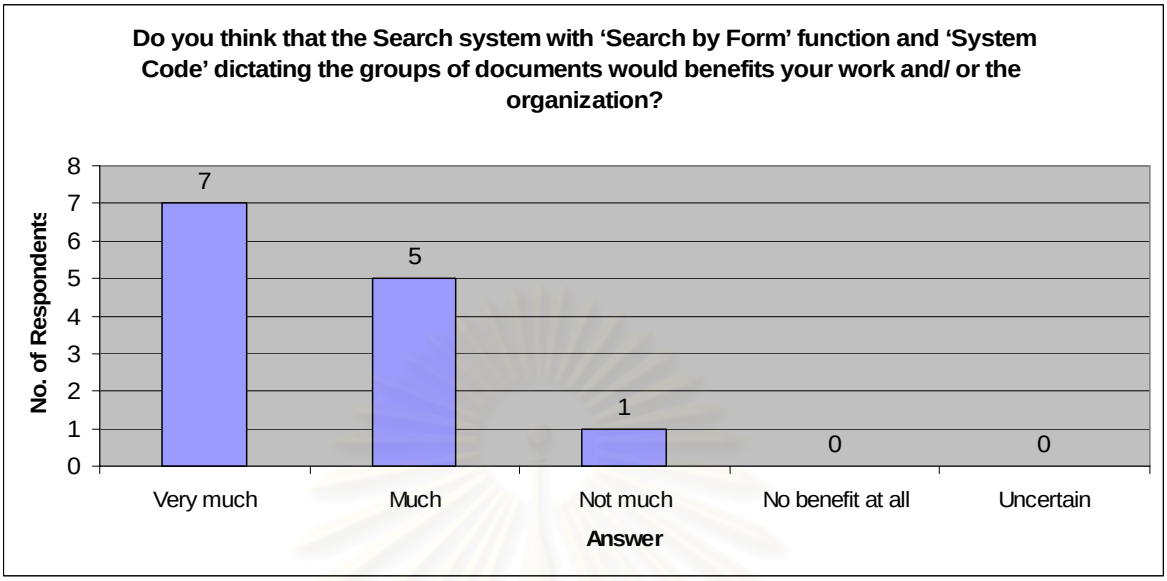

Figure 7.4 The Responses of the Users to the Third Question - Do you think that the Search system with 'Search by Form' function and 'System Code' dictating the groups of documents would benefit your work and/ or the organization?

The third question was asked to see whether the users see the improved search system with "Search by Form" function and the use of system code benefited their works and the organization in conjunction with the reason from each user. Illustrated in Figure 7.4, the responses to this question were that about half of the targeted users thought that the improved search system would benefit them and their organization very much. Meanwhile there was one person noted that the improved search system would not benefit much to the work and the organization, and there was no one thinking that the system has no benefit at all or feeling uncertain.

The reasons behind the positive responses in this particular question were that

1. The improved search system would help speed up the searching of document and help the users know who is responsible for the desired documents.
2. However, noted that the improved search system will be beneficial only when system code works properly as indicated in the answer in question 2.

3. The improved search system makes access to the information of the project easier.
4. The improved search system helps reduce time searching for documents by being more specific about them.

The only user that felt the improved search would not benefit much to the work and the organization gave the reason that because the new system can only help users who are not in the project. For those who are currently working in that particular project, the system may not help much as they already knew where to find the required information about the project. The author is strongly agree to this comment because the new search system was developed to help the users who do not know how to search, where to start search including the users who need to search the documents in the project they are not responsible for.

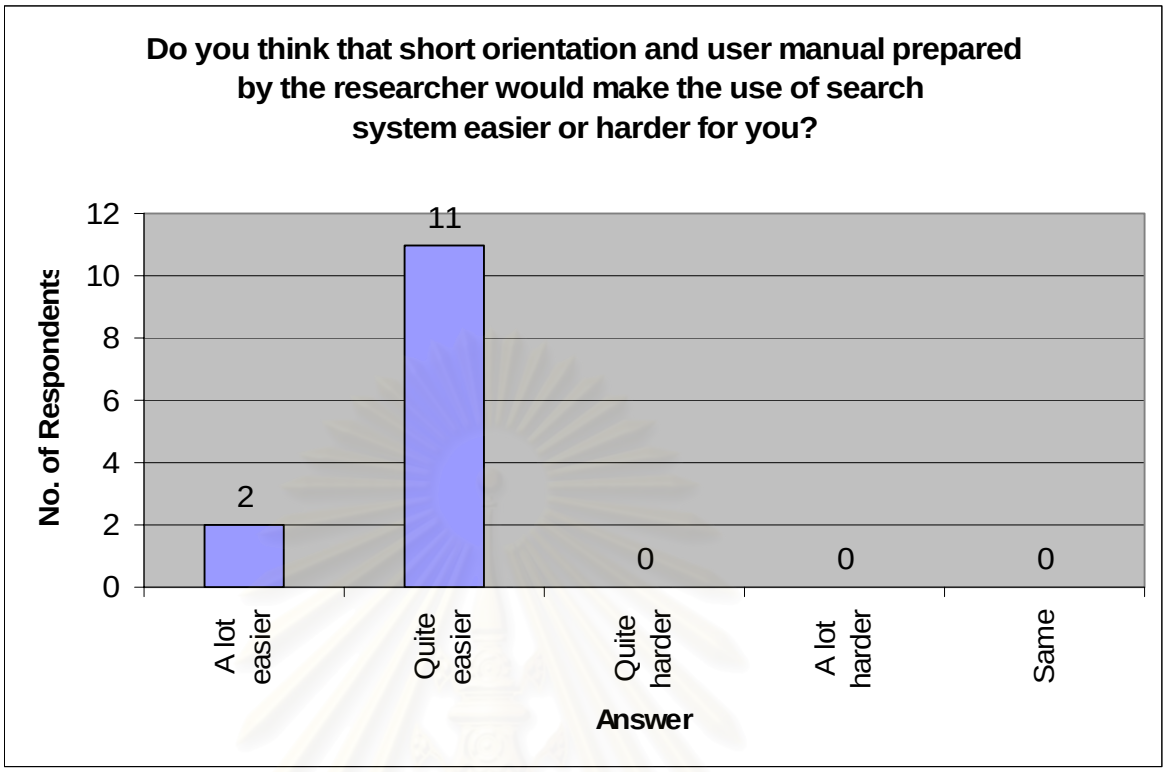

Figure 7.5 The Responses of the Users to the Fourth Question - Do you think that short orientation and user manual prepared by the researcher would make the use of search system easier or harder for you?

The fourth question being asked in the Post-Development Questionnaire was about the users' opinions regarding the preparation of user manual and short orientation provided by the researcher in order to see if these would make the use of the improved search system easier. According to the feedbacks from the users shown in Figure 7.5, all of them thought that user manual and short orientation course would made the use of search system easier, with 11 out of 13 respondents thought that the use of the search system was quite easier and 2 of them thought that it was a lot easier to use the system after being given the user manual and short orientation about the new search system.

The fifth question was designed to be open-ended and asked about the problems that the users have encountered during the test period and expected to be found in the future use. The responses from the users were quite varied. About one fourth of the users reported no specific problem found while some users concerned about the classification of the documents which if done incorrectly, would reduce the search system's performance. Noted that there was one user claimed that the client PC was frozen when viewing the search results and recommended that the number of search results per page should be limited to what was under the limitation of the available server-client power. However, the cause of this problem could possibly be that the user use 'Full-Text' search mode in simple or advanced search and did not use the "Search by Form" function as recommended.

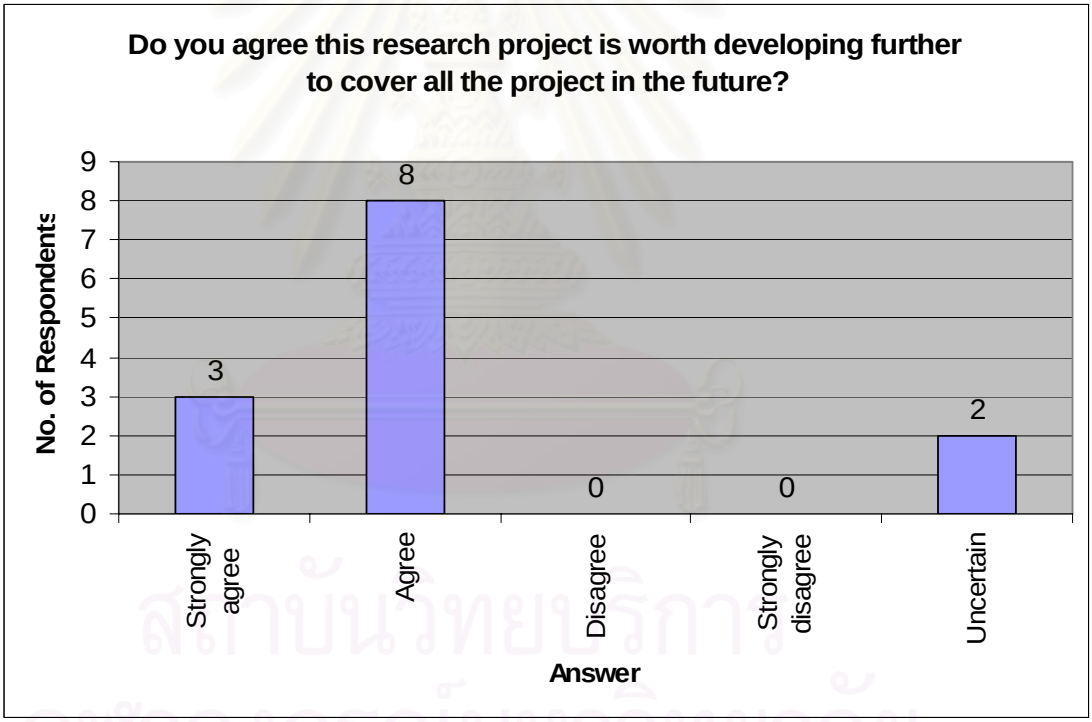

Figure 7.6 The Responses of the Users to the Sixth Question - Do you agree this research project is worth developing further to cover all projects in the future?

The sixth question, which was the last close-ended one in this questionnaire, asked if the users agree that this research project was worth developing further to cover all projects in the future.

The outcomes, as indicated in Figure 7.6, were that the majority of the respondents agreed that the project should be taken further. They commented that the development should cover all projects as it makes storing documents more systematic and possible to know the person who is responsible for the desired documents. In addition, it also provides better accuracy, speed and convenience of work than the existing system.

However, there were 2 users that felt uncertain about this; one claimed that since system code would need someone with expertise in both programming and engineering in every concerned field to fill in information to ensure correct documents classification, another did not fill in the reason.

The last, seventh question was open-ended. It asked for any suggestions the users may have upon the search system after using it for a week. The responses from the users were listed as followed;

1. For this system to work, 1. Contractor must use the specified system code and 2. if the contractor resists to use our system code, EGAT must have someone that can identify and classify the documents and assign proper EGAT system code for them.
2. The developers who classify the documents should have some basic knowledge of engineering if correct classification is to be obtained.
3. It should be cautious that the classification of document is very important. Wrongly classified documents would result in difficulties when searching for documents.
4. The developer should list all of the main systems (for engineering) or provide tick boxes and indicate what the codes of the system are so that the users who do not know the codes can use the search system.

In summary, as it can be seen so far, large proportion of the users were quite satisfied with the convenience when using the system and the accuracy of the search results while some users were not quite satisfied with the speed of the system.

However, this may be due to the personal familiarization with the system of each individual. According to the results from the questionnaire, almost every user agreed to varying degrees that System Code contributed to better performance shown by the new system. Again, almost of them also agreed that the improved search system would benefit their works and organization.

In terms of the effectiveness of user manual and short orientation, it appeared to help make the use of search system somewhat easier. There was a report of a problem with the system which was frozen PC when the program display too many results per a single page. However, the results shown per page can actually be adjusted in the software. The major concern with the search system was, in fact, the classification of documents which if done incorrectly, could reduce the search system's performance.

In addition, the majority of the users agreed that this project should be taken further to cover all projects in the future and suggested that the classification of documents was very important, whoever classified the documents should have basic knowledge of engineering and experience if correct classification of documents was expected.

CHAPTER VIII

Conclusions and Recommendations

This chapter provided the overall impressions, conclusions, limitations and recommendations for the thesis, which were arguably considered to be one of the most important parts of the research process. The whole research processes, problems encountered, limitations of the research, the findings and its relations, the research problems and objectives would be summarized and listed in a digestible manner in the following pages.

8.1 Conclusions

This thesis was carried out to improve the performance of Steam Generator and Turbine Engineering Department which is a part of Engineering Business Unit of EGAT using the AT Biopower Project as the case study. Due to the limitation of time and resources, however, the thesis only focused on mechanical drawings and technical information documents of the AT Biopower Project.

As mentioned earlier in the Statement of Problem, while the department did have PDM system to help manage and control the engineering information and electronic documents, the work still did not flow quite well. This was mainly due to the ineffectiveness of the search system. The way it worked as well as its users interface apparently contributed to the problem. Therefore, steps must be taken to enhance the performance of the search system, which is arguably one of the most important systems for the organization in this Information Technology age.

The primary investigation started by reviewing and analyzing the existing PDM's document storage and search system which cause the delay of the routine work and the project. It was found out that the major problems with the storage system were, for example, incorrect storage of documents, incorrect document revision, mismatch of document details and its title. In terms of search system, which consists of 3 modes including Simple Search, Advanced Search and Search by Keyword, the problems were unfriendly users interface, inaccurate search results, no search constrain in Advanced Search mode, etc.

Having analyzed the PDM's document storage and search system, the researcher had examined the users' requirements and expectations with the search system as well as opinions and satisfactions with existing system by mean of questionnaire (Pre Development Questionnaire). The questions incorporated in this particular questionnaire including ones regarding awareness of PDM system, types of document being search most, possible improvement on the system, etc. The questionnaire was also piloted to check for validity and eliminate possible bias that may accompany with some of the questions. During the making and administration of

questionnaire, the researcher tried not to introduce bias into the research and was careful about the ethical issues, for example, the users had been properly informed about the research project, questions were asked based on the necessity, not the luxuriousness, an inclusion 'neutral' response in the questions indicating that this particular choice is essentially acceptable. This was to ensure the most accurate and reliable results of the survey.

The findings of the first questionnaire which aim to collect information about the users' requirement and satisfaction with the existing search system came out that more than half of the respondents who knew and have used the system before use it for editing, reviewing and searching for documents as well as sending/ receiving e-mails. According to the feedback from the users, e-mail, drawings and technical information documents were mostly searched by the users respectively. Noted that the reason the e-mails were the documents being searched for most could possibly be that e-mail was used in both personal and business affairs of the senders/ receivers, while drawings and technical documents were solely for business purpose. In addition, all of the respondents who knew and have used the search system before suggested that improvement on accuracy, speed and ease of use of the system would certainly bring more convenience to the workflow than ever before.

After the results from the Pre Development Questionnaire were analyzed, the outcome was used as a knowledge/ information based on developing a better search system. The new search system was developed by adding "Search by Form" option in advanced search mode, which enhanced the search system's accuracy and speed. In conjunction with the use of BVI's System Code for proper classification of documents, problems associated with "Full-Text Search" (Simple and Advanced Search modes) such as slow operation, unrelated and overwhelming search results were significantly reduced. For example, if the classification of documents was correct, even though the document contained words that the users typed in as keywords within the body of document but did not have those particular words in its description, it would be excluded from the search result. If "Full-Text Search" was used, this unrelated document would be included in the search results; unnecessarily adding the unwanted information for the users.

Then after the new search system had been developed and tested, the researcher allowed one week for the users to test the system. Short orientation and user manual were given to the users on the first exposure to the new search system to ensure that every user did understand and could work with the new system. Post-Development Questionnaire, which was designed to collect the data regarding the effectiveness of the new search system and the satisfactions of the users, was piloted to check for validity and eliminate unacknowledged bias and administered to the users after the completion of test period.

During the performance test period, it was found that, the effectiveness of the developed search system has been improved. The search accuracy increases by 85.3% and the search speed increases up to 234.4 % compared to the existing system. The results from Post-Development Questionnaire were that the majority of the users felt quite satisfied with such improvement on search accuracy and speed of the search system as well as the convenience of using the new search system comparing to the existing search system and agreed that this project should be taken further to cover all projects for the benefits of the organization. In addition, most of them thought that using of System Code to classify the documents and providing user manual and short orientation/ training were relatively helpful. The possible problem in the users' concerns was the wrong classification of documents, which would lead to incorrect search results. Another problem reported by one of the users was the frozen PC when the search results shown were too many. This problem could be readily cured by using "Search by Form" option and limiting the result shown per page (users can select specify the results shown per page by themselves).

However, because of the limitations of time and resources, all types of reliability measures for the questionnaire including *Test-Retest*, *Alternate form* and *Internal consistency* were not measured. Therefore, the reliability of the questionnaire and the results from it were somewhat questionable.

The validity of the questions asked in the questionnaire could also be quite problematic as the *Criterion* (using 'Gold standard' survey instrument for assessing

search system's user requirements and satisfaction) and *Construct* (having the questionnaire reviewed by experienced investigators) validity were not measured.

Finally, while there were noticeable improvements in users' satisfactions as well as the performance of the search system, it should be cautiously noted that such improvements were obtained under the conditions mentioned in the scope indicated in the early chapter this of thesis and the findings of this thesis are only applicable to the targeted users who have been surveyed twice with both Pre and Post-Development Questionnaires. Generalization over wider population would be impossible because these targeted users were not representative of any larger populations.

8.2 Recommendations

1. Ideally, all types of reliability tests including *Test-retest, Alternate form and Internal consistency* should be performed if more time and resources are available. *Test-retest* reliability could be measured by administering the questionnaire to the same target group twice or more. *Alternate form* reliability could be tested by altering the wordings and layouts of the questionnaire while still maintain the same meanings and administering this revised questionnaire once again to see if the results are the same. Finally, *Internal consistency* reliability which can be tested by various means such as Spearman-Brown Split-half, Cronbach or Kuder-Richardson KR20, etc., however, the primary requirement of this particular test was that there must be at least 2 questions per a single topic.

2. 'Gold standard' questionnaire regarding the topic concerned should be used to test Criterion validity and the questionnaire itself should be also be reviewed by the experienced investigators to ensure maximum validity of the research.

3. Further research should investigate on significantly wider and/or more representative samples/ populations to make generalization possible.

4. In practice, the selection of the System Code standard should be agreed by several parties concerned with the projects/ departments/ divisions, for example, chief engineers, division managers, IT managers, etc. There should also be staffs with knowledge and expertise on both engineering and IT fields working together to look after the use of System Code so that the documents were classified correctly and make the workflow of the organization more effective than it was.

5. For the highest benefits to the organization, all types of electronic documents in addition to drawings and technical information(which has already been investigated to some extent in this thesis), for instance, e-mails, contracts,

bidding documents, etc. should be appropriately classified using proper System Code scheme that all parties concerned have agreed.

6. As may be noticed from the results in Post-Development, every user agreed that orientation or training make the use of the search system easier. Therefore, when exposing the users to anything new or different, proper training is one very crucial elements of success.

7. The improvement on search and storage system as well as the coding of documents should be made on all future projects, since each staff works on different projects, doing it on only one or two projects would limit the usage of system only to those who works on those particular projects. In other words, this would probably limit the growth of the organization.

8. For more reliable findings, the range of time allowing the users to test the new system should be extended. (more than 1 week)

9. For more reliable results of the effectiveness/ performance test, the number of persons performing the test as well as the number of keywords should be increased.

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APPENDICES

APPENDIX 1

Pre-Development Questionnaire

1

PERSONAL INFORMATION OF RESPONDENT

1. Position_ _

2. Currently, Are you responsible for any project?

◯ Yes, I am responsible for project(s) including _

◯ No, I am NOT responsible for any project.

Question 1: Do you know and ever use 'Product Data Management System' (Domino Document Manager) ?

◯ Yes, I do know and have used it before. (Please answer all of next questions)

◯ Yes, I do know but never use it before. (Please stop answering the next questions)

◯ No, neither I know nor never use it before.

Question 2: If you do know and have used 'Product Data Management System' (Domino Document Manager), how often do you do the following activities ?

	Frequency of Use					
	More than 2 times a day	*Once a day*	*Once within 2-3 days*	*Once a week*	*Once a month*	*Never*
1. Searching for electronic documents	◯	◯	◯	◯	◯	◯
2. Sending electronic documents through e-mail.	◯	◯	◯	◯	◯	◯
3. Finding experts or persons who are responsible for the job.	◯	◯	◯	◯	◯	◯
4. Reviewing and editing electronic documents	◯	◯	◯	◯	◯	◯

5. Others (Please specify)_ _

Question 3: If you have used 'Search' function of Product Data Management System (Domino Document Manager), Which type of 'Search' have you use most often?

◯ Using 'Search by Keyword'

◯ Using 'Simple Search'

◯ Using 'Advanced Search'

Question 4: If you have used 'Search' function of Product Data Management System (Domino Document Manager) How satisfied do you feel?

◯ Very satisfied

◯ Somewhat satisfied

◯ Neutral

◯ Somewhat dissatisfied

◯ Very dissatisfied

Question 5: From the last question, please specify the reason that you feel satisfied or dissatisfied with the Product Data Management System (Domino Document Manager).

Reason:_ _

_ _

_ _

*** This questionnaire is designed to extract the valuable information for developing better data searching system for the organization: use solely on educational purpose.*

2

Question 6: Normally, How often do you search for the following documents

Documents	**Frequency of Use** *More than 2 times a day*	*Once a day*	*Once within 2-3 days*	*Once a week*	*Once a month*	*Never*
1. Contract document	○	○	○	○	○	○
2. Technical information	○	○	○	○	○	○
3. User Manual	○	○	○	○	○	○
4. Bidding document	○	○	○	○	○	○
5. E-mail	○	○	○	○	○	○
6. Minute of meeting	○	○	○	○	○	○
7. Drawing	○	○	○	○	○	○

Question 7: Primary information regarding the respondent's use of keywords

_ _
_ _
_ _
_ _
_ _
_ _

Question 8: If there are improvements made to the 'Search' system by providing lists of project names and document names, types of document as well as definition/ information of each document in detail. Moreover, the user still can type in 'Keywords' in order to the wanted documents.

Do you think that such improvements in the system will lead to any more convenience in using the system and why?

Reason:

- ○ Yes, I think it make the use of the system more convenient. _
- ○ No, I think it would not change anything. _
- ○ No, I think it would rather make the use of system less convenient _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Question 9: Overall, Do you think in which areas the 'Search' function of Product Data Management (Domino Document Manager) should be improved ? (It is possible to answer more than one choice)

- ○ The speed of 'Search' function
- ○ The accuracy of 'Search' function
- ○ The ease of use
- ○ Other (Please specify) _

Thank you for your time and cooperation

Chanajit Wongsaengchan

*** This questionnaire is designed to extract the valuable information for developing better data searching system for the organization: use solely on educational purpose.*

APPENDIX 2

Post-Development Questionnaire

POST-DEVELOPMENT QUESTIONNAIRE

1

Instruction: Please mark ✓ in the answer of your choice and answer every question

1. After you have tried the improved version of electronic document management system (Domino Document Manager) which use 'System Code' indicating the groups/ classification of the documents and include 'Search by Form' function, how satisfied you are in the following area, comparing with the existing system;

	Very satisfied	*Somewhat satisfied*	*Somewhat dissatisfied*	*Very dissatisfied*	*Neutral*
1.1: Convenience in searching documents	○	○	○	○	○
1.2: Accuracy in searched results	○	○	○	○	○
1.3: Time consumption in searching documents	○	○	○	○	○

2. Do you agree that using 'System Code' to classify the documents would bring up the efficiency of the search system?

- ○ Strongly agree
- ○ Agree
- ○ Disagree
- ○ Strongly disagree
- ○ Uncertain

Reason……
……
……

3. Do you think that the Search system with 'Search by Form' function and 'System Code' dictating the groups of documents would benefit your work and/ or the organization?

- ○ Very much
- ○ Much
- ○ Not much
- ○ No benefit at all
- ○ Uncertain

Reason……
……
……

– –

Please answer every questions and then go to the next page

2

POST-DEVELOPMENT QUESTIONNAIRE

Instruction: Please mark ✓ in the answer of your choice and answer every question

4. Do you think that short orientation and user manual prepared by the researcher would make the use of search system easier or harder for you?

- ○ A lot easier
- ○ Quite easier
- ○ Quite harder
- ○ A lot harder
- ○ Same

5. After using the improved version of search system for a while, do you encounter any problem that needs a fix?

Problems found……
……
……

6. Do you agree this research project is worth developing further to cover all projects in the future?

- ○ Strongly Agree
- ○ Agree
- ○ Disagree
- ○ Strongly Disagree
- ○ Uncertain

Reason……
……
……

7. Suggestions

……
……
……

– –

Thank you very much for your cooperation

Chanajit Wongsangchan

APPENDIX 3

System Code Handbook

System Code List	
System Category and System Title	**System Code**
Ash and Scrubber Solids	**AS-**
Bottom Ash	ASA
Fly Ash	ASB
Economizer Ash	ASC
Pulverizer Rejects	ASD
Combustion Waste Storage	ASF
Auxiliary Power Supply	**AP-**
AC Power Supply (240 v)	APA
AC Power Supply (416 v)	APC
AC Power Supply (6900 v)	APE
DC Power Supply	API-I
Essential Service AC	API
Emergency Generation	APK
Auxiliary Steam	**PS-**
Auxiliary Steam Supply	PSA
Buildings and Structures	**BS-**
Generation Building	BSA
Bulk Materials (Other than Coal)	**BM-**
Lime Receiving and Storage	BMA
Coal Handling	**CH-**
Coal Receiving	CHA

System Code List	
System Category and System Title	**System Code**
Combustion Gas Cleaning and Exhaust	**CC-**
Chimney	CCA
Air Quality Control System	CCB
Induced Draft	CCE
Compressed Air	**CA-**
Station Air	CAA
Control Air	CAB
Control	**CO-**
Plant Distributed Control	COA
Controls and Multi-system Panels	COF
Cycle Heat Rejection	**HR-**
Circulating Water	HRC
Circulating Water Chemical Feed	HRE
Equipment Cooling	EC-
Closed Cycle Cooling Water	ECB
Feedwater	**FW-**
Boiler Feed	FWA
Condensate	FWC
Condensate Polishing	FWD
Cycle Chemical Feed	FEW

System Code List	
System Category and System Title	**System Code**
Cycle Makeup and Storage	FWF
Fire Protection	**FP-**
Fire Protection	FPA
Fuel Oil	**FO-**
Fuel Oil Receiving and Storage	FOA
Plant Maintenance	**PM-**
Chemical Cleaning	PMA
Primary Power Supply	**PP-**
Substation	PPA
Site Transmission	PPB
Sampling and Analysis	**SA-**
Sampling and Analysis	SAA
Site	**ST-**
Grading and Drainage	STF
Steam Generation	**SG-**
Steam Generator	SGA
Combustion Air	SGB
Igniter Fuel	SGE
Main Steam	SGG
Reheat Steam	SGJ

System Code List	
System Category and System Title	**System Code**
Turbine Extraction	**TE-**
High-Pressure Extraction	TEA
Low-Pressure Extraction	TEE
High-Pressure Heater Drains	TED
Low-Pressure Heater Drains	TEE
Turbine Generator	**TG-**
Turbine Seals and Drains	TGC
Turbine Lube Oil	TGD
Turbine Control and Instrumentation	TGE
Waste Collection and Treatment	**WW-**
Waste Collection and Treatment	WWC
Water Supply and Storage	**WS-**
Service Water Supply and Storage	WSC
Fire Protection Water Supply and Storage	WSE
Desalination Facility	WSH
Water Treatment	**WT-**
Cycle Makeup Treatment	WTD

System Code List	
System Category and System Title	**System Code**
FGD By product	ASE
AC Power Supply (240 V)	APA
AC Power Supply (416 V)	APC
AC Power Supply (3,300 V)	APF
AC Power Supply (11,500 V)	APG
DC Power Supply	APH
Essential Service AC Power	API
Emergency Generation	APK
Auxiliary Steam Supply	PSA
Auxiliary Boiler Fuel	PSB
Auxiliary Boiler Chemical Feed	PSC
Generation Building	BSA
Control Building	BSC
Miscellaneous Building	BSE
FGD Additive Preparation	BMC
Chimney	CCA
Flue Gas Desulfurization	CCC
Induced Draft	CCE
Communications	CMA
Station Air	CAA

System Code List	
System Category and System Title	**System Code**
Control Air	CAB
Hydrogen Storage	CGA
Carbon Dioxide Storage	CGB
Nitrogen Storage	CGD
Distributed Control	COA
Load Control	COB
Unit Protection	COC
Control and Multi-system Panels	COG
Condenser Air Extraction	HRB
Circulating Water	HRC
Circulating Water Makeup	HRD
Circulating Water Chemical Feed	HRE
Condenser and CCCW Heat Exchanger Cleaning	HRF
Drains and Plumbing	DPA
Grounding and Lightning Protection	EEB
Raceway	EEC
Cathodic Protection	EED
Protective Relaying	EEE
Metering	EEF

System Code List	
System Category and System Title	**System Code**
Closed Cycle Cooling Water	ECB
Boiler Feed	FWA
Condensate	FWC
Condensate Polishing	FWD
Cycle Chemical Feed	FWE
Cycle Makeup and Storage	FWF
Plant Fire Protection	FPA
Fuel Gas Supply	FGA
Site Fuel Oil Storage and Supply	FOA
Fuel Oil Supply and Unloading System	FOB
Fuel Handling System	FHA
Generator Bus Duct	GTA
Generator Transformer	GTB
Generator Surge Protection and Voltage Transformers	GTC
Generator Neutral Grounding	GTD
Lighting	LTA
Chemical Cleaning	PMA
Shutdown Corrosion Protection	PMB
Combustion Gases Sampling and Analysis	SAA
FGD Liquids Sampling and Analysis	SAB

System Code List	
System Category and System Title	**System Code**
Water Quality Control System	SAC
Roads, Parking and Sidewalks	STA
Grading and Drainage	STF
Space Conditioning	SCA
Steam Generator	SGA
Boiler Combustion Air	SGB
Air Preheat	SGC
Boiler Vents and Drains	SGF
Main Steam	SGG
Burner Control	SGH
Boiler Soot Blowing	SGI
Reheat Steam	SGJ
Temporary Blowout	SGK
Air Heater Wash Water	SGP
High-Pressure Extraction	TEA
Low-Pressure Extraction	TEB
Extraction Traps and Drains	TEC
High-Pressure Heater Drains	TED
Low-Pressure Heater Drains	TEE
Heater Vents and Miscellaneous Drains	TEF

System Code List	
System Category and System Title	**System Code**
Turbine System	TGA
Generator and Excitation	TGB
Turbine Seals and Drains	TGC
Turbine Lube Oil	TGD
Generator Cooling, Sealing and Purge	TGE
Turbine Control and Instrumentation	TGF
Chemical Waste Collection and Treatment	WWA
Sanitary Drainage and Treatment	WWB
Wastewater Collection and Treatment	WWC
Oil Spill Prevention	WWD
Service Water	WSC
Fire Protection Water Supply and Storage	WSE
Raw Water System	WSA

APPENDIX 4

User Manual for the PDM's Search System

USER MANUAL FOR THE PDM'S SEARCH SYSTEM

Because of time constraints, the developed search system was designed to work on the AT Biopower Project only. The documents of the project were duplicated and put in 'Test' project in file cabinet named '003 Engineering Document' as the scope of this thesis only cover drawings and technical information documents.

There are 3 ways to search for documents using PDM's search system as followed;

1. Full-Text Search (Users can specify the desired file cabinet or choose to search through every project that they have access to)

1. Run Lotus Notes → Click  as shown in Figure 1.

Figure 1. Main View

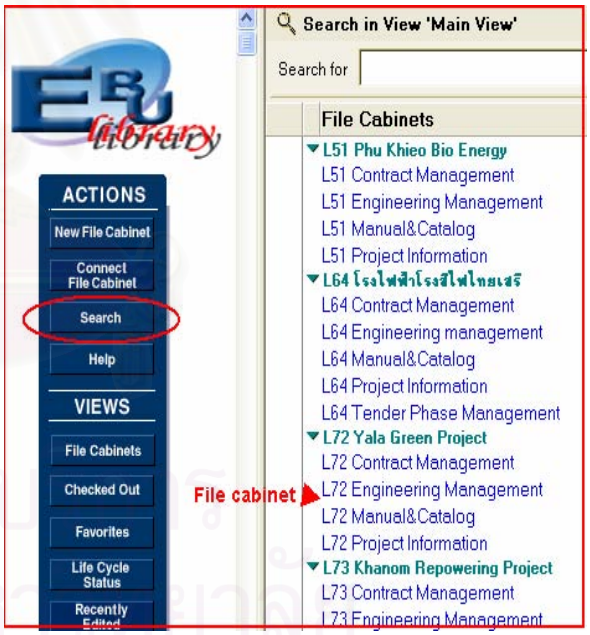


Figure 2. Search Menu

2. On screen, File Room and File Cabinet will appear as in Figure 2

3. Click on 'Search' button, Simple search dialog will appear on screen as can be seen in Figure 3.

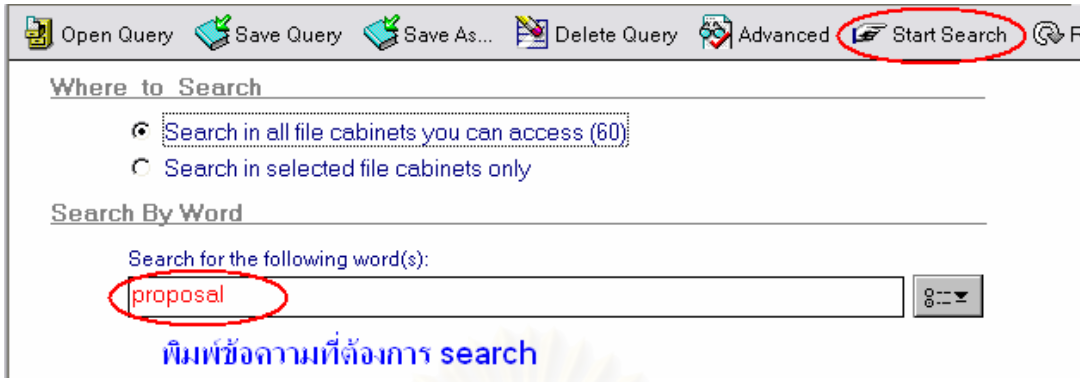


Figure 3. Simple Search View

4. Specify the following details

Search in all file cabinets you can access**:** *Search in all file cabinets you can access.*

Search in selected file cabinets only**:** *Specify file cabinet once at a time (In this case, choose 003 Engineering Management to test the new system).*

** In the case that limited search area is required, click 'Advanced' button, the detail of search parameters will be displayed** With the improved search system, the users are able to search by type of documents using' Search by Form' option.

5. If the users choose to use Advanced Search. Choose 'Search by Form' and select the type of documents to be searched for (In this case, only drawings and technical information are available). See Figure 4.

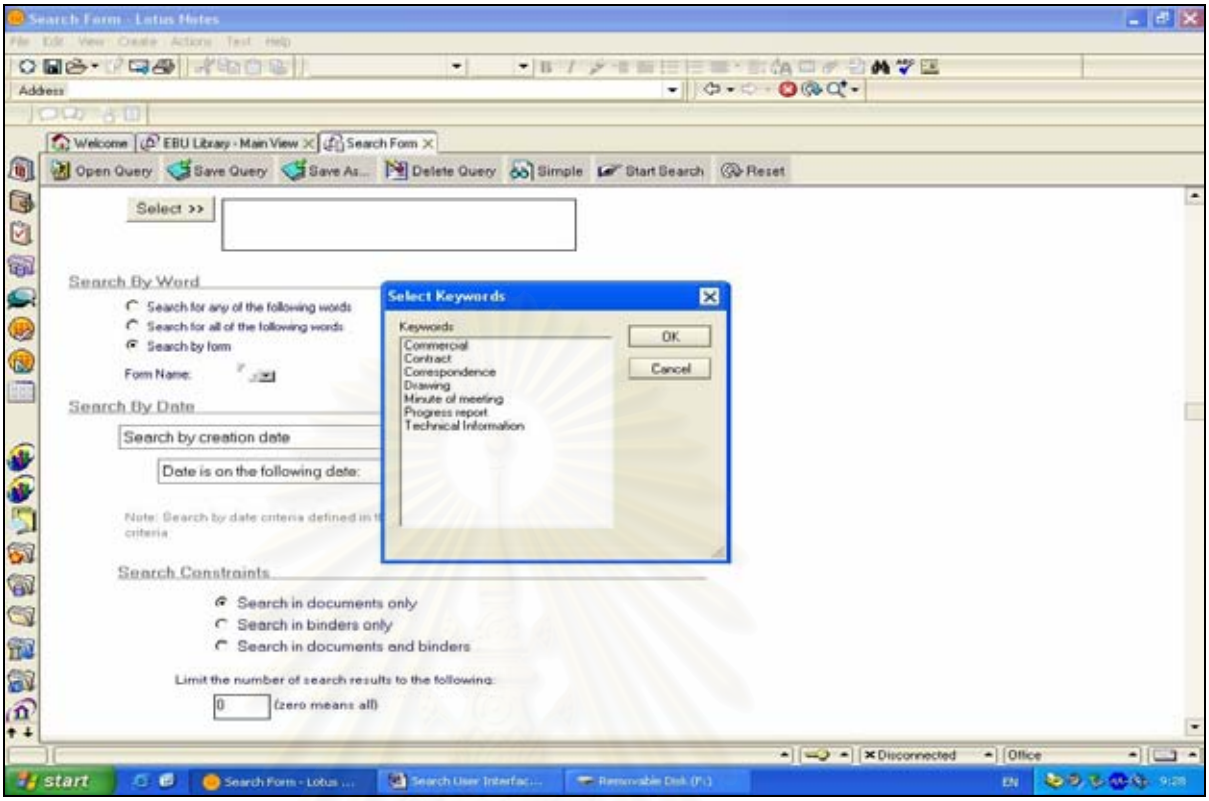


Figure 4. Advanced Search: Search by Form

6. Then the search dialog box will appear on screen as shown in Figure 5 and 6.

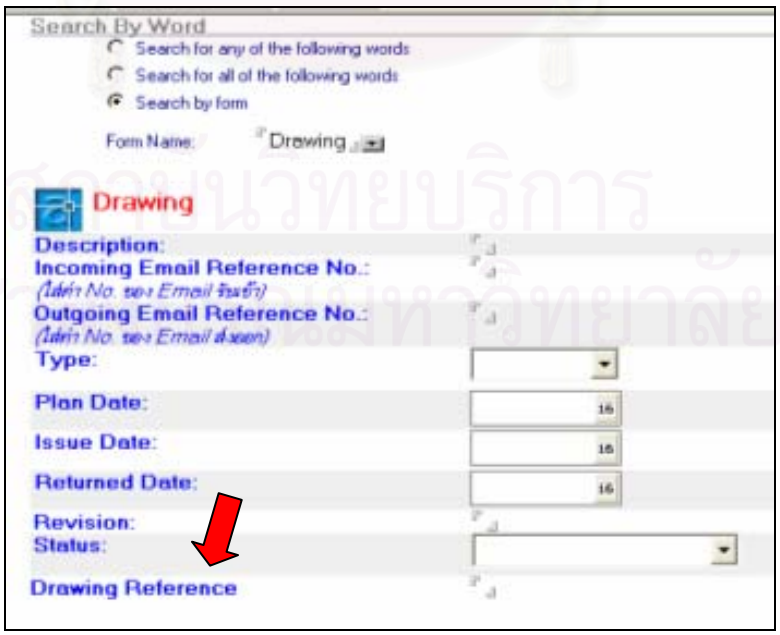


Figure 5. Search by Drawing Form

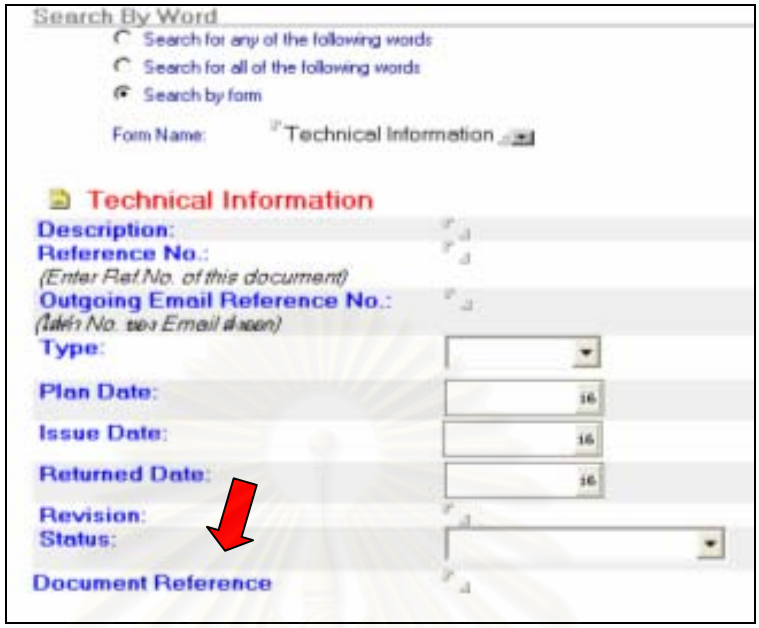
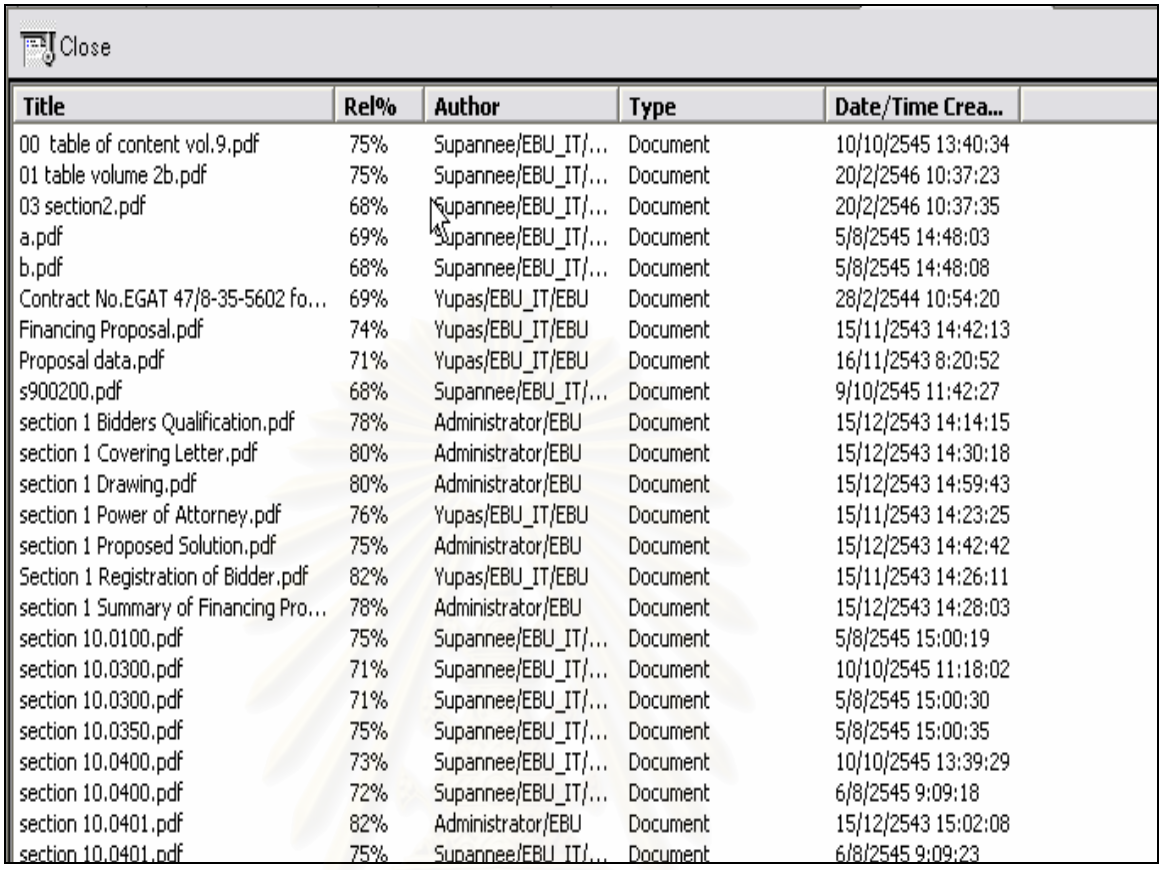


Figure 6. Search by Technical Information Form

7. Type in words that the users want and other details if desired. In drawing/ document reference section, the users can fill in System Code as listed in the attached documents (System Code Handbook) to specify the type of document. For example, users can fill in 'SGA' when searching for 'Steam Generator'. Filling in document references would help the search engine to target the documents more precisely and effectively. ** In document reference (Technical Information Form), the users can select the type of document by using codes such as 'TS' for technical specification or 'TC' for calculations, for example. See 'System Code Handbook' for more information.

8. After specify all search criteria, click 'Start Search' button. The program will start searching and will display the results similarly to what is shown in Figure 7.


Close

Title	Rel%	Author	Type	Date/Time Crea...
00 table of content vol.9.pdf	75%	Supannee/EBU_IT/...	Document	10/10/2545 13:40:34
01 table volume 2b.pdf	75%	Supannee/EBU_IT/...	Document	20/2/2546 10:37:23
03 section2.pdf	68%	Supannee/EBU_IT/...	Document	20/2/2546 10:37:35
a.pdf	69%	Supannee/EBU_IT/...	Document	5/8/2545 14:48:03
b.pdf	68%	Supannee/EBU_IT/...	Document	5/8/2545 14:48:08
Contract No.EGAT 47/8-35-5602 fo...	69%	Yupas/EBU_IT/EBU	Document	28/2/2544 10:54:20
Financing Proposal.pdf	74%	Yupas/EBU_IT/EBU	Document	15/11/2543 14:42:13
Proposal data.pdf	71%	Yupas/EBU_IT/EBU	Document	16/11/2543 8:20:52
s900200.pdf	68%	Supannee/EBU_IT/...	Document	9/10/2545 11:42:27
section 1 Bidders Qualification.pdf	78%	Administrator/EBU	Document	15/12/2543 14:14:15
section 1 Covering Letter.pdf	80%	Administrator/EBU	Document	15/12/2543 14:30:18
section 1 Drawing.pdf	80%	Administrator/EBU	Document	15/12/2543 14:59:43
section 1 Power of Attorney.pdf	76%	Yupas/EBU_IT/EBU	Document	15/11/2543 14:23:25
section 1 Proposed Solution.pdf	75%	Administrator/EBU	Document	15/12/2543 14:42:42
Section 1 Registration of Bidder.pdf	82%	Yupas/EBU_IT/EBU	Document	15/11/2543 14:26:11
section 1 Summary of Financing Pro...	78%	Administrator/EBU	Document	15/12/2543 14:28:03
section 10.0100.pdf	75%	Supannee/EBU_IT/...	Document	5/8/2545 15:00:19
section 10.0300.pdf	71%	Supannee/EBU_IT/...	Document	10/10/2545 11:18:02
section 10.0300.pdf	71%	Supannee/EBU_IT/...	Document	5/8/2545 15:00:30
section 10.0350.pdf	75%	Supannee/EBU_IT/...	Document	5/8/2545 15:00:35
section 10.0400.pdf	73%	Supannee/EBU_IT/...	Document	10/10/2545 13:39:29
section 10.0400.pdf	72%	Supannee/EBU_IT/...	Document	6/8/2545 9:09:18
section 10.0401.pdf	82%	Administrator/EBU	Document	15/12/2543 15:02:08
section 10.0401.pdf	75%	Supannee/EBU_IT/...	Document	6/8/2545 9:09:23

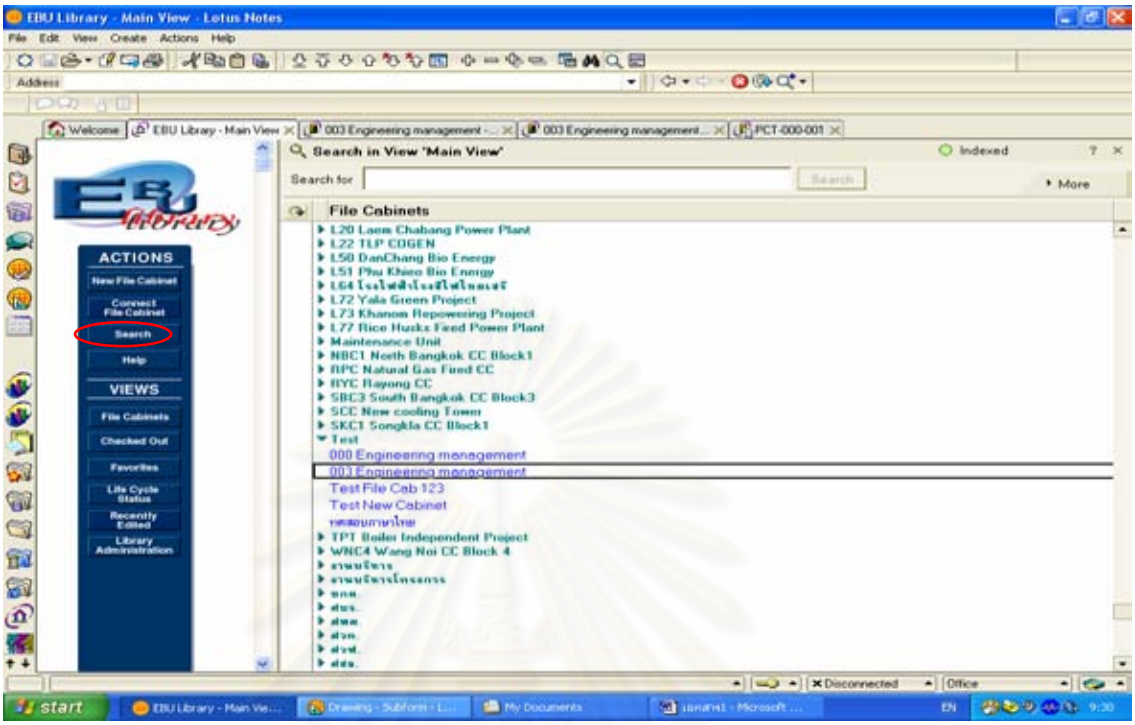
Figure 7. Search Results View

2. Full-Text Search (Users can specify the file cabinet to search for on main view)

This type of search is very similar to the first type. What differ between the two is that, in this type of search, before clicking ‘Search’ button, the users must select the file cabinet to search for first. In this example, select ‘003 Engineering Management’.

1. Run Lotus Notes → Click  as shown in Figure 1

2. Go to File Room named ‘Test’ and select File Cabinet named ‘003 Engineering Management’ shown in screen shot on the next page.



3. When the screen displays binders of the file cabinet, click ‘Search’ in the menu.

4. The Simple Search dialog box will appear as shown in Figure 8.

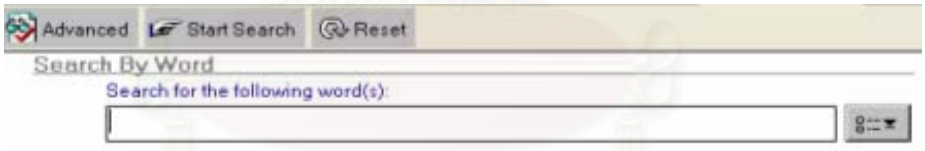


Figure 8. Simple Search Dialog Box

** In cases that limited search area is required, click ‘Advanced’ button, the detail of search parameters will be displayed** With the improved search system, the users are able to search by type of documents using’ Search by Form’ option.

5. Follows steps 5-7 of the first type of search.

3. Search by Keyword (The system will search through every field of document profiles in the selected binder)

1. Run Lotus Notes → Click  as shown in Figure 1

2. Go to File Room named 'Test' and select File Cabinet named '003 Engineering Management'.

3. Select the desired Binder, for example, Drawing/ME or Technical Information/Calculation/ME

** In this case, searching by filling in System Code is possible in Drawing and Technical Information Binder in ME section only**.

4. When the search system displays all documents in that particular binder, the users can search for documents right away by typing in the words of choices in 'Search for' field as shown in Figure 9.

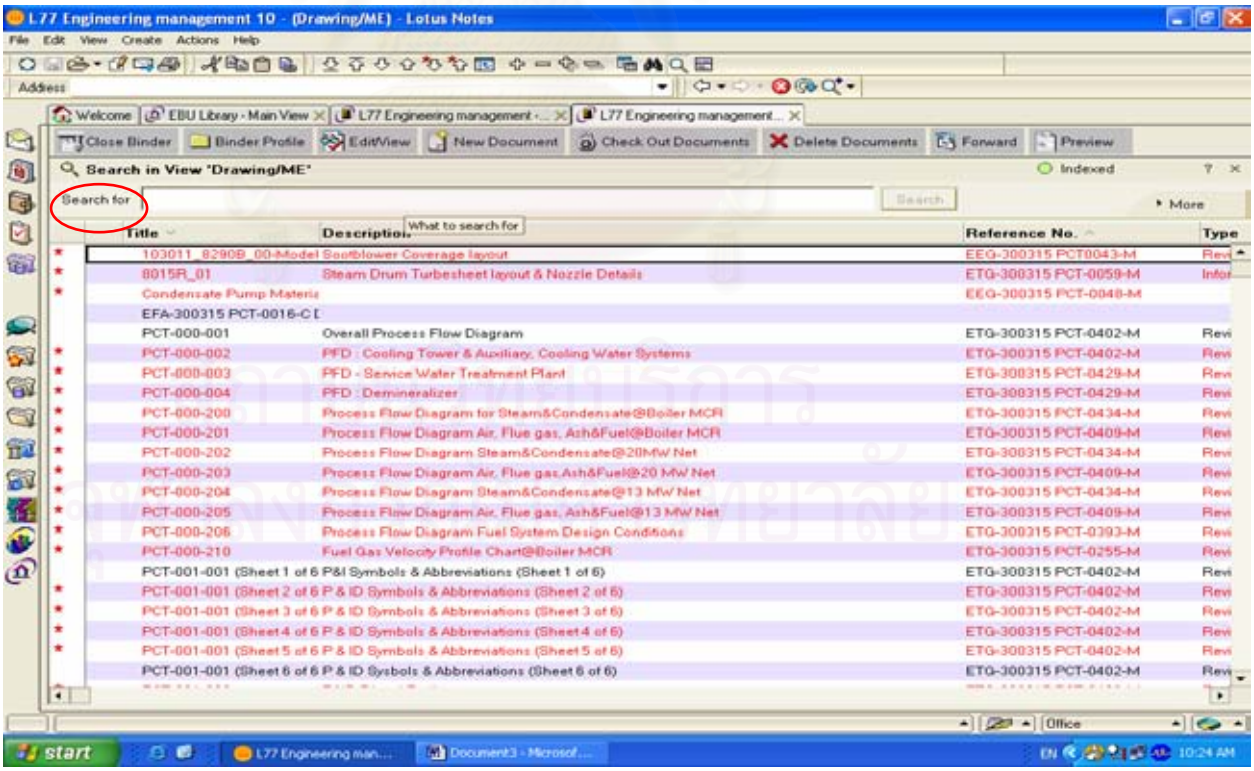


Figure 9. Search by Keyword View

5. Typing in the Keyword of choices. It is also possible to type in several words and use ‘& or and’ to link words together. For example, if the users want to find documents that contain word ‘Mud Drum’ in Boiler group (code – SGA), the users can type in ‘Mud Drum & SGA to specify the documents. In addition, if the users want to search for documents containing one of the Keywords typed in, it is possible to use ‘|, or’ to link words together, for instance, Mud Drum | SGA.

6. Click on ‘Search’ button to begin searching for documents.

** Noted that this type of search only looks for words in title, document descriptions, reference numbers, etc. not Full-Text Search. This type of search will suit the users who know exactly where the documents are**.

BIOGRAPHY

Miss Chanajit Wongsaengchan was born on 29 August 1980 in Lampang, Thailand. In 2002, she has obtained her Bachelor Degree in Mechanical Engineering, Second Class Honours from Sirindhorn International Institute of Technology (SIIT), Thammasat University. In the same year, she started working for the Electricity Generating Authority of Thailand (EGAT) as a mechanical engineer. She worked in the Steam Generator and Turbine Engineering Department for one year. After that, she had decided to continue her study for Master Degree in Engineering Management at the Regional Centre for Manufacturing Systems Engineering (RCMSE), Chulalongkorn University, Thailand and University of Warwick, United Kingdom.