



Study and Analysis of Knowledge Acquisition Techniques for Acquiring Knowledge on Product Functionality

C.Janani¹, T.Devi²

¹Research Scholar, Department of Computer Applications, Bharathiar University, Coimbatore, India

²Head I/C, Department of Computer Applications, Bharathiar University, Coimbatore, India

Abstract: This research is concerned with the Study and Analysis of Knowledge Acquisition Techniques, detailed study on Product Functionality, comparison of various Knowledge Acquisition Techniques and to select a Knowledge Acquisition Method for Acquiring Knowledge on Product Functionality efficiently. This study investigates the efficiency of the various knowledge acquisition techniques in product functionality. The most important venture of this research is to present detailed analysis of the Knowledge Acquisition techniques, design a questionnaire for acquiring knowledge on product functionality, and then test the designed questionnaire with certain industrial product data collection. The purpose of this research is to understand knowledge acquisition techniques, perform analysis in a structured way as well as ensure that important aspects of product data are taken into account in knowledge management projects.

Keywords: Questionnaire, Knowledge Management (KM), Knowledge Acquisition (KA), Knowledge Acquisition Techniques (KAT), Product Functionality (PF)

I. Introduction

This research is concerned with the selection of a Knowledge Acquisition Method for Acquiring Knowledge on Product Functionality efficiently. Researchers describes the term Knowledge Management (KM) as follows: "Knowledge management is concerned with the exploitation and development of the knowledge assets of an organization with a view to furthering the organization's objectives. The knowledge to be managed includes both explicit, documented knowledge, and tacit subjective knowledge. Management entails all of those processes associated with the identification, sharing, and creation of knowledge. This requires systems for the creation and maintenance of knowledge repositories, and to cultivate and facilitate the sharing of knowledge and organizational learning. Organizations that succeed in knowledge management are likely to view knowledge as an asset and to develop organizational norms and values, which support the creation and sharing of knowledge" [Rowley, 2000]. Knowledge Management is a critical success factor and challenge for the future. The main idea driving KM is that knowledge must be managed like an asset, which entails creating, codifying and sharing knowledge. In order to be successful in a global market, a product developed must provide better functionality to its users in comparison to the current products. The analysis of business processes along with KM business strategies and organizational structures are essential to study the implications of knowledge acquisition techniques. In this research, an attempt has been made to study the knowledge acquisition methods used for product development processes with the help of industrial product knowledge acquired from the recently employed methods and tools used in industries. A framework for analysis and guidelines for the selection of methodologies of knowledge acquisitions are presented. The main objectives are:

- 1) To study and analyse the knowledge acquisition techniques and tools;
- 2) To conduct a detailed study on product functionality;
- 3) To compare the knowledge acquisition techniques and to select a knowledge acquisition method for acquiring knowledge on product functionality efficiently;
- 4) To design a questionnaire for acquiring knowledge on product functionality;
- 5) To test the above knowledge acquisition techniques using industrial product data collection.

II. Knowledge Acquisition

Knowledge acquisition is one of the most difficult and error-prone task which is done by knowledge engineer while building a knowledge-based system. Knowledge acquisition includes the elicitation, collection, analysis, modelling and validation of knowledge for knowledge engineering and knowledge management projects. In the traditional approach to acquiring knowledge, a knowledge engineer consults reference materials, databases, and human experts. The knowledge captured will be both explicit and tacit knowledge. Explicit knowledge is acquired through printed material. Several sources of explicit knowledge includes company policy manuals and regulations, reports, memos, published books, journal articles, program source code and database stored procedures [Rhem A.J., 2001]. Knowledge acquisition is a crucial process in knowledge management and knowledge engineering fields. Knowledge is obtained from diverse sources, such as media, Internet, printed material and document, reports, and experts.

The process of knowledge acquisition also involves a variety of personnel, such as knowledge engineer, domain expert users, and programmers. Before meeting the experts, the knowledge engineer is supposed to acquire explicit knowledge from existing sources to employ the expert's valuable time most effectively. Depending on the type and nature of the knowledge, different techniques for acquisition are used. Experts have gained knowledge by learning and working in different conditions and different places. Conferences, symposiums, seminars, books, magazines, and journals are just some of the ways they can share their knowledge. It is always advantageous to collect the opinions and knowledge from multiple experts, cross-verify them and represent the views and knowledge in the system. Knowledge acquisition is a fundamental process for survival which begins early and continues throughout the life span. The acquisition process can be implemented by elicitation, collection, analysis, modelling and validation of knowledge. Research within the last decade proves that from the beginning the early age knowledge is organized into theories that are elaborated and revised over time and that serve as vehicles for understanding the world. In other words, knowledge acquisition to a large degree occurs through a process of theory formation and revision [Deanna, et al., 1995].

A. Knowledge Acquisition Techniques

This section discusses how the various knowledge acquisition techniques and its features are used to deduce relevant knowledge in a particular locale. The following are the various knowledge acquisition techniques [Bechhofer] widely used to gather information about a particular aspect [Mostafa J. et al., 2011]: ①Protocol-generation techniques, ②Teach-back Technique, ③Protocol Analysis techniques, ④Laddering techniques, ⑤ Matrix-based techniques, ⑥ Repertory Grid technique, ⑦ Sorting techniques, ⑧ Limited-information and constrained-processing tasks and ⑨Diagram-based techniques. In Table I, column “Techniques” represents a few knowledge management techniques, which are carefully organized into a set of acquisition rules. Second and third column of Table I define the structure of inputs and outputs for the respective KA techniques. The column “Result” depicts what form of knowledge data is obtained via the given input. The last two columns portray the robustness of each technique [R.Hepziba, C.Janani and T.Devi, 2013]. In Table II, analysis on the efficiency of the various KA techniques is depicted.

Table I Comparative Study on Knowledge Acquisition Techniques

Techniques	Input	Output	Result	Efficiency	Type
Unstructured	Interview	Based on Procedure followed, Knowledge used.	Varies depending on the Questions asked	Time Consuming	Direct
Structured				N/A	
Semi-Structured				Based on Application	
Observation	Observed Data(Image s, Presentatio ns)	Taxonomy of tasks/subtasks or functions/procedures, Problem-solving strategy, knowledge and skills needed for tasks	Information used, Procedure Followed	Time Consuming	
Commentary	Self Report	Problem-solving strategy	Online/Offline Reporting		
Laddering	Documents, Interview, Verbal Question	A Hierarchical Map	Varies by Procedure followed, Rationale	Based on Application	Indirect
Matrix	Interview	Attributes, Relationship	Attribute and Relationship Matrices	Time Consuming	
Frames		Representing properties of Concepts.	Validating captured Knowledge		
Time Line		Flowchart	Capture of basic Processes		
Forms	Software Application , Interview	Attributes and Entities (if provided by subject)	Hyper Text, Web Pages		
Repertory Grid			Entities, Attributes and Relationship	Based on Application	

Table III Analysis of Knowledge Acquisition Techniques

Techniques	Limitations	Efficiency	Result
Protocol Generation	Not suitable for detailed or implicit and tacit knowledge. Co-operation from the domain expert can be difficult.	Time Consuming	Avoids preconceived ideas.
Teach-back	Poor understanding can lead to serious problems. Interpreter needed if knowledge is not acquired/delivered clearly. Mostly this technique results in repetition of tasks.	Depends on the expert system used.	Clear communication is essential for effective knowledge acquisition.
Protocol Analysis	Analysis of protocols is difficult. Skilled interpreters required to analyse knowledge repository.	Based on Application.	No knowledge Engineer is necessary.
Laddering	In-depth interview. Repetition of structures. Indirect questioning.	Time Consuming based on application.	Easy to represent the knowledge acquired. Hidden data.

Matrix-based	Allocation of resources conflict. Cost can be increased if problems occur in source of knowledge.	Time Consuming	Enables usage of newer environments. Dynamic.
Repertory Grid	Difficult to monitor in independent environment. Not a good choice when schedule is tight.	Time Consuming depending on the system used.	Enables comparison of data across organisation or experts.
Sorting	Requires special skill of the knowledge engineer. Difficult to master when large number of concepts is involved.	Based on Application.	Produces artificial structures. Gives global structure of domain.
Limited-information and Constrained Processing	Requires sensitivity and responses to physical environment. Requires empirical data.	Time Consuming	Must be able to verbalize the attributes and values of a decision alternative.
Diagram-based	Experts with familiarity of the domain are necessary. Very little factual information is provided.	Based on Application.	Insight into general problem-solving method and declarative knowledge used is provided.

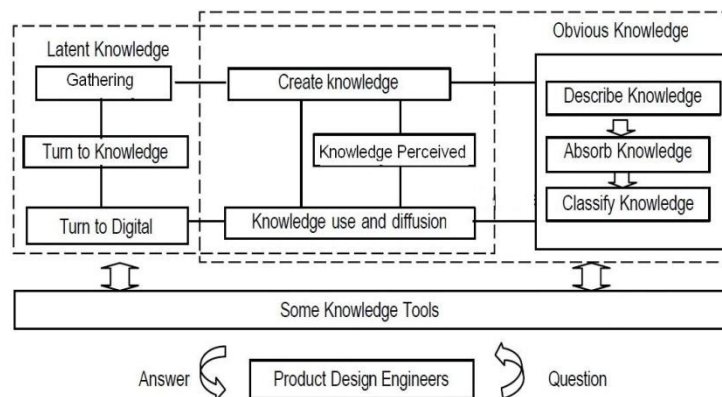
III. Product Functionality

A product can be described from many different points of view, each potentially defining a different product structure. A product structure called Bill-of-Materials (BOM) is a collection of component descriptions organized as a part of functional hierarchy. Each component description contains the necessary information for making a piece of the product [Tomi M., et al. 1996]. Functionality is an abstract product characteristic that a customer or sales person uses to describe what the product can be used to do and what requirements the product can satisfy [Alexander et al. 2001]. A conventional type of product knowledge comprises of product design skills, process scheduling experiences, management artifice, and market necessity information. The purpose of product functionality is to represent product family through a general design structure. Actually it is a process that acquires and represents product knowledge briefly with its functional structure. This depicts the components that are needed for a product, the quantity of components and their dependencies. This assists the design team to identify and rank areas of focus for product improvement. The product's functionality depends on the product features relevant to the target market. Critical topics include prioritization of functionalities and capabilities based upon market demands. The functionality of the product plays an important role in the technical process. At any stage of the process it is necessary to see whether the product's functionalities have been achieved. Based on this the decision about the direction of the project, the resources required to achieve the product functionalities would be planned. The functionality of the product is treated as the separate element from the product itself. Thus, functions during technical process are achieved through specifying and identifying changes in the attributes of the product elements and relationship between the product elements [Thirupathi, 1998].

A. Interweaving Knowledge Acquisition and Product Functionality

Knowledge management in product development covers a broad spectrum of activities and operations at many levels, from the individuals to the whole enterprise and between enterprises. Effective KM can only be achieved through a holistic approach, addressing not only technological solutions, but also people, processes and links of core business activities. The purpose is to reuse knowledge, create worth in enterprise, create new knowledge by any possibility, and thus provides economical knowledge mobility for the circle of knowledge management. Knowledge management is a gradual and circular process in knowledge-based product development system as shown in Fig. 1 [Li and Xie, 2004]. It is important that KA techniques are extended to cover not only the static knowledge about a product, but also the dynamic knowledge about the design processes of the product. Due to their high complexity, product development processes should be expected to be a highly rewarding field for the application of knowledge management [Christian W, et al., 2004]. The lack of a proper product representation which includes its function, behaviour, and structure is a foremost limitation of the existing systems.

Figure 1 Process of Knowledge Acquisition in Product Development [Li and Xie, 2004]



Knowledge management of new product development provides an approach to represent and manage product domain entities and relations. KA is depicted as the major problem in illustrating the functionality of any product. But the complexity of the product descriptions in certain businesses causes difficulty. The product engineers/developers can no longer understand a product the way it is portrayed. The problem is due to brief

addressing of the configuration product structure models in the object oriented methods look more comprehensible than its detailed functional components.

IV. Design and Analysis of KAT for Acquiring Knowledge on PF

A. Design of Techniques for Acquiring Industrial Knowledge on Product Functionality

An abstracted description of work is that a product must perform to meet customer needs. Functional requirements capture the intended behaviour of the product- what the product will do. This behaviour may be expressed as functions, tasks, or services the product is required to perform. Therefore, functional requirements do not include performance characteristics, operating conditions, use cases, and specifications. The information that is supported is in the form-features cannot be obtained easily. The functional requirements of a system will be capable of overcoming these deficiencies [Shah, 1988]. A product is a set of profits put forward for exchange which can be tangible or intangible asset. Product development process is sequence of steps for imagination, design and maturity of a product. The product knowledge can operate as a bond for integrating processes that are carried out in various domains of an enterprise.

Figure 2 Design of Questionnaire for Acquiring Knowledge on Product Functionality

QUESTIONNAIRE																																	
Dear Design Engineer, I am pering research on "Techniques for Eliciting Product Functionality Knowledge". In this connection, I request your kind co-operation in filling up the questionnaire on product knowledge and new product development process. Please kindly fill the following information. This is purely for the academic research purpose. Thanking you, Yours sincerely, C Janani Name : _____ Age : _____ Designation : _____ E-mail address : _____ 1) Name of the product: 2) Segments of the product: 3) Specifications of the product: 4) What is the usage/purpose of the product?	5) Tabulate the names of the components/assembly and provide their corresponding functions. <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">COMPONENTS OF THE PRODUCT</th> <th style="width: 50%;">FUNCTIONS</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </tbody> </table> 6) List out all the functions of the product. 7) Categorize the products as primary or secondary functions. <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">PRODUCT FUNCTIONALITY</th> <th style="width: 50%;">PRIMARY / SECONDARY</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> <tr><td> </td><td> </td></tr> </tbody> </table> 8) What parameters do you use to measure the usage/functionality of the product? 9) How do you rate the functionality of the product? 10) Do you digitally save the product data? ☐ Yes ☐ No 11) If you to question no. (10), please provide the details how you save it? ☐ Excel ☐ CAD ☐ Others, (Please Specify) _____ 12) Are you storing the product functionality/functions mentioned in (answer to) question no. (5) digitally? ☐ Yes ☐ No 13) If yes to question no. (12), please provide the details how you save it? ☐ Text Documents ☐ Diagrams with Comments ☐ Others, (Please Specify) _____	COMPONENTS OF THE PRODUCT	FUNCTIONS															PRODUCT FUNCTIONALITY	PRIMARY / SECONDARY														
COMPONENTS OF THE PRODUCT	FUNCTIONS																																
PRODUCT FUNCTIONALITY	PRIMARY / SECONDARY																																

Mastering product functionality data allows a better integration of the product development process. In due course of time, if the product is manufactured in bulk quantity then, the knowledge about functionality and hence the product may disappear. To gain a broader perspective on Knowledge Acquisition techniques in functional product knowledge, certain aspects in the techniques need to be revised. This necessitates the analysis of the entire product knowledge in an organization. Based on the analysis done in the Knowledge acquisition techniques, it is studied that only particular aspects of the methodologies have been utilized. With appropriate usage, knowledge acquisition in product functionality can successfully increase product innovation capability beyond that of a firm's competitors. In order to get the product functionality from the design engineers during the interview/questionnaire, the following questions (as in Fig. 2) need to be asked. This analysis illustrates how the product functionality knowledge acquisition can affect development of novel products in a more convenient way for the design engineers' usage.

B. Analysis of Techniques for Acquiring Industrial Knowledge on Product Functionality

The product knowledge of an enterprise can operate as a bond for integrating processes that are carried out in various domains. Mastering product functionality data allows a better integration of the product development process. For acquiring product data and its functionality, manufacturing companies involved in new product development process have been considered. In order to acquire this product knowledge, a questionnaire has been designed. The sample size of the data acquired is thirty corresponding to different products. The gained product knowledge corresponds to thirty products from thirty different design engineers. Each product has its own purpose, specification, assembly/components and functions. The designers have produced few details about each of the components in the product and their functions. The questionnaire gathers creditable information about the product data such as:

- Name and segments of the product
- Specifications and purpose of the segments
- Assembly/Component functions
- Functionality of the product
- Parameter used for rating the product and
- Electronic storage details of the product data and product functionality

From the analysis so far done, it reveals that most of the design engineers are not aware of product functionality and the data relevant to it. This causes ambiguity which results in a collection of wasted knowledge. Approximately only 2% of the respondents have awareness on product functionality and data associated with the product. The collected product knowledge corresponds to thirty products and they can be categorized into three branches of product data storage. The product data storage can be sorted out into data which are digitally stored, which are not stored digitally and which details about storage are not specified. Table III shows information about the product data digital storage. The Fig. 3 depicts the product data-wise storage acquired with a sample of 30. With a sample size of 30 only, 11(37%) experts store their product data digitally. Almost 50% of the design engineers do not store their product data electronically, whereas about 13% of the engineers have no idea about product data storage. Based on the response from design engineers on product data storage, product functionality information storage facets are gained.

Table III Product Data Storage Analysis

DATA STORAGE	DATA SIZE (30)	PERCENTAGE (%)
Not Specified	4	13%
Stored Data	11	37%
Not Stored Data	15	50%

Figure 3 Pie-chart for Product Data Storage Analysis with Samples of 30

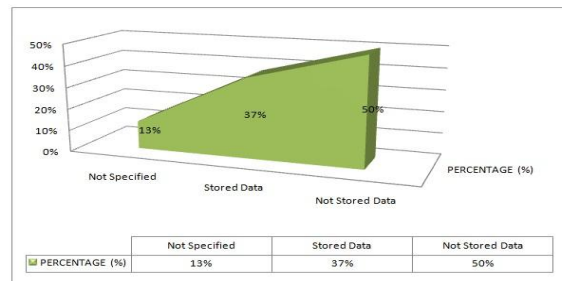
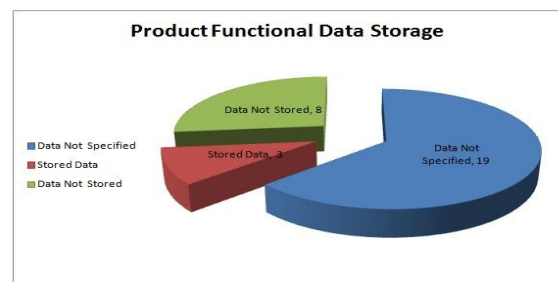


Table IV explains information about the product functionality data digital storage. Among the sample data size of 30, only 11 have motivation for product functionality data storage, only 3 have stored their functional data digitally. From the table IV, it concludes that only 10% of product functionality data is stored digitally and approximately 90% (No knowledge of storing product functionality data=63%, and product functionality data not stored=27%) of designers do not store functionality information digitally. The Fig. 4 is a pie-chart that represents the facts about functionality of a product's data storage.

Table IV Product Functionality Data Storage Analysis

DATA STORAGE	DATA SIZE (30)	PERCENTAGE (%)
Data Not Specified	19	63%
Stored Data	3	10%
Data Not Stored	8	27%

Figure 4 Pie-chart for Product Functionality Data Storage Analysis with Samples of 30



C. Results and Discussion

This research is an outcome of the study and analysis of knowledge acquisition techniques and tools, for selecting a knowledge acquisition method for acquiring knowledge on product functionality efficiently. The main objective of this research is to analyse the use of knowledge acquisition techniques in acquiring product functionality knowledge. This analysis is useful in analysing the data based on segments, components, functions and parameters of a product and its functionality. It concludes that most of the design engineers are unaware of product functionality. Those who have knowledge about the functionalities of a product do not store them digitally. Those who store product data do not store product functionality data. It affirms that only one in a tenth digitally store the functionality data.

V. Conclusion and Further Work

This study reports a literature review on knowledge management and the various types and sources of knowledge are reviewed. A brief discussion on the evolution of knowledge management tools and techniques is made. Also, an analysis on knowledge acquisition process and various techniques involved in acquiring knowledge in an enterprise are studied in detail. The outcome of a comparative study on the various techniques available is also reported. It highlights about a product, its functions and sub-functions, its overall functionality while developing a new product. A questionnaire to collect the knowledge on product functionality has been designed and developed. The questionnaire is used to collect creditable product data and its functionality. The product functionality data is not stored digitally. Most of the design engineers are unaware of the importance of

product functionality and relevant associated data; they concentrate only on the physical design of a product in the development process. In due course of time, if the product is not manufactured in bulk quantity, then the knowledge about product functionality and hence the product may disappear. In order to overcome this issue, it is necessary to cultivate knowledge in the minds of designers to store every minute functions and parameters of a product during the development process. In short, there is no single right way to acquire knowledge based on product functionality in all enterprises. Hence, experts are in need of a general technique or tool that ensures consistency and offers appropriate mechanisms for mass data processing for integrating knowledge management and product development. The comparative study on the various knowledge acquisition techniques enables one to further modify or improvise the techniques based on the requirements of all enterprises. In order to avoid ambiguity in the process of acquiring knowledge, example-based knowledge acquisition techniques can be used. Semantic based knowledge acquisition methods can be proposed and tools can be developed. Future work can also include making a tool that uses other forms of knowledge, showing the interconnections between each technique that shows how the knowledge so far acquired has evolved along the product development process. An automatic interactive questionnaire analysis tool may be developed.

VI. References

- [1]. Alexander Felfernig, Gerhard Friedrich, Et Al (2001). "Conceptual Modeling For Configuration Of Mass-Customizable Products". *Artificial Intelligence In Engineering*, 15, Pp.165-176.
- [2]. Bechhofer Sean. (2006). *Knowledge Elicitation*, © University Of Manchester, Comp30411.
- [3]. Christian Wagner. (2006). "Breaking The Knowledge Acquisition Bottleneck Through Conversational Knowledge Management". *Information Resources Management Journal*, 19(1), 70-83, Jan-Mar '06. Copyright © Idea Group Inc.
- [4]. Christian Weber, Martin Pohl, Michael Steinbach. (2004). "New Ideas For Knowledge Management In Product Development Projects". *International Design Conference*, Dubrovnik, May 18 - 21.
- [5]. Deanna Kuhn, Merce Garcia-Mila, Anat Zohar, Christopher Andersen, Sheldon H. White, David Klahr, Sharon M. Carver. (1995). "Strategies Of Knowledge Acquisition". *Monographs Of The Society For Research In Child Development*, Vol.60, No. 4.
- [6]. Hepziba Gnanamalar R, Janani C, Devi T. (2013) "Knowledge Acquisition Techniques And Tools: A Review". *International Journal Of Emerging Technologies In Computational And Applied Sciences (Ijetcas)*, Issn (Print): 2279-0047, Issn (Online): 2279-0055, Issue 3, Vol. 2, Dec '12-Feb '13.
- [7]. Li Shaobo And Xie Qingsheng. (2004). "Knowledge Management In Product Development Integration System". *Cad/Cims Institute, Guizhou University Of Technology, Guiyang Guizhou China, 550003. Proceedings Of The 6th International Conference On Frontiers Of Design And Manufacturing*.
- [8]. Mostafa Jafari, Peyman Akhavan, Maryam Akhtari. (2011). "Exploration Of Knowledge Acquisition Techniques In Tunnel Industry: The Case Study Of Iran Tunnel Association". *International Journal Of Business And Management* Vol. 6, No. 8; Aug '11 Published By Canadian Center Of Science And Education.
- [9]. Nedhal A. Al-Saiyd, Adel H. Mohammad, Intisar A. Al-Sayed, Muna F. Al-Sammarai. (2011). "Distributed Knowledge Acquisition System For Software Design Problems". *European Journal Of Scientific Research* Issn1450-216x Vol.62 No.3, © Eurojournals Publishing, Inc.
- [10]. Rhem. A.J. (2001). "A Framework For Knowledge Acquisition". A.J. Rhem & Associates, Inc-Providing Today's Solutions With Tomorrow's Technology. White Paper, May '01.
- [11]. Rowley, J. (2000). "From Learning Organization To Knowledge Entrepreneur". *Journal Of Knowledge Management*, Vol 4, Pp.7-14.
- [12]. Shah J.J., Rogers M.T. (1988). "Functional Requirements And Conceptual Design Of The Feature-Based Modelling System". *Computer-Aided Engineering Journal*, 5(1). Pp.9-15.
- [13]. Thirupathi D. (1998). "Integrated Information Model For Managing The Product Introduction Process". Ph.D. Thesis, Coventry, U.K. University Of Warwick.
- [14]. Tomi Männistö, Hannu Peltonen And Reijo Sulonen. (1996). "View To Product Configuration Knowledge Modelling And Evolution". *Helsinki University Of Technology, Iia Research Centre And Laboratory Of Information Processing Science*.