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A WEB-BASED INFORMATION-PORTAL FOR THE EARLY STAGES OF DESIGN

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1. Introduction

In developing new and innovative products in the age of information technology, knowledge and information management are becoming increasingly important factors for companies. The early design phase is especially essential to the success of a company. According to the differences of existing products, the tasks of a designer are very heterogeneous. In order to deal with them, a designer needs, on one hand, special knowledge about techniques and natural science, and on the other, skills in methodogical problem-solving and the systematic structuring of a design task. To support engineers in the field of product development, an approach for supporting engineers with information is necessary. Such an approach has been generated within the pinngate-project[1] at the pmd department at the Darmstadt University of Technology. It aims at eliminating deficits concerning the availability of design knowledge and the support of methods. The paper presents the concept of a web-based information tool which is based on a sub-project of pinngate and relates the first experiences using the tool in a R&D-project.

2. Background

2.1 The pinngate-Project

The pinngate-project aims to establish a teaching and learning system which is also ready to use in the field of product development. All the improvements are conceived to adapt to the individual situation, the special background education and the specific task of the designer. Thus, the pinngate-system is characterised by three sub-systems:

- Knowledge-bases, where the theory of product development, design methods and concrete solutions are described according to an integrated product-model.
- Learning and teaching environments presenting learning documents which consider the different requirements of special target groups.
- Design method tools which are ready to use supporting the designer working on concrete design tasks.

The paper focuses on the first part of the pinngate-system (Figure 1: The pinngate-project), the solution-based knowledge (objects). An information portal will be shown, which uses the modularised contents of the objects knowledge base to provide engineers with information during their work in a design project.

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[1] www.pinngate.de

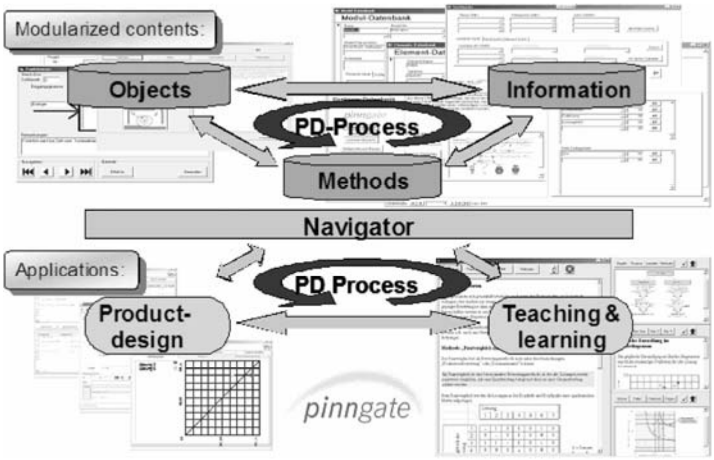

Figure 1. The pinngate-project [Sauer 2004]

2.2 Information management in the early stages of product design

At the present time, known solutions are collected in design catalogues. Design catalogues are well-known information bases containing physical effects, working principles, principle solutions and machine elements, etc. They are suitable for a wide range of design tasks and their structure supports the methodogical design process. But design catalogues are not used very often in practice because an engineer can just start to work with it after obtaining the design catalogues. Normally, design catalogues are printed and so there is no accessible central place where the catalogues are collected. This also means that the catalogues' contents cannot be extended, adapted or updated. In order to overcome these disadvantages, several research projects were established in the last few years.

The catalogue-system *eKat* has been started within the framework of the research-project GINA [Franke 2004]. eKat aims at eliminating the aforementioned deficits of printed design catalogues by using modern data processing technologies.

Web-based design catalogues are also being developed at the Stuttgart University. The approach of Garibay and Binz [Garibay 2005] contains physical effects and working principles, like the eKat-System. But their system is not only a database; it is also used to teach designers in the field of microengineering. The system uses XML-Technologies to realise a web-based application which can be used by designers who want to work in the field of microengineering.

Projects which aim to increase the availability and quality of information, like pinngate and the two projects described above, are dependent on the level of development of modern data-processing systems. The XML-Technology is of special importance.

During the early stages of design, engineers work with abstract models (e.g. function models) and generate mainly text-based information. The structure of a XML-Document has several advantages because it is very suitable to represent text-based information. However, not only text can be represented and processed by XML. It is also possible to store any kind of binary data (e.g. geometry-data which is normally stored in a STEP-file).

3. A web-based information tool for the early stages of design – approach and concept

As a part of the pinngate-system, the web-based information tool stores and processes solutions of the early design phase. The tool uses the XML-Technology to realise an information portal. Compared to the systems described above, pinngate does not aim to generate only a web-based design catalogue. Rather, the objective is to develop an integrated application, which provides any information about product design (design knowledge, solutions, methods). The information portal is only a part of that integrated application. Within the pinngate-system, the contents of the information portal can be re-used in different sub-applications. For instance, it is possible to generate examples for an E-Learning

system [Sauer 2004]. But the paper focuses on the availability of information in design projects. The next parts of the paper describe the concept of the information portal. It is a XML-Application, which allows for the adapting of web-based information tools for different products, companies and users.
In developing a XML-Application, the following areas have to be taken into account:

- The XML-Architecture, which defines the functions of the application.
- The XML-Vocabulary, which provides a semantic frameset in which to describe and store the information.

3.1 The architecture of the XML-Application

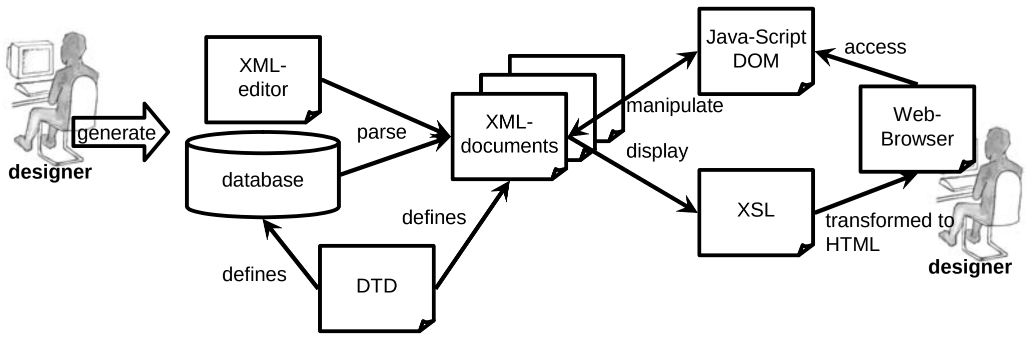

Figure 2. Concept of the web-based information-tool

For many design projects, especially during the early phase, the design work is distributed among different groups of designers. Thus, the support with information about the latest results of the project work is of special importance [Ehrlenspiel 2003]. The web-based information-tool supports the distributed design work by providing the following functions:

- Generating new content during the design process
- Splitting content and presentation
- Providing access to the contents over a standard internet explorer

Figure 2 shows the architecture of the XML-Application. Designers generate new contents by editing XML-documents. The application provides adapted editors to generate the information, or standard-editors (e.g. XML-Spy) can be used. The XML-documents are stored on a web-server. A designer who wants to inform himself about the latest project results can use his standard internet browser. The XSL-processor in the running system loads a XSL-script from the web-server. With the script and the inputs the designer has made, the XSL-processor loads the XML-documents, fitting them to the inputs and transforming them into HTML documents. These are then shown on the browser.

3.2 A model-based XML-Vocabulary to describe technical systems

In order to store the generated results of a design project in XML-documents, a vocabulary is needed. The key to defining such a vocabulary is to generate a model which demonstrates the successive definition of the product and shows the information links between the different sub-results. Such a model is the so-called "pyramid-model" [Sauer 2003]. During a design-project, the pyramid must be run from top to base. Each level of the pyramid typifies a sub-result with defined "design-characteristics" [Andreasen 1987].
Representing the different sub-results of a design-project and the information links between them, the model promotes the definition of the XML-vocabulary. Each level of the pyramid is represented by a modular XML-document, which contains the information about the product (result of the early phase of the project) on this level (figure 3: Structure of the XML-Vocabulary). The information links between the different levels are used to link the modular documents together.
The vocabulary is defined in a modular Document-Type-Definition (the so-called Object-DTD). Because of the diversity of design-projects, the information which must be stored in the XML-documents is very manifold. Thus, the Object-DTD defines only a core set of XML-elements. These

elements provide a framework in which to describe the results of a project. The framework can be extended and adapted by parameter entities.

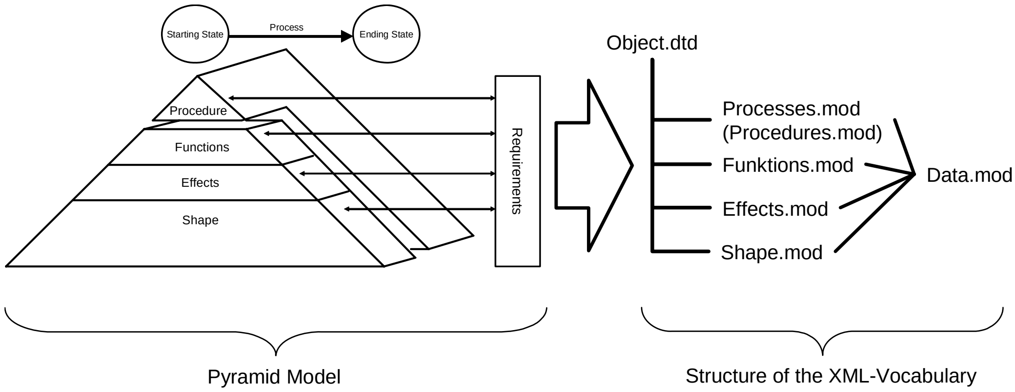

Figure 3. Structure of the XML-Vocabulary

The core framework and its adaptation by setting the parameter entities have three main advantages:

- First, the core framework allows for the implementation of the information through the main functions (e.g. dynamic linking of the content, data access and search functions).
- Furthermore, the framework guaranties the validity and compatibility of the data.
- In setting the parameter entities, the vocabulary can be adapted to describe a wide range of different products.

4. First experiences

The first application of this information portal took place in the research cooperation *„The brake pad as an active element in the braking system“* between the *TMD Friction Group* and the *Chair of Automotive Engineering at TU Darmstadt*. The motivation for this research project was the examination of possible upgrades of brake pads by sensor technology. At the same time, it was clarified in the first quota of work which quantities could be measured in a brake system and how this knowledge could be of use for the research and development of the whole brake industry, on the one hand, and for the driver on the other. After weighting these measurements, various measuring principles were analysed for the favourites by means of requirement lists for their possible application in a brake pad. Sensors based on appropriate measuring principles were first theoretically examined for their integration possibilities in different positions in a brake pad, and after that they were tested in a test bench.

The information portal served the staff during the work on this research project as an information tool, source of ideas and as synchronization with the activities of the colleagues. After finishing the research project, the industrial partner receives the provided results via the information portal. As a result, the staff can be informed quickly and simply about the application possibilities of “active brake pads” and they can also use this database as a work platform in future development projects in which sensors will probably play a leading role. At the same time, they discover which measuring principles are appropriate for their product, which sensors were tested in the brake pad and which prototypes already exist, along with the accompanying measuring data and results.

4.1 Application: Sensors in brake pads

A variety of quantities can be measured in a brake pad, e.g. the temperature, the degree of wear and the acting forces. Application possibilities for a force sensor technology in a brake pad are given in electromechanical brakes (figure 4) or for the electrical parking brakes already available in standard vehicles.

In conventional wheel brakes, the hydraulic brake pressure is measured in order to determine the clamping force. Electromechanical brakes were developed for the aim „Brake by Wire" and thus they do not have a hydraulic, but only an electrical supply. A precise determination of the clamping force is not possible from the present amperage.

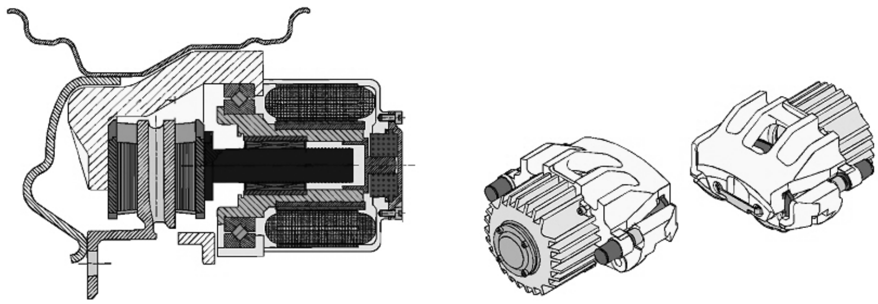

Figure 4. Continental Teves Brake Disk [Balz 19969]

The Piezo-Effect (figure 5) and the resistance change of electrical conductors under strain crystallize as appropriate measuring principles.

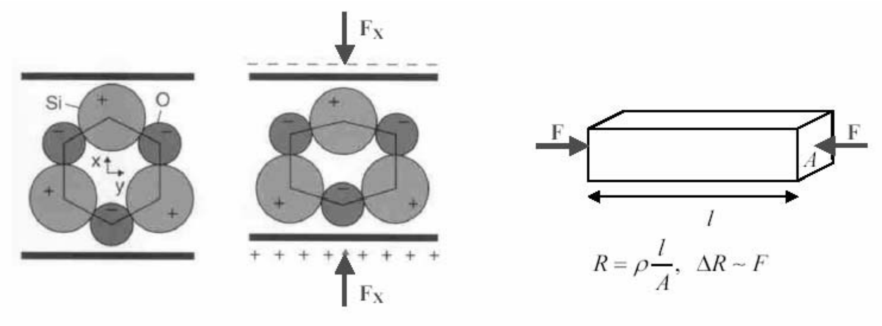

Figure 5. Piezo Effect and Resistance Changing [Bill 2002]

Common sensors which are based on the principles shown are piezo-quartz, piezo-ceramic and strain gauges. In the brake pad these sensors can be applied in different positions (figure 6) in order to determine the respective force components.

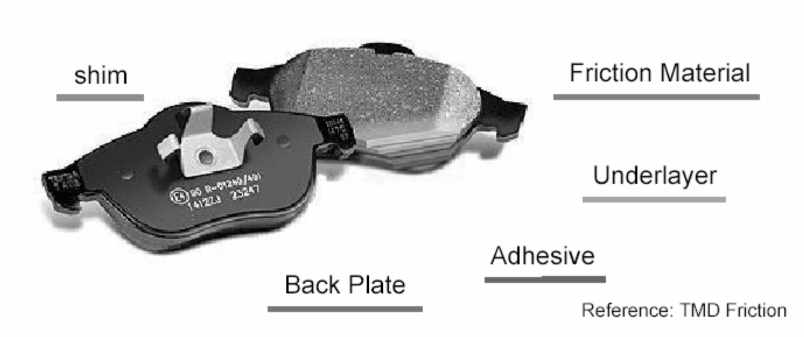

Figure 6. Elements of a Brake pad [www.tmdfriction.com]

As a result, there are several combination possibilities for the integration of force sensors in a brake pad; for each an example of the measurement of the clamping force and the tangential force (figure 7) is presented.

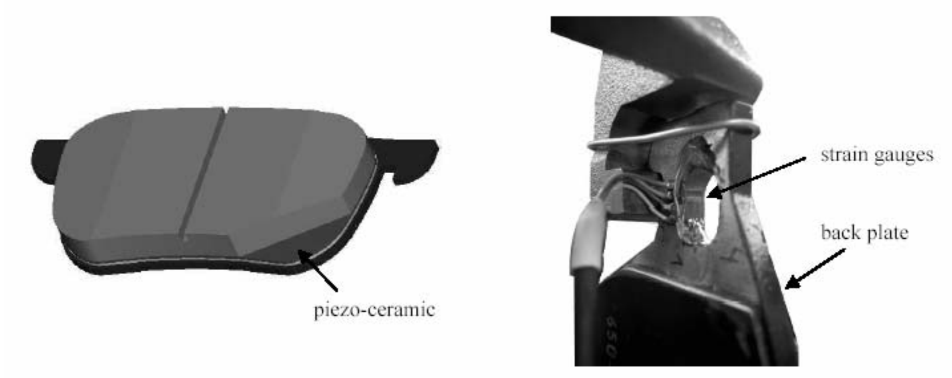

Figure 7. Underlayer with piezo-ceramic and back-plate with integrated strain gauges

The next section gives a more detailed description how the information about the brake pads are stored in the modular XML-Documents which are defined by the Object-DTD.

4.2 Adaption of the information-tool

As mentioned in chapter 3.2, the XML-vocabulary has to be adapted to the products which shall be provided. First the necessary modules of the XML-documents which contain the information must be identified. In the next step, the XML-vocabulary has to be adapted. According to chapter 4.1 the following documents have to be drawn up:

- Processes and Procedures: This XML-document contains information about the different quantities which can be measured in a brake pad. At present three quantities are of main interest: force, temperature, abrasion. Each quantity can be described by a set of XML-Elements (e.g. name, description, requirements). The XML-document "processes" is used to generate the main navigation bar in the information portal (Figure 8).
- Effects: This document contains information about the physical effects which can be used for measuring. Each effect can be described by a name, a description, a picture and the mathematical description. Furthermore each effect can be categorized by a set of metadata (e.g. the category of the effect). An IDREFS-Attribute makes it possible to link the effects to one ore more quantities which are described in the "processes"-document. The attributes are used to generate the drop-down-lists shown in figure 8.
- Shape: This part is split into two documents. One contains the information about common sensors which can be applied. The other document contains information about the integration of a sensor in the brake pad.

Even though the XML-vocabulary has been adapted to cover a wide range, the XML-documents are still valid to the Object-DTD. Thus, the implemented functions of the information-portal can be used without any changes (e.g. the dynamic linking of the XML-documents). This means that the navigation concept of the information-portal must not be generated because it is already implemented. XSL-Sheets supplemented by Java-Scripts (XML-Data-Islands) transform the adapted XML-documents into an integrated HTML-portal with navigating links.

4.3 Using the web-based information tool

The following illustration (figure 8) shows an extract from the presented information portal. The horizontal parameter input bar is the main navigation level. The vertical parameter input bar (left-hand side) is to be handled from top to bottom. It corresponds to the procedure from chapter 4.1. Furthermore, additional information about the single subject areas can be taken from appropriate literature or patents, for example.

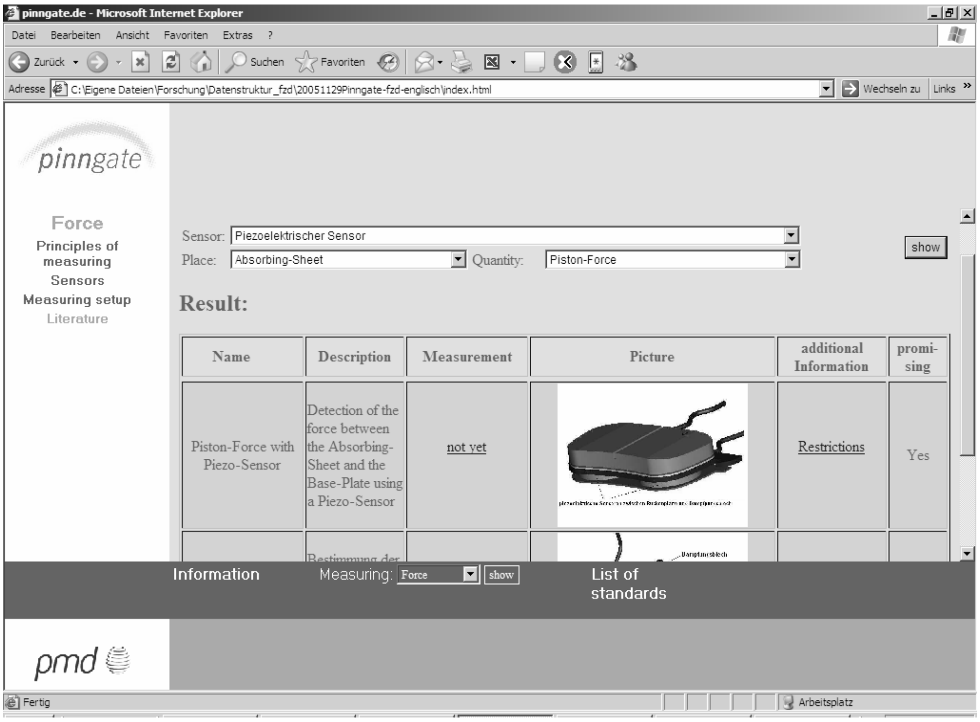

Figure 8. Screenshot of the information-tool

5. Outlook and Summary

5.1 Outlook: Next steps

At this stage of the project, each single XML-document is stored in the file system of the web-server. Designers generate new documents by feeding the data into a XML-file. This concept works while the number of files and designers who generate the files is limited. In the future, however, the growing data and the increasing number of designers involved in the project will cause problems. Therefore, a database will be implemented. The architecture of the information tool, extended by a database is shown in figure 9.

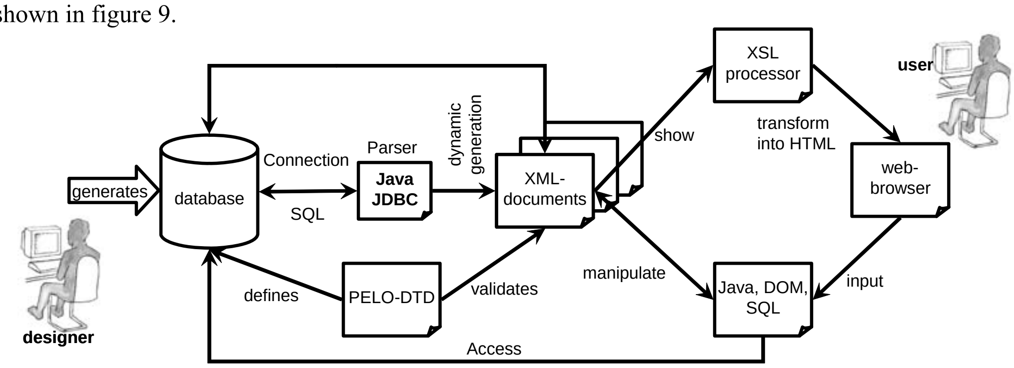

Figure 9. Extended information tool

First, a database will be derived from the linked XML-documents [Schöning 2003]. Then a database-front-end to feed the data will be generated. A Java-XML-Parser transforms the database into XML-documents. Because the structure of the database is similar to the structure of the XML-documents,

the parsing can be done efficiently without losing any data. As described above, the XML-documents will be transformed into HTML by XSL-sheets.
Besides the better handling of the amount of data and a large number of users, this concept enables access to each single record set of the database (SQL-access). Thus, the XML-documents can be transformed dynamically in order to adapt them to different users.

5.2 Summary and conclusions

In the paper an information portal which is generated within the pinngate-project is presented. The portal consists of two main elements: XML-Architecture, XML-Vocabulary.
The paper shows how these two elements can be used to generate information portals which serve designers with information about the results of a design project. The adaptivity of the modular XML-documents allows to store only the information which is individually needed. The first experiences using the portal in a collaborative research project were shown.

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