XML-based knowledge management for DFM

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ABSTRACT: During the last ten years, concurrent engineering has been largely studied and this new industrial organisation has been commonly adopted in most of huge automotive and aeronautics enterprises and in several SMEs as well. Every design phases are currently more and more narrowed and realised simultaneously during product design process. Product life cycle knowledge has now to be integrated as soon as possible during product development in order to improve the collaborative design. This paper aims at presenting an approach to manage and integrate manufacturing knowledge in design. Some first specifications are presented for the database structure using XML (eXtended Markup Language). This manufacturing knowledge is used in several contexts as teaching and scientific research on Design for Manufacture (DFM). XML language allows filtering information according to the real need of users. This need is straight linked to user's activity and the main idea of knowledge management is then to provide the right information to this designer at the right time during his activity. The DFM activity is also briefly presented in the paper via product manufacturability analysis and synthesis method and modelling.

1 INTRODUCTION

Manufacturing integration is a large thematic that has been studied in the design for X scientific community [1]. Most of these works present an analysis aspect of the problem of integration. Our contribution focuses on the synthesis aspect of product manufacturability assessment. In other words, the modelling of manufacturing constraints integration in design process of mechanical systems is presented. This problem of integration is treated in two points:

– How to choose manufacturing process. In industries, this selection is not studied with a lot of importance whereas it strongly constrains the end of design process. Indeed, manufacturing process is linked to materials properties, to design parts geometry, to production costs, etc. It would then be very profitable to give more importance to this choice. Our research proposes some concepts to organise manufacturing process selection earlier in the product design process.

– How to integrate manufacturing constraints in product definition. Once the manufacturing process is selected, most of current software for manufacturing analysis (stamping, casting, etc.) requires the complete geometry of each part, materials properties, etc; in other words those applications can only be used during the detail design phase. At this stage, it is sometimes too late, a lot of design decisions have already been taken, and a lot of parameters cannot be changed any more. Manufacturing is then constrained by product definition. Our research presents some solutions to integrate manufacturing constraints sooner in the product development.

Manufacturing will then partly prescribe product definition.

The main innovative idea of our approach remains in bringing new concepts to even more support the knowledge integration (knowledge synthesis) in design. It is necessary to deliver the right information to the designers at the right time. XML technology is then very useful to carry out an appropriate portal for engineers [2].

Part 2 presents how knowledge management is used in our research work. Indeed, beyond knowledge acquisition method, it is very important to define the real need of information for manufacturing integration. This need is obviously close to information use context (activity) as teaching, scientific research or product development.

Part 3 deals with the integration methodology and modelling to show how to really support manufacturing data to have the product definition emerged.

Part 4 and 5 give the first specifications and results for developing knowledge management applications for design for manufacture.

Finally, part 6 concludes this paper and gives some recommendations for future research work and developments.

2 KNOWLEDGE MANAGEMENT SETTINGS FOR MANUFACTURING SYNTHESIS IN PRODUCT DESIGN

For few years knowledge management appears as a fundamental aspect of the industrial way of working. Indeed a lot of industries do not want to loose their knowledge when people retire, when people move to another industry, etc. Our research does not aim at looking for new methods of knowledge management but at setting the already-tested ones for the problem of manufacturing integration.

This work has to be planned in three steps:

- What is the context of knowledge use and/or reuse? Over knowledge management methods existing in the literature, the first question is to know in which context (i.e. activity) the information has to be used.
- Which knowledge has to be acquired and managed? Data acquisition has to be done in coherency with the use context studied in the first step. It is not worthwhile to have plenty of information without knowing how to use it.
- Which method of knowledge management has to be used (cf. section 2.3)?

2.1 Knowledge management context

In our daily activities as assistant professors, the problem of manufacturing integration, as presented in the introduction, has been so far identified in three domains.

- Teaching activity: during design lectures and projects, students do not have enough knowledge on manufacturing. Thus, they cannot justify design choices that should be relative to manufacturing constraints.
- Research activity: in a context of integrated design, product definition emerges as the integration of knowledge [3]. Therefore, designers must know or must have an access to specific knowledge on manufacturing processes.
- Research activity: selection and integration of manufacturing knowledge can open the way of new design alternatives. We must have to quickly evaluate the feasibility of several manufacturing process alternatives and to know their impact on product design ones.

The approach of manufacturing analysis and synthesis is later on detailed in the paper (cf. part 3) and briefly presented on Figure 2.

2.2 Knowledge for manufacturing synthesis

In order to handle activities, as previously presented, appropriate information is needed (cf. Fig. 2) and has to be well-structured. Different sets of knowledge on manufacturing processes have therefore to be identified; for example:

- What are the limits of each manufacturing process? Those limits are on the one hand relative to physical principles (electrical conduction for EDM[1] process) that are linked to manufactured material properties (ex. electrical resistance). On the other hand, limits can be issued from manufacturing process technologies (ex. geometrical limits for turning machine, energetic limits for forging press, etc.).

[1] Electrical Discharge Machining

– How designers get used to design parts according to a chosen manufacturing process. This activity is more and more systematic in manufacturing industries. Indeed, nowadays requirements lists only give minimal information issued from conceptual design (geometrical envelope, parts loading, limit points admissible displacements, etc.). Manufacturers have therefore to define the rest of the part and have to assess the final cost of the process. In our research we do not work on cost point of view at all. This problem indeed involves a lot of parameters that are very difficult to manage. We only focus on technical aspects of product manufacturability.

Part 4 and 5 present a first XML-based structure for handling this information (i.e. knowledge). Obviously, other information (ex: costs, etc.) has to be taken into account in order to integrate manufacturing in design as previously presented. However they are not studied in this paper.

2.3. Knowledge management method

Regarding knowledge management methods, we decided to collaborate with the TechCICO[2] laboratory that has a very long time experience in this field [4]. Three main fields have to be taken into account (cf. Fig. 1):

– Static knowledge acquisition (ex: limits of each manufacturing process). This knowledge can mainly be extracted from the literature. Data mining and text mining methods are widely used for such a research [5].
– Expert's knowledge acquisition. The methodology is mainly based on interviews that must be structured and guided according to what we want to capitalise (cf. section 2.2). Those interviews are therefore managed by a knowledge engineer [6].
– Knowledge acquisition "au fil de l'eau" for dynamic knowledge. This acquisition methodology is relative to the creation of project memories [7]. The memory is dynamically extracted from the design process. In our problem of manufacturing integration, it will then be possible to know for instance how industries design product parts according to a selected manufacturing process.

The literature currently proposes some XML-Based frameworks to keep coherent the managed knowledge of an industry [8]. This work could be thus linked to our structure presented in part 4.

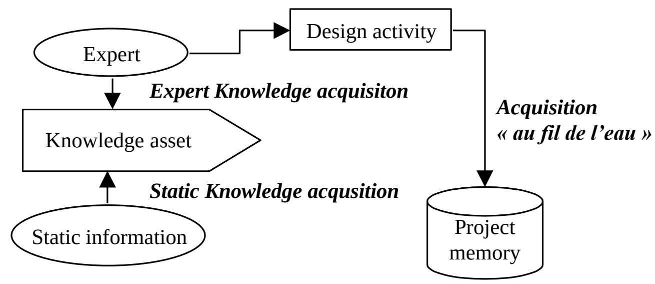

Figure 1. Three ways for knowledge acquisition.

3 METHOD AND MODELLING FOR MANUFACTURING CONSTRAINTS SYNTHESIS

Considering concurrent engineering as set of simultaneous activities [9], ones of these activities are related to manufacturing knowledge:

– The selection of manufacturing process to obtain every part of the mechanical system.
– The integration of manufacturing process knowledge in the mechanical product design.

The second activity can of course only start once the first one has been realised. One of the objectives of our work is to realise knowledge integration as soon as possible and even during the conceptual design. Conceptual design is one of the design phases defined in [10]. Thus, the selection of manufacturing process has to be also done as soon as possible. Figure 2 shows how this activity of process selection and manufacturing constraints synthesis are related to product definition using an input and output data loop. This loop progressively has the product definition emerged.

[2] http://tech-cico.utt.fr.

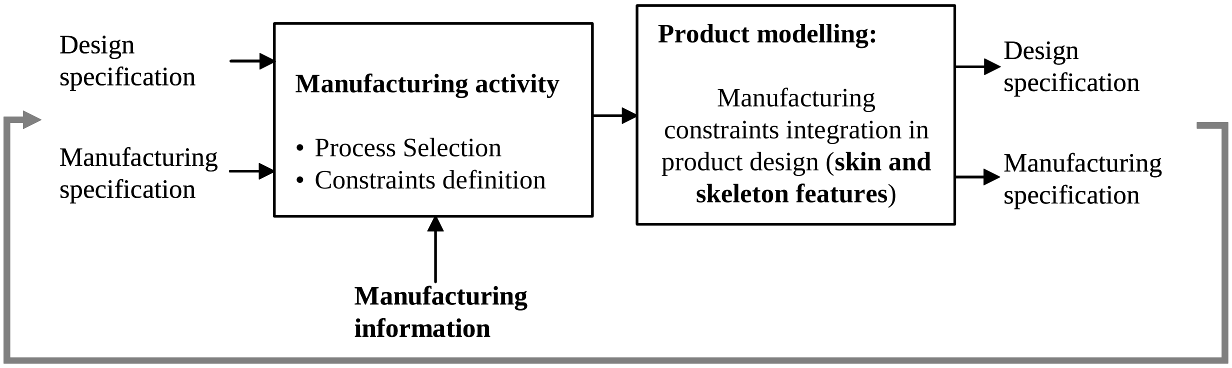

Figure 2. Manufacturing activity and product definition.

3.1 Manufacturing process selection activity

Our work on manufacturing process selection activity is mainly based on Ashby's results [11]. We therefore decided to create database to structure processes limits (physical and technological limits). This database is coupled to a geometrical approach based on Schey's matrix [12].

From a certain product definition and certain data (materials properties, product forms, cost specifications, etc.) the developed database [13] proposes a set of available manufacturing processes (cf. Fig. 3). This set can afterwards be limited again according to new specifications.

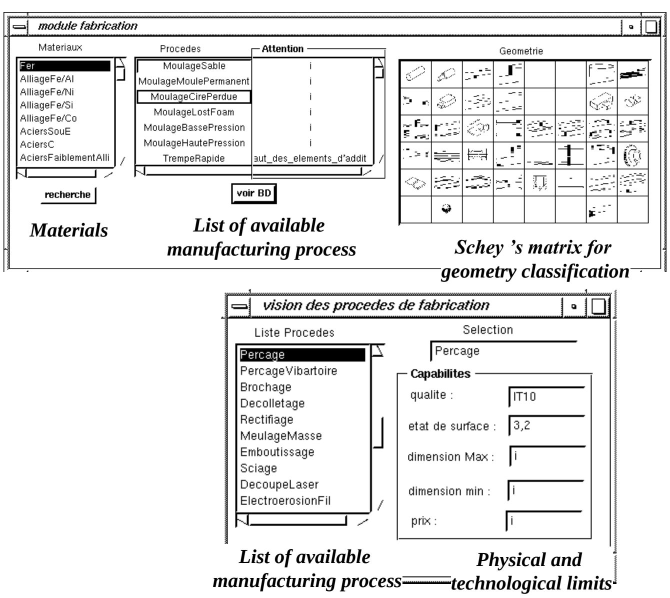

Figure 3. Proposal of available manufacturing processes.

On the one hand our current work now focuses on defining new criteria to be able to choose manufacturing process sooner. On the other hand, this activity is linked to the integration of manufacturing constraints in product design.

3.2 Manufacturing knowledge integration activity

For knowledge integration in product definition, our work is based on a multiple views product modelling [14]. This product modelling and the associated computer-based system "CoDeMo" [3] support the feature-based decomposition of the product. Thus, all life cycle product data can be taken into account [15].

The "skin and skeleton" concepts [16], [17] are also enriched (with appropriate attributes) used in our work. This concept is in fact used to really justify the product form geometry (toward the product form and tolerancing emergence) (cf. Fig. 4).

Thus, the first form features of the product, issued from the technological choices modelled with skin and skeleton features (cf. Fig 2) are then used for process selection and manufacturing constraints definition. The main goal is to be able to complete the product form (cf. Fig. 5) integrating new knowledge [18].

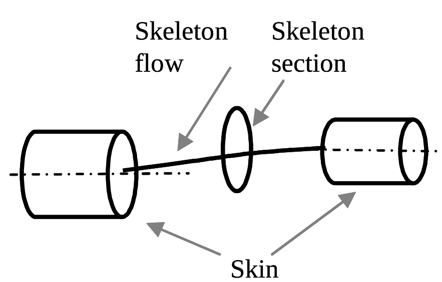

Figure 4. Skin and skeleton modelling.

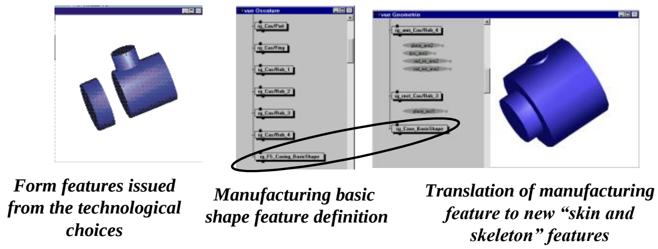

Figure 5. Emergence of the geometry.

4 XML-BASED APPLICATION

So far part 2 and part 3 have respectively presented what is our knowledge management context and how knowledge is used to integrate manufacturing constraints in design.

The paper now presents some first specifications on a computer-based application that must support all the capitalised information. The paper does not aim at presenting the whole information but how it is structured and exploited using XML (eXtended Markup Language). Part 5 shows some first results.

4.1 Information structure using XML

As previously explained in part 2, the capitalisation has to be done knowing the future uses of the information. As introduced in [19], it is like defining an ontological context described with Key Characteristics (KCs). This ontology is in our work related to manufacturing specifications. Those KCs are defined using DTDs (Document Type Definition). The most important work has been to well define every markup according to the knowledge management (cf. Part 5). Afterwards, the XML file that contains the information can be created. Figure 6 presents the methodology to create files using XML.

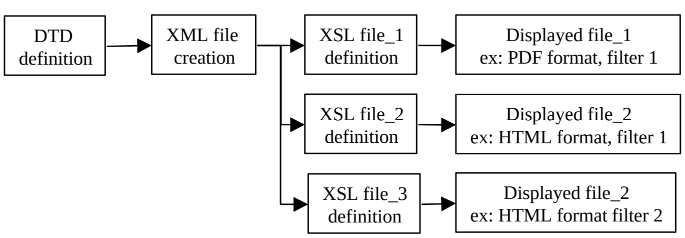

Figure 6. Methodology for the use of XML.

4.2 Multiple formats exploitation of the capitalised information

Once the knowledge is structured, we have a large source of information that can be formalised as knowledge handbooks, database, etc.

In our context this knowledge will be used in all of the three manufacturing integration situations for teaching or research work (cf. 2.1). Thus, the information has to be exploited through multiple formats as for instance:

- HTML format for web-based teaching supports. Each student can access the Intranet of the university.
- Microsoft PowerPoint format for lectures.
- PDF format for teaching supports or handbooks.
- Simple text format that would be used in a computer-based application (cf. section 3.1).

XSL (Extensible Stylesheet Language) and XSL-FO concepts propose such a possibility that separate the information (what you have) and its formalisation (what you see) (cf. figure 5).

4.3 XML based filtering for capitalised information

Secondly and beyond the multiple formats of the information, it is very important to give the right information to the right person according to his activity. It is not really worthwhile to present the all information that is not really exploitable. As consequence, the XML file must be filtered before formatting the information.

For example, in the product design process, global information (functional specifications, part geometric envelope, etc.) would be used in conceptual and embodiment design, whereas more precise information (form features, material properties, etc.) during detail design.

These filters are also done using XSL. Indeed a lot of algorithms can be applied to the mark-ups defined in the DTD. For instance, the <xsl:for-each select = "Markup_1"> header let only appear the information contained above the mark-up: Markup_1.

5 FIRST RESULTS

Some XML-based tries have already been done to show the feasibility of the previous specifications: multiple formats and filters for information display. All these attempts were done with XML-Spy™ editor.

5.1 XML files creation

The first results already realised concern the creation of two XML files related to:

- Physical principles of manufacturing processes.
- Technological devices for manufacturing processes.

According to the activity (cf. parts 2&3) the needed static information has been extracted from the literature and from industrial know-how. This information has then been structured and stored in an SQL Database that later on automatically generates the appropriate DTD and XML file.

Those file must now be used in a teaching context in order to validate the two following mechanisms of exploitation.

5.2 Multiple formats display

XML to HTML exchange has been successfully proved. We are now following investigations, developments, and tries for exchanging XML to PDF format. This kind of exchange is currently not well defined in XML, however some new results now appears in the literature [20].

5.3 Information filter

For the filtering problem, static tries have been realised using algorithms proposed in XML (xsl:for-each, etc.). PHP developments are currently in progress to create a web server that will manage dynamic filters using the same XML file via several XSL pages. Thus, it would be possible to create and display files dynamically according to the users' settings. Files would not have to be previously created any more.

6 CONCLUSION AND RECOMMENDATIONS FOR FURTHER WORK

This paper has presented our research work on knowledge management using XML. The application focuses on manufacturing knowledge integration in mechanical product design.

Nowadays the methodology, the models and the contexts (teaching and research) of integration are well defined and have been tried on several examples. However, developments of new XML-based applications are now in progress to have better supports for such activities. Those applications are currently developed coupling XML with multiple computing languages as PHP, C++ and SQL Database.

Those micro-applications that manage knowledge on manufacturing processes could later on be integrated in the co-operative design environment proposed in [15]. Results as presented in [21] propose hybrid XML and CORBA architecture to exchange data among heterogeneous CAD/CAM software. In our situation, XML data could be issued from the knowledge management application presented in part 4.

7 ACKNOWLEDGEMENT

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REFERENCES

1. Boothroyd, G. 1994. "Product design for manufacture and assembly". Marcel Dekker, New York.

2. Puzey N.J. A knowledge management portal for engineering. 2002. CE'2002 Conference., Cranfield (UK). June 27-31 2002.

3. Roucoules, L. & Tichkiewitch, S. 2000. "CoDE: a Co-operative Design Environment. A new generation of CAD systems". CERA journal, Vol.8, n°4, pp 263-280, December.

4. Matta, N. & Ermine, J-L. & Aubertin, G. & Trivin, J-Y. 2001. "Knowledge Capitalisation with a knowledge engineering approach: the MASK method". In proceedings of IJCAI'2001 workshop on Knowledge Management and organisational Memory.

5. Aussenac, N. 1989. "Conception d'une méthodologie et d'un outil d'acquisition des connaissances experts". PhD report of the University of Paul Sabatier. Toulouse (France).

6. Ermine, J.L. 2000. "Les systèmes de connaissances". Edition Hermes, Paris, 1996, second edition.

[3] http://fr.groups.yahoo.com/group/opalys/

7. Matta, N. & Eynard, B. & Roucoules, L. & Lemercier, M. 2002. “Continuous capitalisation of design knowledge”. ECAI'2002 Workshop on Knowledge Management and Organizational Memory. July 21-26, 2002, Lyon (France).

8. Mili, F. & Ma, Z. 2002. Modelling and Maintaining Engineering Knowledge: Issues and Solutions. IEEE-SMC Conference. Yasmine Hamamet (Tunisia) October 6-9 2002.

9. Sohlenius, G. 1992. “Concurrent Engineering”. Annals of the CIRP, vol. 41, n°2, pp 645-655.

10. Pahl, G. & Beitz, W. 1996. “Engineering design : a systematic approach”. Springer-Verlag, London.

11. Ashby, M.F. 1993. “Materials Selection in Mechanical Design”. Pergamon Press, ISBN 0-08-041907-0.

12. Schey, J. 1987. “Introduction to manufacturing Processes”. McGraw-Hill Co., Singapore.

13. Tichkiewitch, S. & Roucoules, L. 1999. “Innovative design methodology”. Integration of process Knowledge into Design Support (Kluwer Academic Publishers). ISBN 0-7923-5655-1, pp. 79-88.

14. Tichkiewitch, S. 1996. “Specification on integrated design methodology using a multi-view product model”. ESDA Proceedings of the 1996 ASME System Design and Analysis Conference, PD-Vol. 80.

15. Roucoules, L. & Eynard, B. 2001. “Background and specifications for a Computer Co-operative Design Environment for Concurrent Engineering”. In proceedings of the 8th IPSE International Conference on Concurrent Engineering – CE’2001, Anaheim, USA.

16. Muh-Cerng W. & Wu T.Y., “A skeleton approach for modelling assembly products”. Journal of Design and Manufacturing, n°3, pp 121-133, 1993.

17. Tollenaere, M. & Belloy, Ph. & Tichkiewitch, S. 1995. “A part description model for the preliminary design”. Advanced CAD/CAM Systems - State-of-the-art and future trends in feature technology, pp 129-143, Chapman & Hall , Ed. Soenen.

18. Roucoules, L., & Salomon, Otto. & Paris, H. 2003. “Process planning as an integration of knowledge in the detailed design phase”. International Journal of Computer Integrated Manufacturing, Vol. 16, N°1, pp. 25-37.

19. Rezayat M. “Knowledge-based product development using XML and KCs”. 2000. Computer Aided Design, Vol. 32, pp 299-309.

20. Delestre N., Frénot S., Mottelet S., Vayssade M., Novembre 2002, “Distributed PolyTeXML Une nouvelle plateforme de partage d'items didactiques”. In proceedings of TICE 2002 conference, Lyon, 13-15, pp. 149-156.

21. Chung J., Lee K., “A framework of collaborative design environment for injection molding”. 2002. Computer in Industry, Vol 47, pp 319-337.

22. Troussier N., Daidié A., DeVaujany J.P., Eynard B., Gomes S., Rémond D., Roucoules L., Toumine A., November 2002, “Exemple d'application des TIC pour un projet de création de support pédagogique” In proceedings of TICE 2002 conference, Lyon, 13-15, p. 381-382.