附件 2

法国巴黎高科——国立工程技术大学校（**Arts et Metiers ParisTech**）
博士生项目

2.1 研究课题一览表

1. “**Models and Method for variation and uncertainty management in Micro-manufacturing during the design phase”**
FIELD OF INDUSTRIAL ENGINEERING
(Key words: Design, Tolerancing, Micro-manufacturing, Uncertainty management and propagation)
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

2. “Formal Characteristics Properties Model for Reconfigurable Process Plan”
FIELD OF INDUSTRIAL ENGINEERING
(Laboratory: Design, Manufacturing Engineering and Control Lab.)
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

3. “Performance Measurement and Management of Industrial Systems: A Cost, Benefit, Value and Risk - based Framework”
FIELD OF INDUSTRIAL ENGINEERING
(Applied Mathematics, Industrial Engineering and Simulation theory)
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics
Department of Applied Mathematics

4. “Towards predictive numerical simulation of sheet metal forming processes as well as impact and crash phenomena using new advanced solid–shell finite elements”
FIELD OF MATERIAL AND INDUSTRIAL ENGINEERING
(Scientific fields: Solid Mechanics, Computational Mechanics, Finite Elements, Sheet Metal Forming)
(Key words: Finite elements, solid–shell, explicit dynamics, forming processes, metal sheets, impact / crash, elasto-plasticity, composite behavior)
College of Material Science and Engineering
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

5. “Finite elements and discretization techniques for the prediction of flatness defects during sheet metal forming processes”
FIELD OF MATERIAL AND INDUSTRIAL ENGINEERING
(Key words: Buckling, plastic instabilities, residual stresses, thin sheets, rolling, flatness, enhanced shell elements, solid–shell elements)

College of Material Science and Engineering
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

6. "Theoretical and numerical modeling of instability criteria (localization, necking, wrinkling): application to sheet metal forming"
FIELD OF MATERIAL AND INDUSTRIAL ENGINEERING
(Scientific fields: Solid Mechanics, Stability/bifurcation, Thin stretched sheets)
(Key words: Stability, bifurcation, geometric instabilities, material instabilities, thin metal sheets, stretching, diffuse necking, localized necking, shear band localization)
College of Material Science and Engineering
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

7. "Advanced machining of austempered ductile iron (ADI) for automotive applications"
FIELD OF MATERIAL AND INDUSTRIAL ENGINEERING
College of Material Science and Engineering
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

8. "Colloids transport in porous media: Direct numerical simulation at the microscopic scale"
FIELD OF MATERIAL
(Scientific fields: a good knowledge of fluid mechanics and numerical analysis and a real will to invest in direct numerical simulations in fluid mechanics)
College of Material Science and Engineering

9. "Detection and treatment of inconsistent or locally over-constrained configurations during the manipulation of 3D geometric models made of free-form surfaces"
FIELD OF INDUSTRIAL ENGINEERING
(Key words: geometric modelling, numerical optimisation, local over-constraints, inconsistent configurations, bipartite graphs)
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

10. "Design Process and product data modelling toward the propagation of engineering changes"
FIELD OF INDUSTRIAL ENGINEERING
(Key words: product design process, system engineering, change management)
(Candidate profile: engineering design, process modelling (ex: UML/BPMN), computer programming)
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

11. "Knowledge modeling of Design and manufacturing interface for DFM approach during product development process. Application to foundry process"
FIELD OF INDUSTRIAL ENGINEERING
(Key words: DFM, manufacturing knowledge, Product-Process interface, manufacturing and material Database, foundry process)

(<u>Candidate profile</u>: engineering design and manufacturing, CAD modeling, C/C++ programming, database modelling)
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

12. "Contribution to the development of kinematics full-field measurements at microscopic scale for experimental solid and material mechanics"
FIELD OF MATERIAL
(<u>Candidate profile</u>: The applicant will have to possess good aptitudes in solid mechanics experimentation as well as knowledge in mechanics of materials. It will be appreciated if he, or she, has got some background in full-field measurement techniques)
College of Material Science and Engineering

13. "Surface fatigue damage prediction: Pitting and micropitting on gears"
FIELD OF MATERIAL AND INDUSTRIAL ENGINEERING
(<u>Competences required</u>: Continuum mechanic, fatigue mechanic and microstructural, X-ray diffraction knowledge are required to work on this Phd-project)
College of Material Science and Engineering
College of Mechanical Engineering
College of Aerospace Engineering and Applied Mechanics

14. "Thermo-mechanical performance of multilayer coatings on machining FRP composites: multiscale analysis"
FIELD OF AEROSPACE AND MATERIAL
(<u>Key words</u>: FRP, dry cutting, multilayer coatings, fiber scale, Interface consumption, wear)
College of Aerospace Engineering and Applied Mechanics
College of Material Science and Engineering
College of Mechanical Engineering

15. "Micromechanical modeling of drilling hybrid composite stacks: toward an improved investigation of cutting mechanisms governing the assemblies' interfaces"
FIELD OF AEROSPACE AND MATERIAL
(<u>Key words</u>: Drilling, hybrid composites, Interface behavior, subsurface, damage, chip formation)
College of Aerospace Engineering and Applied Mechanics
College of Material Science and Engineering
College of Mechanical Engineering

16. "On the thermal and environmental performance evaluation of a movable building in its future living context, by the use of measurements in its current context"
FIELD OF GREEN BUILDINGS AND MATERIAL
(<u>Key words</u>: Sustainable buildings, Thermal and environmental performance, Thermal and environmental metrologies)
Research Center of Green Building and New Energy
College of Civil Engineering
College of Material Science and Engineering

17. "Definition, Design and Dimensioning of the participation of France to Solar Decathlon China 2015: to a reproducible and thermally and environmentally successful movable solar building"

FIELD OF GREEN BUILDINGS AND MATERIAL

(Key words: Sustainable buildings, Thermal and environmental performance, architecture and design, Solar Decathlon China 2015)

Research Center of Green Building and New Energy

College of Civil Engineering

College of Material Science and Engineering

18. "Integration of renewable energy sources in spinning reserve for weak grids"

FIELD OF ELECTRICITY

(Scientific field: Electrical Power System, Probability

(Key words: spinning reserve, statistics, stability, renewable source)

Research Center of Green Building and New Energy

19. "Characterisation of the variability of behaviour of bonded interfaces. Influence of microstructure and bonding defects"

FIELD OF MATERIAL

College of Material Science and Engineering

20. "Microstructure evolution and material flow characterization during the complete thixoforging process of a steel part"

FIELD OF MATERIAL

College of Material Science and Engineering

21. "Multi scale global forgeability study of the multi material"

FIELD OF MATERIAL

College of Material Science and Engineering

22) Quantitative assessment method and tool to measure environmental impacts of Eco-districts

Key words: Sustainable buildings, Thermal and environmental performance, Eco-districts

Research Center of Green Building and New Energy

College of Mechanical Engineering

23) Proposal of PhD subject in Fluid Mechanics

College of Aerospace Engineering and Applied Mechanics

2.2　研究课题概述

1) Models and Method for variation and uncertainty management in Micro-manufacturing during the design phase.

Background

For the purpose of this study, the term micro-manufacturing refers to the creation of high-precision three dimensional (3D) products using a variety of materials and possessing features with sizes ranging from tens of micrometers to a few millimeters. While microscale technologies are well established in the semiconductor and microelectronics fields, the same cannot be said for manufacturing products involving complex 3D geometry and high accuracies in a range of non-silicon materials. At the same time, the trends in industrial and military products that demand miniaturization, design flexibility, reduced energy consumption, and high accuracy continue to accelerate -- especially in the medical, biotechnology, telecommunications, and energy fields. By and large, countries with traditional strengths in manufacturing have continued to invest heavily in recent years in micromanufacturing R&D for several reasons. First, the demand from the global market for ever-smaller parts and systems at reasonable cost and superior performance is strong. This demand tends to drive the high-end research. Second, the prospects of multidisciplinary research are causing companies increasingly to blend material science, biology, chemistry, physics, and engineering to speed up technology innovation and thereby new applications based on microtechnology.

The technologies used to design NLBMM (non-lithography-based meso- and microscale) parts and the processes and equipment used to fabricate them are in a nascent stage. These technologies have been, for the most part, borrowed from the design practices of macroscale engineering and very large-scale integration (VLSI). At present, most designers have difficulty ascertaining the appropriate time to use pre-existing design knowledge, theory and tools. Designers must be able to assess the suitability of pre-existing technology for the design of NLBMM parts. Otherwise, design processes will be long and iterative, with the result that the products' benefits will be either delayed or lost.
Fabrication processes are often scale dependent. For instance, traditional macroscale techniques such as milling are not generally applicable at the nanoscale. Likewise, the nanoscale processes used by nature to build biological systems are not generally applicable to the fabrication of some large-scale parts. The range of utility for a specific fabrication process generally terminates within the meso- or microscale. This is an important point for designers to realize; designers must "design for" compatibility of microscale parts with parts that were fabricated using a macro- or nanoscale fabrication processes. Microelectromechanical systems (MEMS) and very large scale integration (VLSI) designers encounter this issue in the form of packaging challenges.
The link between design and manufacturing has led to design for X (DFX) methods (Boothroyd et al., 1994) and concurrent design practices (Syan and Menon, 1994) that are used to help designers select appropriate design-fabrication process combinations. Although the general idea of DFX and concurrent engineering may be considered scale-independent (the design of parts to be made with fabrication processes that are cost and/or time appropriate), the implementation of these practices depends upon the fabrication processes that are to be used. The small-size scale of NLBMM parts makes it necessary to use new or adapted versions of existing manufacturing technology. As a result, new DFX rules will be needed to help designers make design-process choices that ensure scale-specific manufacturability and cross-scale compatibility.
Standards for NLBMM parts are currently in a nascent stage and require better definition. Of particular importance are the standards for measurement and evaluation of part characteristics. Without these standards, designers will have difficulty talking with vendors, customers, and others about the specifications that drive the design and fabrication of their parts. These standards should cover geometry, material properties, optical properties, electromagnetic properties, and other related

characteristics. Designers need to understand how to design NLBMM parts so that they are compatible with standard measurement methods. The existing techniques for measuring the characteristics of NLBMM parts are far from ideal. Many of these techniques are slow, provide only 2D information, and require destructive evaluation. Clearly, improved measurement tools are needed, as will be explained in a later chapter of this report. A set of rules that govern the design of NLBMM parts “for measurement” does not exist. As a result, most designers use intuition and advice from metrology vendors to design parts that may be measured in a way that does not affect the rate of manufacturing and does not lead to long time constants for manufacturing processes control. Metrology technology is traditionally slow to develop. As such, early designs must be compatible with available technology. “Design for Standard Measurement” will be important to the rapid adoption of NLBMM parts.

Scientific issue:

This proposal focuses on design for variation and uncertainty management of the micro-manufactured product and its micro-manufacturing process. At the most basic level, “design” is a process that is used to generate, evaluate and select a solution for a given problem. Uncertainty and risk are unavoidable when designing in the absence of full knowledge. Uncertainty stems from the lack of knowledge required to model performance. The risk that is associated with a particular design may be ascertained if one is able to use models to define a probability of success. In short, it is better to be in a position to ascertain risk than to be in a position of uncertainty. Throughout this assessment, little evidence has been found to suggest that stochastic methods have been employed during the design of NLBMM parts. Given the nascent state of the NLBMM technology, one finds variation in fabrication processes, metrology tools, material properties, and other aspects which must to be considered during the design process. The ability to model these variations and use such models to assess risk is important for two reasons:

- Knowing the risks may help to prevent the stifling of design concepts in the face of erroneously perceived high risks.
- A good understanding of risks may be used to guide the distribution of resources toward designs that have a higher probability of success.

The scientific main objective is to improve methods for variation and uncertainty management during this design phase. This proposal will focus on a contribution in developing:

- Models to predict the quality of micro-manufactured part (Prediction of surface roughness and dimensional deviation). Prediction of surface finish and dimensional deviation is an essential prerequisite for developing a micro-manufacturing process. Two main attributes of job quality are surface roughness and dimensional deviation. Surface finish has a great influence on the reliable functioning of two mating parts. A reasonably good surface finish is desired for improving the tribological properties, fatigue strength, corrosion resistance, aesthetic appeal of the product, ... Excessively better surface finish may involve more cost of manufacturing.

- Methods for risk assessment. There is a need for modeling and simulation tools that link the performance of components to variations in the characteristics of the part and the variations in the performance of a system to variations in the performance of its parts. In many cases, the preceding may be addressed by custom-made, stand-alone simulations (e.g., Monte Carlo simulations). Unfortunately, many of these tools are difficult to learn and they are not integrated with existing geometric and behavioral modeling tools. This is perhaps the reason that stochastic design tools are not widely used in engineering design.

- Methods for parts tolerancing. Micro-manufacturing processes are characterized by high process variability and an increased significance of measurement uncertainty in relation to tight tolerance specifications. Therefore, it is important to take into account not only the micro manufacturing process capabilities but the measurement uncertainty.

Key Words: Design, Tolerancing, Micro-manufacturing, Uncertainty management and propagation
Laboratory: Design, Manufacturing Engineering and Control Lab. (LCFC - EA 4495)
PhD Supervisors: Prof.Jean-Yves Dantan, Dr Jean-François ANTOINE
Email: jean-yves.dantan@ensam.eu

Application:
Please send your CV and motivation letter by email to the PhD supervisor with copy to your University International Office and to Yvon VELOT (yvon.velot@ensam.eu).
If selected, you should then apply for scholarship to the Chinese Scholarship Council (CSC) through your University International Office.

2) Formal Characteristics Properties Model for Reconfigurable Process Plan

In the keynote paper presented at 2010 CIRP General Assembly, T. Tolio, D. Ceglarek, H.A. ElMaraghy, A. Fischer, S.J. Hu, L. Laperrière, S.T. Newman and J. Vàncza identified some future research priorities for the co-evolution of products, processes and production systems; one of same is:

"Reconfigurable process plans. CAPP represents the area where information about product and process design (CAD/CAM) needs to be coupled with information about available manufacturing resources to generate process plans. In production contexts characterised by frequent changes, the need to be supported by reconfigurable CAPP systems is imperative. However, the development of tools to support automatic reconfigurable process plans for evolving P3S (Products, Processes and Production Systems) is challenged by the need for integrated information and a comprehensive knowledge about the actual manufacturing environment."

Therefore, this proposal focuses on the **P3S knowledge model for the CAPP and the reconfigurable process plan**.

The Process Specification Language (PSL), initially proposed by the National Institute of Standards and Technology (NIST), is an effective effort in the research domain to represent process information and to integrate process-related application systems based on ontologies. The underlying language used for PSL is KIF (Knowledge Interchange Format) and formal logic. The PSL ontology is the abstract summary of the manufacturing process information; it could be used to express the complex process information.
The scientific main objective is to **create a formal language for P3S which allows defining the concept, activities and control flows in decision making, analysis problem description and problem solving process.**
The fundamental characteristic of this language is the clear separation between characteristics of a P3S and its properties:

- Characteristics (Ci) describe the feature of a P3S and can be directly established, assigned and modified by the designer";
- Properties (Pj) describe the current behavior of a P3S (e.g. weight, manufacturability, function, cost, user friendliness etc.) and cannot be directly established by the designer; they can only be indirectly influenced by changing the depending characteristics. They are the indicator of the actual performance of the product, resulting from a given set of characteristics.
- Required Properties (PRj) describe the properties that have to be fulfilled by the designed artifact". Required properties are the reference values which are fixed while considering a customer's preferences.

P3S development strives to define a set of characteristics such that the established properties are sufficiently close to a set of required properties (PRj), i.e. the difference $\Delta Pj = RPj - Pj \rightarrow 0$. Thus, minimization of ΔPj is in fact driving the development process.
We will add a **hybrid description logic/rule reasoning to manipulate the properties**.

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3) Performance Measurement and Management of Industrial Systems: A Cost, Benefit, Value and Risk -based Framework

Performance Measurement and Management (PMM) has been posing daunting challenges to practitioners in companies as well as to researchers in industrial engineering and management sciences for several decades. Even today, companies are able to meet some objectives but at the expense of others. Indeed, it is not an easy task for companies to meet all stake-holders' objectives simultaneously. The issue complicates further when two or more conflicting objectives have to be met at the same time. PMM has evolved since the 60's from methods solely based on cost to methods based on financial and non-financial performance measurement and, more recently, to integrated performance management systems (PMSs) addressing the multi-dimensional nature of performance by means of performance indicators. A thorough review and analysis of the existing PMM approaches and methods reveals that none of them can globally handle the relevant established performance concepts, i.e. multi-dimensionality, multiple stake-holder perspective and multi-level performance. In addition, the fierce world-wide competition and the economic crisis in Western countries are changing the criteria to be considered.

Therefore, it is proposed to develop a new PMM framework built around four main evaluation axes: Cost, Benefits, Value and Risk (CBVR). Cost is about the price or total cost of the system, process or project being evaluated. Benefits are the potential gains for the enterprise. Value is the degree of satisfaction of the stake-holders computed as the aggregation of elementary performance indicators relevant for the objective(s) to be achieved. Risk represents an estimation of the global risk of infringing the achievements of the objective(s), also computed as an aggregation of elementary risk values. The work will be based on previous doctoral theses supervised by the two Ph.D. supervisors, especially work on value creation and value/risk-based performance evaluation.
It is proposed to apply the CBVR framework to the design and control of supply chain processes, preferably in the manufacturing industry.

The profile of the Ph.D. candidate should include:
- Sound background in mathematical studies, preferably in operations research, applied mathematics and optimisation
- Strong interest in the fields of industrial engineering with good knowledge on supply chain principles, systems modelling, evaluation and performance management
- Studies and experience in simulation theories and simulation tools would be an advantage

The student must be a hard-worker, committed to achievements and be result-oriented with a high sense of quality of work.

The work will be performed and supervised in Metz, France.

Laboratory: Design, Manufacturing Engineering and Control Lab. (LCFC - EA 4495)

PhD Supervisor: Prof. François VERNADAT , Dr. Ali SIADAT and Dr Alain ETIENNE
Email: ali.siadat@ensam.eu

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4) Towards predictive numerical simulation of sheet metal forming processes as well as impact and crash phenomena using new advanced solid–shell finite elements.

The accurate numerical simulation of forming processes as well as dynamic (high speed) phenomena (crash, impact) is a matter of primary concern to sheet metal producers, and hence represents one of their major research topics. Indeed, it is well-known that in such processes or phenomena, complex loading conditions come into play combining various kinds of non-linearities: large deformations, plasticity, contact, etc. The capability of simulating these phenomena with sufficient accuracy is a key issue since such a numerical predictive tool would represent a very interesting alternative to the time-consuming and costly experiments.

The aim of this PhD thesis is to extend the concept of solid–shell finite elements (FE) to the explicit dynamics framework, for application to the simulation of forming processes and impact phenomena. This new solid–shell concept combines the advantages of both types of formulations (3D and shell). The resulting enriched FE bring several interesting features (only displacement degrees of freedom, capability of simulating complex geometries while taking into account various through-thickness phenomena, free from membrane and transverse shear locking, large admissible aspect ratios, computational efficiency, … etc.). A family of solid–shell FE has been recently developed, in its implicit form, and validated through structural applications and elasto-plastic buckling analyses. It consists of two linear FE (8-node hexahedron and 6-node prism) as well as their quadratic counterparts (20-node hexahedron and 15-node prism), which were formulated based on a purely 3D approach along with assumed-strain enrichment. The intended purpose in the current work is to develop the explicit versions of these solid–shell FE, to implement them into explicit dynamics FE software packages, and to validate them through simulation of forming processes and impact and crash problems.

With regard to existing formulations, the originality of the proposed approach lies mainly in the solid–shell strategy allowing us to overcome the limitations inherent to purely 3D or shell approaches. Indeed, 3D elements not only require mesh refinement leading to overly high CPU times, but also suffer from locking phenomena that considerably reduce their accuracy. On the other hand, with shell approaches the major drawbacks are the use of classical plane-stress assumptions, the inadequacy in dealing with double-sided contact, and the intricacies associated with 3D mesh connection.

Scientific field: Solid Mechanics, Computational Mechanics, Finite Elements, Sheet Metal Forming.

Key words: Finite elements, solid–shell, explicit dynamics, forming processes, metal sheets, impact / crash, elasto-plasticity, composite behavior

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Laboratory: LEM3 (Laboratoire d'Etude des Microstructures et de Mécanique des Matériaux), UMR CNRS 7239.

Team: Computational Mechanics.
Head of the team: Michel POTIER-FERRY.
Supervisor: Farid ABED-MERAIM.
Email: farid.abed-meraim@ensam.eu
Collaboration with other partners during the PhD:
In France: M. POTIER-FERRY (LEM3, Université de Lorraine); H. CHALAL (LEM3, ENSAM).

References:

1. F. Abed-Meraim, A. Combescure. « SHB8PS – a new adaptive, assumed-strain continuum mechanics shell element for impact analysis ». Computers & Structures, vol. 80, 2002, pp. 791–803.

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12. M. Schwarze, I.N. Vladimirov, S. Reese. « Sheet metal forming and springback simulation by means of a new reduced integration solid–shell finite element technology ». Computer Methods in Applied Mechanics and Engineering, vol. 200, 2011, 454–476.
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14. V.D. Trinh, F. Abed-Meraim, A. Combescure. « A new assumed-strain solid–shell formulation “SHB6” for the six-node prismatic finite element ». Journal of Mechanical Science and Technology, vol. 25, 2011, pp. 2345–2364.
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16. H.J. Xu, Y.Q. Liu, W. Zhong. « Three-dimensional finite element simulation of medium thick plate metal forming and springback ». Finite Elements in Analysis and Design, vol. 51, 2012, pp. 49–58.

Application:
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5) Finite elements and discretization techniques for the prediction of flatness defects during sheet metal forming processes

The prediction of buckling is a matter of primary concern to sheet metal producers and hence represents one of their major research topics. Indeed, the flatness defects, which manifest themselves in the form of waves of various orientations, represent one of the main criteria that allow the qualification of the product quality. Numerous attempts have been made to determine the origin of these defects for decades, which aim to eliminate or at least noticeably reduce them.
In sheet metal forming processes, such as rolling, complex loading conditions come into play, combining plasticity, contact, highly compressive stress state in the vicinity of tools, elastic tool deflection, significant stress variations consecutive to the contact zone, very flat geometry of the product… Under the extreme loading conditions characteristic of rolling, the deformation of the rolls (flattening, bending, and thermal dilatation) results in elongation heterogeneity subsequent to the contact zone in the rolling direction. This heterogeneity induces residual stresses that may lead to buckling.
The finite element simulation of this problem is underpinned by numerous difficulties. Three-dimensional finite elements, which are well suited for the simulation of the contact zone, are not appropriate for accurately predicting large rotation buckling. On the other hand, traditional shell elements commonly used for modeling flat products are not suited to carry the compressive loading induced by two-side contact with the tools.
The objective of this research is to investigate innovative discretization procedures that allow the proper analysis of the metal sheet both under contact zone and in the rest of the sheet. The numerical chaining of a rolling code, based on three-dimensional elements, and a buckling code using shell elements has been recently applied to this type of problem [1]. Other more or less strong coupling approaches may be tackled, exploiting e.g. the observation that stress field relaxation induced by buckling does not affect the rolling zone. Another promising research direction would be the accommodation of different finite elements within a single, unified simulation. The development of enhanced shells [2] or solid-shell elements [3,4] that are able to model the entire process would be a significant progress in this field. Indeed, the complex nature of the rolling stress state is one of the limitations of the current shell elements available in the literature [5-8]. Clearly, the simplest method would be to adopt the same discretization technique for all zones of the metal sheet. This common finite element would be either an enhanced shell or a solid-shell formulation, for which the LEM3-ENSAM team has a well acknowledged experience [9], and the investigation of this finite element technology represents the major objective of this PhD thesis. Let us mention another more complex alternative, which should be assessed, consisting of the coupling of two FE models (Arlequin technique or « bridging ») allowing thus shell and 3D finite elements to be connected.
Although this research work is of fundamental nature, its potential/prospective applications are important. This project would allow two research teams to interact combining their well recognized core competences, namely the modeling of rolling processes and the associated buckling and flatness defect predictions, and the development of enhanced, solid-shell finite elements that combine the advantages of both types of elements. In the two above-mentioned research fields, the LEM3 laboratory already has long term partnerships with well-known industrial corporations as well as existing collaborations with other laboratories (CEMEF, LaMCoS) through joint projects funded by the ANR research agency.

Scientific field: Solid Mechanics, Computational Mechanics, Mixed Finite Elements.

Key words: Buckling, plastic instabilities, residual stresses, thin sheets, rolling, flatness, enhanced shell elements, solid–shell elements.

Application:
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Laboratory: LEM3 (Laboratoire d'Etude des Microstructures et de Mécanique des Matériaux), UMR CNRS 7239.

Team: Computational Mechanics.
Head of the team: Michel POTIER-FERRY.
Supervisor: Farid ABED-MERAIM.
Email: farid.abed-meraim@ensam.eu
Collaboration with other partners during the PhD:

In France: M. POTIER-FERRY, H. ZAHROUNI (LEM3, UDL); P. MONTMITONNET (CEMEF, Mines ParisTech).

References:
[1] H. Zahrouni, M. Potier-ferry, N. Legrand, P. Buessler. « Etude du flambage d'une bande métallique soumise à différents chargements mécaniques ». Rapport de contrat de recherche, 2007.
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Application:
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6) Theoretical and numerical modeling of instability criteria (localization, necking, wrinkling): application to sheet metal forming

The research project proposed through this PhD thesis lies within the general framework relating to the prediction of instability phenomena. These phenomena manifest themselves most often in presence of thin or sufficiently slender structures. A twofold approach is proposed - theoretical and numerical - in order to develop effective prediction tools based on state-of-the-art finite element structural simulations. The applications of these developments are very important, particularly in metal forming processes in relation with the prediction of sheet metal defects. The latter may have various forms, which have themselves different physical origins: plastic strain localization in the form of shear bands (material instabilities), wrinkling or buckling (geometric/structural instabilities) or necking observed on the formed parts (coupling between material and geometric instabilities). The common consequence to all these aspect defects is to cause the formed parts to be rejected, which is very detrimental for many industrial sectors (automotive, packaging, aerospace etc), in terms of cost and delay. Therefore, the predictive capability, with sufficient accuracy, of these phenomena, which are limiting factors in sheet metal forming, is of primary concern for many mechanical industries.

Although stability and bifurcation issues in solids and structures have been tackled by a number of researchers for decades, the advent of new grades of high-strength steels keeps this research topic still very active. In order to enhance the degree of reliability of prediction models (criteria and indicators), it is necessary to improve the current development of finite element (FE) software packages by enriching them with the latest theoretical advances in the field. The aim of this project is thus to contribute to improving the predictive capabilities of sheet metal defects, in particular for new materials, by simultaneously focusing attention on the following aspects:

- Theoretical and numerical modeling of reliable and validated criteria for the prediction of localized and diffuse necking,
- Critical evaluation and review of structural instability criteria for elasto-plastic and visco-plastic solids in view of the recent advances in the field,
- Implementation of these material and structural instability criteria into FE simulation programs in order to build effective tools for the prediction of sheet metal defects.

More specifically, the tasks that need to be conducted within this PhD project are described in what follows:

I. The first important theoretical development is concerned with the prediction of local defects in sheet metal forming. Various approaches, based either on bifurcation analyses (loss of uniqueness of rate equilibrium equations) or on linearized perturbation techniques (stability of the fundamental solution), have led to the formulation of existing prediction criteria. Examples of rigorous approaches for the prediction of these phenomena are the Rice localization criterion [1] (loss of ellipticity) or the Hill bifurcation criterion [2] (positiveness of second-order work). Concurrently, engineer-type approaches are widely used in the industry for the prediction of forming limits. The Marciniak-Kuczynski model [3] as well as the maximum force criteria, introduced by Considère [4] and subsequently extended by Swift [5], are examples of such simplified approaches. The first task would be to reformulate these local criteria within a unified approach and to evaluate them on the prediction of diffuse and localized necking (see [6, 7]). These criteria will then be compared for classification purposes: the goal being to establish relationships between theoretical and more pragmatic (simplified) approaches. This comparison will also allow an in-depth understanding of these instability phenomena and will help to select the most relevant criteria. For rate-sensitive (elasto-visco-plastic) materials, alternative criteria

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will be investigated based on stability theory of non-stationary solutions and taking into account the non-autonomous character of the governing differential equations.

II. The second important fundamental development concerns the geometric instability (buckling) of structures. To this end, the theoretical foundations of stability for visco-elastic, visco-plastic or elasto-plastic solids will be revisited. The key idea is to investigate the problem, no longer in terms of equilibrium stability or bifurcation from fundamental path, but rather as a stability problem of the quasi-static evolution (see, e.g., [8, 9]). This is more consistent whenever equilibrium states do not exist (case of viscous solids). For elasto-plastic solids, the obtained criterion [10, 11] is shown to be more conservative than that given by the flow-theory tangent modulus of plasticity (see Hill [2]), and seems to be close to the one given by the deformation theory of plasticity. On the other hand, it is well-known that the criterion based on flow theory of plasticity overestimates the critical buckling loads, which are found to be more realistic using the deformation theory of plasticity. Therefore, the criteria obtained by means of stability analysis of quasi-static evolutions may conciliate these buckling approaches and provide a more founded justification to the use of the deformation theory of plasticity. These resulting criteria will be implemented into FE software packages and evaluated for comparison purposes with both approaches: flow theory and deformation theory of plasticity.

Scientific field: Solid Mechanics, Stability/bifurcation, Thin stretched sheets.

Key words: Stability, bifurcation, geometric instabilities, material instabilities, thin metal sheets, stretching, diffuse necking, localized necking, shear band localization.

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Laboratory: LEM3 (Laboratoire d'Etude des Microstructures et de Mécanique des Matériaux), UMR CNRS 7239.

Team: Computational Mechanics.
Head of the team: Michel POTIER-FERRY.
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Collaboration with other partners during the PhD:

In France: M. POTIER-FERRY(LEM3, UDL).

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Application:
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7) Advanced machining of austempered ductile iron (ADI) for automotive applications

Project description:

The Austempered Ductile Iron (ADI) has a unique “ausferrite” microstructure due to which it has high strength-ductility combination mostly above all ferrous material (iron and steels). This material has the potential to replace steel casting, forging and assemblies in most industrial fields. However, ADI is considered as hard-to-machine material due to its inherent properties. In the current scenario, there is a growing demand of high material removal rates to increase throughput and minimize the overall manufacturing cost. However, machining at higher material removal rates requires parts with uniform microstructures, consistent properties, and a minimum volume fraction of abrasive inclusions. The ADI materials cause rapid tool wear, which leads to the loss of tolerances and surface quality, a loss in productivity, machine down time, and higher scrap rates. To solve this problem, there is a need of correlating the machining characteristics of ADI materials with its microstructures and production parameters. Moreover, there is a need to contribute towards creation of knowledge by undertaking research relating to dry and near dry (MQL) machining of ADI materials in order to achieve sustainable manufacturing of ADI parts for automotive applications.

In this context, the purposes of the PhD position are to:
Design and perform experimental machinability tests together with associated analysis involving tool-workpiece and tool-chip interactions, chip morphology characteristics, surface integrity and process mechanics etc.;
Develop numerical or analytical modeling methods to understand the tool-workpiece and tool-chip interactions while considering the inherent properties of the ADI material. These methods can be used to determine the chip formation mechanisms as well as stress and temperature distribution. Moreover, it can be further utilized to understand the influence of tool's geometry, tool wear behavior and cutting conditions to optimize the ADI machining process;
Optimizing the tribological interactions between tool-workpiece and tool-chip interactions in correlation with tool geometry, coating material, cutting parameters under dry and near dry machining conditions.

Eligibility:

Applicants must have first class master degree in a relevant engineering or science subject (e.g. mechanical engineering, manufacturing engineering, materials science, or similar discipline) (preferably with some experience or knowledge of conventional machining systems) and should be enthusiastic about research but also have a strong interest in laboratory and hands-on activities. Candidate should be able to combine challenging experimental work with computer simulations. Good communication/writing skills (in English) are necessary.

Contact person:
Please send your CV and reference letters to:
Prof. Mohamed EL MANSORI
Deputy General Director in Charge of Research & Innovation of Arts et Métiers ParisTech,
Chair the Mechanical Engineering and Manufacturing Research Group (www.lmpf.net).
Email: mohamed.elmansori@ensam.eu
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References:

Application:
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If selected, you should then apply for scholarship to the Chinese Scholarship Council (CSC) through your University International Office.

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8) Colloids transport in porous media: Direct numerical simulation at the microscopic scale.

Natural porous media such as soils or aquifers contain colloidal particles. These particles in suspension in the fluids present in the pore-space can be of different nature (bacteria, clay particles, pollutants …). In the case of aquifers, according to geochemical and hydrodynamic conditions, colloids can be transported by water, develop a high reactivity and a high mobility and act as vehicles to pollutants. Some colloidal particles such as bacteria are also likely to present a risk to the environment and health by altering the quality of drinking water.

Particle transport is also known to be of particular interest in the petroleum industry, since the release and adsorption of natural particles present in reservoirs may alter the petrophysical properties of the porous rocks and lead to additional loss or gain in oil production.

In order to better understand the behavior of colloidal particles in porous media, experimental and numerical studies have been conducted in our laboratory.

Since the behaviour observed during laboratory experiments can not be easily analysed by classical theories, during a recent PhD thesis, a special effort has been put into direct simulation of transport, deposition or detachment of a particle near a rough surface. New numerical modules have been implemented in order to take into account lubrication forces and physicochemical forces between moving particles and rough pore-surfaces. Test cases, chosen on the basis of experimental results presented in the literature, have been limited for the moment to the transport of isolated particles near a solid surface for given hydrodynamic conditions (a given Reynolds number) at different values of ionic strength and the influence of various surface roughness types were analysed.

The objective of this PhD project is to further develop the numerical fluid mechanics code in order to take into account a large number of colloidal particles and carry out a statistical analysis of particle behaviour in porous media. The relative importance of hydrodynamic forces vs physico-chemical interactions on the deposition and release of particles in a pore space for different types of pore-surface roughnesses will be thoroughly analysed.

Required competencies: a good knowledge of fluid mechanics and numerical analysis and a real will to invest in direct numerical simulations in fluid mechanics.

Supervising team: Azita Ahmadi – Henri Bertin – Aziz Omari

Contact: Pr. Azita Ahmadi – I2M TREFLE – Arts et Métiers ParisTech, Bordeaux,
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Application:
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9) Detection and treatment of inconsistent or locally over-constrained configurations during the manipulation of 3D geometric models made of free-form surfaces

Subject description:

The evolution of the manufacturing technologies and the advances in the domain of new materials have significantly increased the degree of freedom when defining the shape of a product that can now become very complex. Today, free form shapes are not only used to answer needs related to aesthetic criteria but also to be able to satisfy to functional criteria. The dashboard, the wings or the optics of a car, a turbine blade, a lemon squeezer and so on, are so many products that can be made of very complex free form shapes whose design is not always easy with actual CAD/CAS software.

To enable the modelling of the free form shapes of a product, actual CAD modellers mainly use NURBS curves and surfaces. Subdivision surfaces also enable the representation of free form surfaces through a recursive subdivision at the infinity of a control polyhedron. But their use in mechanical engineering is still limited.

During the last decades, numerous methods have been proposed to ease the definition and manipulation of NURBS surfaces without going back to the underlying mathematical models. Most of these methods try to modify an initial model while satisfying a set of user-specified constraints. The constraints can be indirectly specified on the control points of the control networks/polygons, or directly onto the surface potentially made of multiple trimmed patches connected together with continuity conditions (Pernot04). Some of these approaches enable the specification of higher level constraints enabling the insertion of discontinuities inside the patches (Cheutet06). Some constraints may also be defined directly onto the trimming curves lying in the surface parametric space to enable simultaneous deformation of the patches and their trimming lines (Pernot08). But constraints may also be defined through the use of different supports such as the digital images that can be easily taken with a digital camera (Panchetti09). The common denominator to all these approaches lies in the fact that they all suppose that there are enough Degrees of Freedom (DOF) to enable the desired modifications without encountering locally over-constrained or inconsistent configurations. This hypothesis is very restrictive since it does not optimize at best the NURBS model description capabilities. Its satisfaction often requires the insertion of numerous DOF through the use of the Boehm's knot insertion algorithm. This uncontrolled increase of the DOFs impacts the quality of the final model which becomes heavier than the initial one. Some approaches try to improve this process while defining hierarchical NURBS surfaces (Qin01).

This thesis aims at defining models, methods and tools to detect and treat locally over-constrained and/or inconsistent configurations that may occur when defining and/or modifying NURBS surfaces. The detection module should produce an analysis of problematic configurations, i.e. a set of areas where either some new DOFs or some local changes in the constraints are mandatory. The treatment module should enable the definition of mechanisms to help the decision on modifications. On the basis of actual 2D sketchers, the idea is to be able to propose some appropriate tools to analyse the constraints and suggest some modifications in 3D. Thus, the number of DOFs will be optimized and there will be no systematic insertion of new DOFs.

Through the tools already developed and available within the INSM team of the LSIS laboratory, the candidate will have to analyse some critical configurations to identify the logical structures of some over-constrained configurations, thus enabling their analysis and post-treatment (identification of corrective solutions). The candidate will take advantage of the work of D. Lesage (Lesage02) that has been working on the definition of models and methods for the detection of such configurations on planar curves within a 2D sketcher.

Application:

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PhD Proposals 2013 for China

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Hosting laboratories: Laboratory LSIS of Aix-en-Provence (France)

Director: JP. Pernot / jean-philippe.pernot@ensam.eu
Co-director: M. Kleiner / mathias.kleiner@ensam.eu

Websites: www.aix.ensam.fr, www.lsis.org

Keywords: geometric modelling, numerical optimisation, local over-constraints, inconsistent configurations, bipartite graphs.

Candidate profile: computer graphics, applied mathematics, C/C++ programming.

Candidature: send CV + motivation letter to the above mentioned contacts.

(Cheutet06) Towards semantic modelling of free-form mechanical products, Cheutet V., Thèse de doctorat en cotutelle entre INP-Grenoble (France) et Università degli studi di Genova (Italy), 2006.

(Lesage02) Un modèle dynamique de spécifications d'ingénierie basé sur une approche de géométrie variationnelle, Lesage D., Thèse de doctorat INP-Grenoble, 2002.

(Panchetti09) Exploitation d'images numériques pour la simplification et la déformation de modèles polyédriques, Panchetti M., Thèse de doctorat ENSAM, 2009.

(Pernot04) Fully free-form deformation features for aesthetic and engineering designs, Pernot J-P., Thèse de doctorat en cotutelle entre INP-Grenoble (France) et Università degli studi di Genova (Italy), 2004.

(Pernot08) A hybrid models deformation tool for free-form shapes manipulation », Pernot J-P., Falcidieno B., Giannini F., Léon J-C., 34th Design Automation Conference (ASME DETC08-DAC49524), New-York, USA, 2008.

(Qin01) Hierarchical D-NURBS surfaces and their physics-based sculpting. Meijing Zhang et Hong Qin, SMI 2001 International Conference, pp. 257 – 266.

Application:
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10) Design Process and product data modelling toward the propagation of engineering changes

Background

To remain competitive, the industrial companies have to act on their performance parameters (Cost, quality and delay). Consequently, it is important to identify the Five Ws in order to master their know-how and then to innovate.
Currently, we focus on the product design phase as more than 80% of product lifecycle costs emanate from the collaborative developments engaged during this phase. In this context, the product design is a highly complex and iterative process as it includes various pieces of information and knowledge associated with the evolution of the product throughout its lifecycle.
This thesis is, fully, in "what-if design" approach [Lutters et al. 2004] that supports designers, with methods and tools, in order to converge into a suitable design solution, within a heterogeneous context (models, information, tools…). The major performance lever is then to link product information to process ones. This requires integrating different processes and product models resulting from the collaborative design.
The main issue of this thesis is then to master the collaborative process modeling and eases engineering change management in product design context.

Objective

This involves developing a method to take into account the integrated product/process information to identify, first, the 5 Ws of the design process and, second, to simulate the impact of any technical modification (CAD model, tool, material…) on this design process. This method aims to capitalise all the effective transformation occurred between the different processes/product models and to capitalise the process execution trace (report on the results of process executing) in order to ease the identification of the "zone of the process" where is suitable to make change to drive a new solution for example.
The thesis intent is to develop a computer- demonstrator in order to support this method.

The first scientific objective is to model the various data and links between design processes models, and product data in order to eases the 5 Ws identification. It will be essential to consider the link between:

• The product data that are conveyed through heterogeneous supports and models. This information is then the value of the design process as it links the different data during the product lifecycle [Skander et al. 2008].
• The process models that capitalise all the knowledge related to the design processes and the choices made during this phase. Those choices have a critical impact on the obtained design solution and on the design process itself [Wang et al.2008].
An important issue concerns the study of the different process models by considering different point of view: information coverage, comprehensiveness, tools, simulation etc... The second issue concerns the identification of the effective transformation between process models. In this context, we could consider MDA (Model Driven Architecture) approach [Iraqi-Houssaini et al.2011].

The second objective is related to the engineering change management [Weidlich et al. 2012] and to the capability to trace the modifications (its propagation) through the design process and to evaluate the impact of its modifications, for example, on the context of an innovative design process.

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Indeed, it is primordial to allow processes simulation, in order to capitalise the transformation required when acting a modification. A related issue, concerns the capitalisation of the process execution trace.
The developed demonstrator should take on consideration all these requirements.

With respect to the candidate profile, those objectives will be treated totally or partially.

Method

First year
- Bibliography (design processes models, integration product / process, engineering change management)
- Study of protocols for data/model exchange within the global information system
- Definition of the work program and digital tools that will be used (Choice of environmental technology and computer interfaces between applications).
- Specification of scenarios and case studies that will highlight the value added of the thesis

Second year
- Implementation of the product/process models
- Development of computer software tool.

Third year
- Implementation of the validation scenarios
- Application to complex parts
- Writing a doctoral thesis.

Progress reports of the thesis will be written once a year. Publications to present the intermediate results will be written and presented in national and international conferences during the first two years. The entire process will be finalized in the form of international conferences and articles in international scientific journals with peer review. A point detailed progress will be made every six months with the presence of different partners.

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Hosting laboratories: Laboratory LSIS of Aix-en-Provence (France)
Director: Lionel ROUCOULES
Co-director: Esma YAHIA
Contacts: lionel.roucoules@ensam.eu
Websites: www.aix.ensam.fr, www.lsis.org

Keywords: product design process, system engineering, change management
Candidate profile: engineering design, process modelling (ex: UML/BPMN), computer programming,

Candidature: send CV + motivation letter to the above mentioned contacts.

References

[Lutters et al. 2004] What-if'design: a synthesis method in the design process, Lutters, D. and Vaneker, THJ and Van Houten, F, CIRP Annals-Manufacturing Technology, n°53, 2004

Application:
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[Wang et al.2008] Design Knowledge for Decision-Making Process in a DFX Product Design Approach, Wang, K. and Roucoules, L. and Tong, S. and Eynard, B. and Matta, N, Global Design to Gain a Competitive Edge, 2008

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[Weidlich et al. 2012] Propagating changes between Aligned Process Models, Weidlich, M. and Mendling, J. and Weske, M., Journal of systems and software, 2012

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11) Knowledge modeling of Design and manufacturing interface for DFM approach during product development process. Application to foundry process

Background

Currently, the industrial design process is fully focused on the geometric model of the product. This model is clearly created from a design intent outcome of the choice of architecture to meet the structural features of the product. Unfortunately, the geometric model (commonly called CAD model) does structure only the information on the nominal geometry of the product which is then not related to business knowledge of each of the experts involved in the design process.

In order to master the design solution then it is essential to structure the information around an advanced CAD to link information (i.e. knowledge) of business entities geometric product. This thesis is an approach fully in DFM (Design For Manufacturing) for which it is necessary to bind the manufacturing information to geometric data. XAO software tools must then expand to include more data from manufacturing processes. This requires the development of models to integrate in what will be new design tools, expert knowledge data, parameters of manufacturing protocols, their consequences on the mechanical part in terms of geometry, internal stresses, at the material science ... The lock here is to formalize the knowledge to propose models sufficiently general to be useful in different applications while providing practical applications in the short term.

The results of this study offer a new paradigm for creating the CAD model partly generated by "translation" of manufacturing plan selection. This new paradigm fully supports simultaneous engineering approaches for which the activities of “processes selection” are positioned early in the design process even before the CAD model is completely defined. DFM method is then fully seen as a design method.

Objective

This involves developing a method to take into account the manufacturing information to predict the geometric shape of the object, taking into account different levels of product definition (topologies, dimensional tolerances, roughness, and residual stresses) introduced with manufacturing processes. The thesis will provide a demonstrator for computer support this method.
The first scientific objective is to model the various data and links between manufacturing processes, materials and product data. It will be essential to consider the duality between:
• The data structure that can generate a 4D CAD model. This structure is then the value of the DFM approach proposed because it allows to link a given geometric and manufacturing data. This link is then essential to master the impact of a change in upstream solution (functional analysis) and downstream (selection processes).
• Database processes / materials / product that will capitalize on the knowledge and assumptions relating to manufacturing processes. This knowledge base is also a high value of the thesis work to capitalize on information relationships that currently exist in various forms: analytical, numerical, heuristic [Moraru et al. 2004] [Martin et al. 2006] [Moraru et al. 2009] [Martin et al. 2009].

This work is in full continuity of work already framed by L. Roucoules [Roucoules 2007] that have already provided a first demonstration of the DFM approach to create a CAD model into line with the selection process [Skander 2006] [Skander et al. 2008] [Elgueder et al. 2009]. The main issue is to model the global IT system that should be based on inference solver, database, CAD model, FEA solver…

Application:
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If selected, you should then apply for scholarship to the Chinese Scholarship Council (CSC) through your University International Office.

The second objective relates to the management and protocols for exchanging data between the application of DFM and the other applications in the design environment and simulation. Indeed, it will clearly position the demonstrator in the DFM global information system and specifying the exchange of data needed:

• upstream (from the functional analysis - application of functional analysis). Some functional surfaces, viewed as the specification of the choice of manufacturing processes, are in fact derived from the analysis of energy flows [Meyer Klein et al. 2007].

• in the industrialization phase (simulation of manufacturing processes) for the application of DFM to rely on numerical analysis of processes in complex situations [Cochennec et al. 2008]

This integration approach (ie interoperability) software will be based on standards (eg STEP) or approaches the highest level (eg MDA - Model Driven Architecture) [Etienne et al. 2008].

The third objective is to specify new graphic metaphor to represent product information with respect to the design/manufacturing interface (i.e. material flows). That should give a new vision of the information to provide innovative solutions.

With respect to the candidate profile, those objectives will be treated totally or partially.

Method

First year

- Bibliography (manufacturing processes, KBE applications, integration product / process)
- Study of protocols for data exchange within the global information system
- Definition of the work program and digital tools that will be used (Choice of environmental technology and computer interfaces between applications).
- Specification of scenarios and case studies that will highlight the value added of the thesis

Second year

- Implementation of the DFM process-model-product materials
- Development of computer software tool.

Third year

- Implementation of the validation scenarios
- Application to complex parts
- Writing a doctoral thesis.

Progress reports of the thesis will be written once a year. Publications to present the intermediate results will be written and presented in national and international conferences during the first two years. The entire process will be finalized in the form of international conferences and articles in international scientific journals with peer review. A point detailed progress will be made every six months in the presence of different partners.

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Hosting laboratories: Laboratory LSIS of Aix-en-Provence (France)

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Co-directors: L. MARTIN
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Websites: www.aix.ensam.fr, www.lsis.org

Keywords: DFM, manufacturing knowledge, Product-Process interface, manufacturing and material Database, foundry process.

Candidate profile: engineering design and manufacturing, CAD modeling, C/C++ programming, database modelling.

Candidature: send CV + motivation letter to the above mentioned contacts.

References

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12) Contribution to the development of kinematics full-field measurements at microscopic scale for experimental solid and material mechanics

Objectives of the thesis

Following the developments previously made in the framework of the project called NANODEF [1,2], the present research work has the objective to develop, improve and exploit displacement and strain fields optical measurement techniques. More especially, these techniques have to show micrometric spatial resolutions, in order to be able to analyze the physical phenomena of deformation at the surface of solicited materials, down to the characteristic scale of the material heterogeneity. This work will consist in i) continuing the development and the exploitation of micro-grids for metallic materials ii) adapting the previous methodology to materials with a gradient of property, like for material processing for example.

Originality and novelty of the research work

This research work fits perfectly with the new orientations of the international research in mechanics of materials (full-field measurement, micro and nano systems and materials). Indeed, the deep study of the materials mechanical behaviour needs absolutely observation means of the physical deformation phenomena at the scale of their heterogeneity, this in order to formulate well founded macroscopic laws or to define these laws from techniques of scale change (micro-macro conversion, homogenisation). The characteristic scale goes from some tens of micrometres for most of the metallic alloys (grain size) down to a micrometre for an interphase in a fibrous composite material. The pure observation of the material deformation is of course necessary, but to go further and quantify the strains, an extensometric technique has to be implemented. Especially in the case of material with heterogeneity, only a technique adapted to these scales would return pertinent measures of the strain fields.

At the macroscopic scale, many techniques exist (ESPI, DIC, grid method, moiré interferometry…) and commercial devices are available, even if many metrological aspects haven't been solved yet. These last problems are being studied by the GDR CNRS 2519, a French research groups network created in 2003, of which the MSMP laboratory is an active member. This network, named "Full-field measurement methods and identification in solid mechanics", is undergoing some common work in this field of research [3, 4].

But at the micrometric scale, measurement is more difficult and despite some attempts, more or less conclusive, this point still remains very wide to explore. The improvement of measurement methods constitutes an undeniable scientific lock to solve for the local comprehension and identification of materials behaviour. This is also a major issue for the improvement of homogenisation schemes. Thus, the proposed research work will participate to the improvement of existing measurement methods and to the development of new measurement methodologies based on the two instrumentation devices described in the following.

Firstly, the white light interferometric microscope will be used with the grid method. This last technique is well known at the macroscopic scale for its good metrological performances (resolution, spatial resolution), and has been (for the first time) recently adapted to the microscopic scale by the advisors of the proposed thesis work. Even if this work showed a great potential of this measurement methodology, it has just been developed until the proof-of-concept step and should be continued in order to allow notable further dissemination and exploitation.

Another well known technique of kinematic full-field measurement at the macroscopic scale is the digital image correlation (DIC). This method, which was considered in a feasibility study in the framework of the NANODEF project, is well complementary to the grid method. This is the reason

why, during this thesis work, the development of DIC for an observation with a white light interferometric microscope should also be considered.
This research work, dedicated to advanced microscopic scale measurement techniques and metrologies, will lead to a better consideration of the local mechanical effects observed, for a more global material behaviour comprehension and modelling.

Advisors
Dr. René Rotinat (MSMP)/ Rene.Rotinat@ensam.eu

Place
Mechanics, Surfaces and Materials Processing (MSMP) Laboratory
(Arts et Métiers ParisTech in Châlons-en-Champagne, France)

Profile of the applicant
The applicant will have to possess good aptitudes in solid mechanics experimentation as well as knowledge in mechanics of materials. It will be appreciated if he, or she, has got some background in full-field measurement techniques.

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13) Surface fatigue damage prediction: Pitting and micropitting on gears

Main goal
The main goal of this project is the identification of relevant parameters in case of surface fatigue damage due to the original design of teeth of a gear. Investigations will conduct to determine the effect of the microstructure, roughness, residual stresses and damage induced when the manufacturing of the wheel or the pinion, on the fatigue lifetime of the tooth.

Context of the study
On the contact surface, the fatigue behaviour is largely dependant from the mechanical, material and geometric properties of the surface. These properties can change during the service life of the part. These changes occur principally on the running-in stage, but these changes can be affected by the initial properties due to the stage of manufacturing.
In this study, focused on the gear application, the main objective is to build a method to be able to detect the main parameters taking the surface manufacturing and running-in effect into account on the fatigue lifetime.
In order to achieve this objective, two axis of study will investigated:

- In the manufacturing and running-in stages, it will necessary to develop a relevant method to quantify the damage of the material, which reduce the fatigue lifetime in service. Experimental investigation using X-rays diffraction will be conducted in order to quantify the damage.
- In the case of infinite or limited fatigue, it will be necessary to develop a relevant criterion to quantify the damage induced by the non-proportional multiaxial loading due to the roughness of the flank of the teeth.

Competences required
Continuum mechanic, fatigue mechanic and microstructural, X-ray diffraction knowledge are required to work on this Phd-project.

Location of study
This project will mainly develop in Mechanics Surfaces and Materials Processing Laboratory (MSMP laboratory) with Dr. Agnès Fabre in Arts et Métiers ParisTech (Aix en Provence, France), and with the collaboration of Pr. Laurent Barrallier from the same laboratory (MSPM laboratory), and Pr. Pwt Evans from Cardiff University (Cardiff, Wales), and Dr. Fabrice Ville, from INSA-Lyon (Lyon, France).

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14) Thermo-mechanical performance of multilayer coatings on machining FRP composites: multiscale analysis

Superior properties of polymeric composites explain the technological and commercial interest on these materials especially in the aerospace sectors. The gain in energy consumption and performance in improving system because of the high specific characteristics of these materials makes them good candidates face to metallic alloys. However, fiber reinforced polymer (FRP) composites exhibit particular machining response if compared to metals. Generally, the abrasive nature of fibers results in poor surface finish, delamination and tool wear. Thus, the processing of neat-shape parts still remains the common challenge since it closely depends on the surface finish quality. While FRP properties depend on the nature, orientation and volume fraction of fibers, the final quality of parts still remains very sensitive to the cutting conditions. In many cases, the mechanical and physical properties of FRP present an obstacle to controlling properly the applications and still raise various issues during machining. In particular, the interfacial behavior was outlined to be of main role in governing the mechanisms acting before final stage of chip separation.
In open literature, many attempts were conducted in order to set out the prominent parameters when cutting FRP. Most panels of the researches have interested to wear mechanisms on uncoated carbide inserts or single layer coated inserts typically composed of titanium carbide (TiC), titanium nitride (TiN), aluminum oxide (Al2O3), etc. In spite of the economic advantage of the tungsten carbide (WC) at low cutting speeds [1, 2], they exhibit real vulnerability at high cutting speeds since they undergo a severe wear. This affects the surface quality and increases the cutting forces [1, 3]. Nevertheless, only few studies have been conducted on the performance of multilayer coatings on cutting these materials. More than a decade after their apparition, multilayer coatings take increasingly their rightful position in machining FRP. Recently, multi-hard coating layers such diamonds and ceramics demonstrated their efficiency to improve wear resistance and to promote higher surface finish with minimum production costs [4, 5]. However, the elevated thermal gradient between the fiber and the matrix phases, and the relatively poor thermal conductivity of composites makes it rather difficult to industrialize any of the unconventional coating techniques for machining polymeric composites [6]. Hence, the physics of the induced cutting process and associated tribological mechanisms (i.e. heat generation, interface consumption, friction, etc.) [7] become necessary to evaluate the performance of the cutting tools to achieve the required quality of composite components.

The new coating generations obtained by CVD and PVD techniques combine multiple layers such as TiCN, TiN, Al2O3 and AlCrO [8, 9]. Titanium based constituents improve wear resistance to abrasion while oxide constituents are known to offer better chemical stability. Besides, thermal effects that might be of critical role in understanding the tool behavior when long duration cutting were often overlooked! Since the chip is powdery, it potentially able to dissipate only insignificant portion of localized heat. Hence, a high thermal conductivity was outlined as an additional primordial factor in selecting the adequate tool capable of successful FRP cutting [10].

Preliminary tests [11] showed that CVD mullti-layer coated tools are of better ability to dissipate the thermo-mechanical cutting energy due to the good coating-to-substrate adhesion. This acts to prevent catastrophic failure to the detriment of progressive wear compared to monolayer coating. Thermal analysis of fiber and matrix within the surface finish indicated also that the thermal conductivity of each of phases is proportional to wear. AFM micro-scratch tests using sliding contact probe revealed that friction at surface finish sensitively depends on the wear land aspect. The multiplicity of rough asperities seems to favor the thermal conduction on wear track.

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This work covers a study on the performance of multilayer coatings when dry cutting Fiber Reinforced Polymers (FRP). A design of experiments including cutting tests on both unidirectional carbon/epoxy and glass/epoxy with various fiber orientations should be built. Multilayer coatings with neatly different constituents, grain size and substrate-to-coating adherence will be utilized for generating composite surfaces. Scanning Electronic Microscope (SEM) will be employed for characterizing the flank wear modes and highlighting the stages of the material removal process. The adhesive frictional signature of new and worn inserts will be examined by Atomic Force Microscope (AFM) using series of micro-scratch tests. Close inspections on the worn face are also required for correlating observations with physical mechanisms generated. FE simulation should be developed as an alternative to understanding the involved mechanisms. Thus, deep analyses on thermal effects will be necessary for determining heat partition coefficients required for calibrating the FE model. A particular focus must be put on mastering the thermo-mechanical behavior within the interface. The well-established model which is restricted to mechanical behavior will be hence extended for taking into account the thermal effects have been induced par cutting. The numerical analysis will be conducted on ABAQUS code using the options associated with dynamic issues.

Keywords: FRP, dry cutting, multilayer coatings, fiber scale, Interface consumption, wear

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References

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15) Micromechanical modeling of drilling hybrid composite stacks: toward an improved investigation of cutting mechanisms governing the assemblies' interfaces

In order to enhance the characteristics of lightweight structures and to continuously motivate the development of mechanical assemblies favoring the energy consumption, the manufacturing sectors are looking increasingly for innovative materials such as new composites. Specially, the polymeric composites reinforced with long carbon fibers take a prominent position in aircraft and spacecraft structural parts because of their particular mechanical and physical properties (high specific strength and stiffness, low sensitivity to fatigue and corrosion, etc.). However, the polymer-based matrix can undergo relatively rapid degradation when subjected to high level of heat. Hybrid materials composed of both composites and metal alloys offer a good alternative to overcome several technical issues. Materials made of multi-layers of carbon fibers reinforced polymers (CFRP) and aluminum or titanium phase are a typical example of a composite stack. The metal-to-composite alliance aims to combine resistance and increased specific characteristics without increasing significantly the part weight. The ability to deliver energy savings and improving system performance make these materials good candidates to override metals in various applications. Aircraft structures subjected to high thermo-mechanical stresses were successfully fabricated with these materials. Wing-fuselage connections of the Boeing 787 Dreamliner are typical applications.

In this topics, most of the recent works have been interested to the mechanical response when mechanical processing of composite stacks. The machining of mechanical assemblies, made of hybrid materials, is today among the main scientific and technological challenges. Even if their behavior significantly depends on the type, orientation and fiber volume fraction, the quality of the finished product, however, depend sensitively on the manufacturing conditions. The non-compliance between the tool-metal interface, on one hand, and the tool-composite interface, on another hand, induces local interface discontinuities and, hence, affects the cutting behavior. These discontinuities present the major obstacle to overcome for better controlling of cutting conditions. The transfer of loadings from the tool to the constituents of the material still remains understudied in various cutting operations, namely drilling. Perception of the behavior at the interface via the control of the tribological properties and cutting conditions is fundamental for highlighting the mechanisms generated by the material removal process.

Nowadays, it can be noticed that machining of CFRP composite still remains poorly mastered because of interrelated mechanisms i.e. premature tool wear, delamination, matrix damage, etc... [1]. In composite stacks, the control of the processing operation becomes further complicated. In fact, several phenomena occurring during machining generate local and subsurface deteriorations causing hence the disposal of many parts. The burns and damage in the resin are accentuated by the transport of metallic hot chips and the adhesion of metallic phases on the active zone of the tool. The adhesion of micro-fragments and matrix debris owing to material removal process at the CFRP-metal interface significantly affects the quality of superficial layers and subsurface within the generated area of the material [2-5].

In recent years, experimental studies [3-5, 7, 8] have led to a better understanding of the influence of cutting parameters on the physical phenomena involved during drilling operation of hybrid structures. However, the optimization of these parameters using only experimental approaches is often consuming time and very costly. Numerical modeling should be good alternative that can significantly help to optimize investigations of mechanisms when drilling these materials. In this context, a numerical analysis using a multi-physics constitutive approach will be developed and implemented into Abaqus for simulating the material removal process when cutting hybrid materials. The model should include a test of reliability for the numerical integration scheme involving failure and damage criteria of each of the constituents. Thus, the main objective of this study is to understand the thermo-mechanical charge transfer at the interface between the laminate composite and the metal alloy. The analysis will also covers the physical phenomena generated during chip formation versus the cutting parameters. Due to the nature of the machined structures, the assumption of orthogonal cutting can be primarily applied locally for modeling drilling operation. However, a three-dimensional analysis is also necessary to overcome the shortcomings of numerical convergence and to predict the cutting mechanisms in more realistic way. The numerical development will extend the preliminary existing model using ABAQUS code and options associated with dynamic issues. Validation of the numerical approach should be achieved by refer to experimental findings. Some required observations (SEM, AFM, etc ...) on the mechanisms generated have to be correlated with the simulation to explain the physical mechanisms activated during drilling.

Keywords: Drilling, hybrid composites, Interface behavior, subsurface, damage, chip formation

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References

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Application:
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ARTS ET MÉTIERS ParisTech

16) On the thermal and environmental performance evaluation of a movable building in its future living context, by the use of measurements in its current context.

Solar Decathlon Europe is an international competition among universities which promotes research in the development of efficient houses. The objective of the participating teams is to design and build houses that consume as few natural resources as possible and produce minimum waste products during their life cycle. Particular emphasis is put on reducing energy consumption and on obtaining all the necessary energy from the sun.

Arts et Métiers ParisTech (www.ensam.eu), in collaboration particularly with the Civil Engineering Department at the Institut d'Enseignement Technologique de Bordeaux (http://www.iut.u-bordeaux1.fr/gc/www/index.php) and Nobatek (www.nobatek.com), took part in Solar Decathlon Europe 2010 and 2012 in Madrid (http://www.sdeurope.org/). In 2014, this competition will be hosted in France, at the chateau of Versailles in the gardens of the Sun king (http://www.solardecathlon2014.fr/fr).
A consortium composed of Arts et Métiers ParisTech, Nobatek and the Civil Engineering Department at the Institut d'Enseignement Technologique de Bordeaux will be responsible for setting up the monitoring and the thermal and environmental assessment of the houses in competition at Versailles in 2014. This assessment will combine two issues: (1) defining and setting up appropriate measuring systems at the Solar Decathlon Europe 2014 competition site, (2) defining and setting up a digital tool to assess the performances of the houses, in a real life situation (in their home region), based on the measurements taken during the competition in 2014 at Versailles. After the Solar Decathlon Europe 2014 competition, this assessment can be used to exploit all the data and measurements from all 20 participating houses.
The aim of this PhD thesis is, first, to deal with the two issues described above, and then to use the data from the 20 houses in competition at Versailles in 2014 to define efficient, tried and tested strategies to design autonomous solar buildings.
This PhD thesis will be prepared for the most part in Bordeaux. Registration will take place at the Combined Doctoral School of "Sciences et Métiers de l'Ingénieur" at "Arts et Métiers ParisTech" and "Mines ParisTech" (http://edsmi.ensam.eu/). There will be regular working meetings in Paris (at the Ministry of Ecology, Sustainable Development and Energy), at Marne la Vallée (at CSTB - Scientific and Technical Centre for Building) and in Grenoble (at ENSAG - National Higher School of Architecture of Grenoble), with the partner Universities and Institutions who are organising Solar Decathlon Europe 2014.
The successful candidate must have the appropriate competence in mechanics and thermal science. He/She must speak and write English with ease. He/She will join a team of researchers and software developers working in the field of Thermal techniques in Buildings and renewable energies

Key words : Sustainable buildings, Thermal and environmental performance, Thermal and environmental metrologies.

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17) Definition, Design and Dimensioning of the participation of France to Solar Decathlon China 2015: to a reproducible and thermally and environmentally successful movable solar building.

Solar Decathlon Europe is an international competition among universities which promotes research in the development of efficient houses. The objective of the participating teams is to design and build houses that consume as few natural resources as possible and produce minimum waste products during their life cycle. Particular emphasis is put on reducing energy consumption and on obtaining all the necessary energy from the sun.

French regions Rhones-Alpes (Grenoble) and Aquitaine (Bordeaux) competed in Solar Decathlon Europe 2010 and 2012 in Madrid (http://www.sdeurope.org/). In 2014, Grenoble and Bordeaux will be very active in helping to organise Solar Decathlon Europe, at the chateau of Versailles in the gardens of the Sun king (http://www.solardecathlon2014.fr/fr).

The first Solar Decathlon China will take place in Datong, China, in August 2013. The second one will be in China in 2015.

The Rhones-Alpes (Grenoble) and Aquitaine (Bordeaux) regions recently announced their intention to prepare a French entry for Solar Decathlon China 2015.

This preparation will be in two stages: (1) definition of the architecture of the planned building project, and (2) definition of the planned energy strategy (and associated or existing energy systems, and/or any that have yet to be designed and produced).

The aim of this PhD thesis is to carry out the two stages described above. The first task will be to produce a design requirements document, based on the rules of Solar Decathlon China 2013. Research will then be carried out into the conceptual and architectural design of the building shell and associated systems. The endpoint will be to produce a detailed design document, and then lead the student team who will be building the corresponding solar house.

This PhD thesis will be prepared for the most part in Bordeaux. Registration will take place at the Combined Doctoral School of "Sciences et Métiers de l'Ingénieur" at "Arts et Métiers ParisTech" and "Mines ParisTech" (http://edsmi.ensam.eu/). There will be regular working meetings Grenoble (at ENSAG - National Higher School of Architecture of Grenoble).

The successful candidate must have the appropriate competence in mechanics and thermal science. He/She must speak and write English with ease. He/She will join a team of researchers and software developers working in the field of Thermal techniques in Buildings and renewable energies. He/She will also work with colleagues working in Architecture topics.

Key words : Sustainable buildings, Thermal and environmental performance, architecture and design, Solar Decathlon China 2015

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Research Laboratories: I2M-Bordeaux (student location) and Ecole Nationale Supérieure d'Architecture de Grenoble.

Application:
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18) Integration of renewable energy sources in spinning reserve for weak grids

By nature the loads are generally random in a power network. Now, with the introduction of renewable energy, the sources start also to be random. In case of high penetration of renewable energy on power system a problem may occur in term of spinning reserve. Indeed, the dynamic stability of an electrical is based on the possibility for classical source to increase (or decrease) their production within few seconds in case another source is tripping. This supposes to keep a spinning reserve dispatched on several power plants. In case of renewable power source, the power produced is always the maximum available at each moment with no spinning reserve available. If the renewable production is increasing, the classical production will decrease which could lead to a lack of spinning reserve. Transmission system operator are aware of this problem and write some constraints of spinning reserve even for renewable energy sources in new version of grid codes but these recommendations are not effective yet.

In weak grids as for French insular grids, or remote areas, this will be compulsory soon for renewable sources to propose this spinning reserve. A first solution is to add some storage elements which can guaranty this reserve but the cost is still very high. Another solution could be to limit the production of wind turbine when needed to keep this spinning reserve. Depending on local circumstances, the cost could be less than the storage solution and an in-depth study has to be done for each case.

For doing so, it is needed to characterize the quality of the reserve proposed by the wind turbines because it depends on the level of wind in the area where the wind turbines are located. How can we characterize the reliability of the spinning reserve based on renewable power plant? This is a quite new question which will become more and more accurate with the increasing penetration of this type of production.

Even though, powerful statistical tools have been developed to predict the behaviors of wind production, the predicted powers don't match perfectly the real powers produced. It is now necessary to take into account such uncertainty on the powers into order to increase the stability of the network …. Numerical Tools start being available to quantify the effects of the uncertainties on the stability of the power networks. These tools are based on a probabilistic consideration of the uncertain loads and sources that are modeled by random variables or fields. Then, methods of sampling (Monte Carlo Simulation Method) or Reliability Method (FORM/SORM) are coupled with models of power networks to deal with these uncertainties [1]. Indices related to probability of failure, shortage of supplied power for example can be extracted. Moreover, sensitivity analysis tools can help to determine which uncertain parameters have the most impact on a given index. According to this information, modifications can be done on the network (starting another power production in case of a lack of spinning reserve for example) to guaranty an acceptable margin stability.

Some experimentation on distributed energy facility will be achieved to prove the validity of the proposed methodology. An actual SCADA (supervisory control and data acquisition) system is available; it will supervise a real-time simulated weak grid included high level of wind turbine production. The algorithm of supervision will include statistical analysis to determine the optimal partition of spinning reserve on the base of experimental wind production profiles.

Scientific field: Electrical Power System, Probability,
Key words: spinning reserve, statistics, stability, renewable source
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[1] Reliability evaluation of power system with large-scale wind farm integration using First-Order Reliability Method, M. T. Do, J. Sprooten, S. Clenet, B. Robyns, Wind Chapter EPE, Trondheim (Norvege), mai 2011

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19) Characterisation of the variability of behaviour of bonded interfaces. Influence of microstructure and bonding defects

Structural bonding today offers a useful alternative to more classic methods of mechanical assembly. Amongst significant advantages are weight loss, and simplification and/or cost reduction of assembly procedures. Both advantages and disadvantages are recognised in this technique. Amongst the latter, we may mention low strength at high temperature and in deleterious physico-chemical conditions, the irreversible nature of bonded structures (as opposed to bolted systems which can be "undone") and difficulties associated with surface preparation prior to bonding. However, the main limitation to more widespread use of adhesives is lack of reliability, or rather, confidence in the final product, related to variability in results.

Several studies have been undertaken on this subject in the group Adhesion, Bonding & Assembly [Adhésion, Collage, Assemblage (ACA)] of the department DuMAS in the l'Institut de Mécanique et d'Ingénierie de Bordeaux. The first cause of variability identified is that of poor dimensioning of assemblies related to inadequate knowledge of stress criteria. Apart from necessitating the use of many tests to ascertain the complex behaviour of joints, results do not take into account failure started by defects and stress singularities (e.g. edges, corners, material discontinuity). In order to rectify these lacunae, we prefer to use to dimension by using damage tolerance as a criterion. Here, controlled propagation of already existing cracks allows better control of reliability. The second cause is natural variability of the adhesive properties (e.g. batch, production procedure). No rigorous method to control the consequence of this on final structures exists at present.

The present project aims to develop mechanical reliability tools to characterise and model the cracking of bonded structures. We are interested in systems well-known to us, for which much information has already been gathered. We intend to study cracking in modes I and II using DCB and ELS tests on aluminium (series 7000) bonded with filled epoxy resin adhesives. These bi-component adhesives are mixed manually, thus have random internal structure including porosity, whose impact has not yet been clearly identified.

Three scales will be investigated during this work. Firstly, we shall consider the scale of elementary volumes of the adhesive, for which homogenisation schemes will be used to relate microstructure and interface (interphase) behaviour. The following scale is that of crack propagation and cohesive zone models explaining adhesive strain behaviour in the crack front vicinity. Lastly, we shall consider fracture energy, relating it to data forthcoming from the finer scales.

This work will rely to some extent on existing data from our laboratory, but the candidate will have to extend, and reproduce, results to add to the library so that, with the permanent staff, better appreciation of effects of, e.g. bondline thickness, production procedure, porosity, can be obtained. For this study, mainly directed towards mechanical modelling, the candidate must present interest and ability in mechanical modelling and both analytical and numerical modelling. Good acquaintance with the mechanics of polymers, and particularly fracture mechanics, is prerequisite.

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20) Microstructure evolution and material flow characterization during the complete thixoforging process of a steel part

Thixoforging is a manufacturing process of metal alloys at semi-solid state. Semi-solid state is obtained by heating the material from the solid state, up to a temperature within the solidus-liquidus temperature range. The rheological behavior of the material at this temperature is highly dependent on the structure formed by the liquid and solid phases. For thixoforging, the liquid fraction is quite low, less than 20%. The liquid-solid structure characteristics are function of the alloy (chemical composition, as-received metallurgical structure…) and the heating. During forming, the liquid-solid structure undergoes quick modifications which correspond to rheological properties changings of the thixoformed material. These last ones are source of material flow heterogeneities and heterogeneities of the metallurgical structure within the thixoforged part. The solid fraction mainly depends on and is very sensitive to the temperature. For steel, a temperature variation of few Celsius degrees can lead to an increase or decrease of the liquid solid fraction corresponding to not negligibly different behavior. During thixoforging operation, thermal exchange between material and dies, the plastically dissipated energy are source of heterogeneity of the temperature field and of the associated behavior. The heterogeneity of the plastic strain and plastic strain rate fields may lead to important heterogeneity of the thixoforged microstructure.

The proposed subject is dedicated to the characterization of the evolution of the microstructure and the associated rheological behavior of the material during the thixoforging process. More precisely, from thixoforging testing on simple shape parts, with the help of simulation and using the experimental characterisation techniques, the projects consists in identifying the phenomena leading to the heterogeneization. The thixoforging testings could be performed with different alloys according to the future characterization. The main objectives of the research is to identify and characterize these phenomena in order to propose guidelines for thixoforged part and thixoforging process design.

Laboratory: Design, Manufacturing Engineering and Control Lab. (LCFC - EA 4495)
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PhD Proposals 2013 for China

21) Multi scale global forgeability study of the multi material

Context

To meet complex requirements and / or to achieve a compromise between performance and manufacturing cost, it is possible to manufacture a multi-material part. Generally, multi-material parts are obtained by joining processes such as fusion welding, friction welding or brazing, etc. The manufacturing process consists of the manufacturing of the different parts of the work-piece which will then be joined. Another common solution is to clad the work-piece surface with a material with improved surface properties. In all cases, the part design is strongly constrained by the geometric constraints of the joining process.
To partially solve this problem the idea is to reverse the conventional fabrication layout. The multi-material is joined first and then formed. Joining would be performed on simple geometry. The complex geometry of the multi-material part is reached thanks to the following forming process.

Objectives

The main idea of the proposed thesis is to study the global forgeability of multi-material. As the forgeability is an intrinsic charracteristic of any material therefore due to the difference in rheological properties at different positions of the workpiece, three levels of forgeability are considered:
- Micro scale, corresponding to the intrinsic forgeability of the different materials constituting the multi-material considered separately.
Meso scale, corresponding to the deformation behaviour of the structure consisting of the two materials and their interface. The interface geometry local geometry is important to be considered due to its possible wavy shape (fusion welding cladding, explosion cladding…)
- Macro scale, corresponding to the ability of a multi-material under forming to obtain a desired defect free material distribution and structure.

Methods

The proposed work is based on the study of a set of characterization tests:
-The upsetting test;
-The hot bending test
-The two-punch compression test
The methodology for the forgeability characterization consists in:
-Parametric forming experimental study
-Numerical simulation of the forming process
-Macrographic and micrographic metallurgical characterization of the obtained multi-material parts.
The results of the method are the identification of the phenomena limiting the forgeability domain of multi-material (limit of ductility, debonding of the interface ...). By comparing simulation and experiment (using inverse methods of optimization), the idea is also to obtain a constitutive behavior law of the coating. The simulation study of the entire process of forming including in particular the cooling stage should allow, by comparison with the results of the metallurgical characterization, to estimate the residual stresses obtained at the workpiece surface.
Expected results: Expected results of the study are, first, the identification of the key parameters of the forging of multi-material. In a second step, a methodology for characterizing the forgeability must be proposed and validated in the case of two applications (part shape, couple of materials and joining processes)

Laboratory: Design, Manufacturing Engineering and Control Lab. (LCFC - EA 4495)
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22) Quantitative assessment method and tool to measure environmental impacts of Eco-districts

Key words: Sustainable buildings, Thermal and environmental performance, Eco-districts

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Research Laboratories: I2M-Bordeaux (student location), Nobatek and School of Architecture

Eco-districts use a design process that combines urbanism, architecture and sustainable building; this initiative was started in northern Europe where there are now some benchmark projects (Hanover, Malmö, London, Freiburg, Stockholm), and many more operations have now been completed in countries all over Europe.

Research into this topic was started at the University of Bordeaux by the National School of Architecture and Landscaping of Bordeaux (ENSAPBx) and the research centre Nobatek, with a design process using Life Cycle Assessment (LCA) methods to evaluate impacts objectively.

The aim is to look beyond Europe to see how these procedures and these tools can be extrapolated; China is a particularly interesting case in point: in their megacities, experiments with "large districts" have been developed very recently which combine notions of "green" buildings and districts.

The research will consist of:

- Determining how the environmental characteristics of materials and building envelope components are assessed in China: what are the criteria? What methods are used and what is the LCA perimeter?
- Compiling an inventory of existing databases; in France we have the INIES database, and other software tools from America or northern Europe, to carry out our LCA.
- Are there specific environmental issues in China regarding building materials and envelope components? What are they? What actions are being undertaken? How do they make the transition from the LCA of a material to that of a building, then that of a district?
- How does Chinese building certification take this question into account (LCA materials / LCA buildings)?

The successful candidate will work within the Institut I2M, but in parallel he/she will also work at the Nobatek research centre which has many examples and applied studies available. Also to be considered is the participation of Nobatek and the Aquitaine Region in a Sustainable Urban Development project in Hubei province.

Nobatek: Resource Centre for sustainable building technologies: www.nobatek.com

Grace YEPEZ-SALMON, CONSTRUCTION D'UN OUTIL D'EVALUATION ENVIRONNEMENTALE DES ECOQUARTIERS : vers une méthode systémique de mise en œuvre de la ville durable. Doctorat Université Bordeaux, Décembre 2011

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PhD Proposals 2013 for China

23) Proposal of PhD subject in Fluid Mechanics

Supervisors: O. Coutier-Delgosha (olivier.coutier@ensam.eu), M. Marquillie (Laboratoire de Mécanique de Lille), M. Dular (Laboratory for Water and Turbine Machines, University of Ljubljana)

Location of work: main part at ENSAM Lille / partially at Laboratory for Water and Turbine Machines, University of Ljubljana

Title of the project: DNS and LES simulations of cavitating flows

Summary: Cavitation is the partial vaporization of a liquid in low pressure areas due to hydrodynamic effects such as local flow acceleration. In pumps, it leads to performance decrease and/or to perturbations due to the development of instabilities. Other problematic effects may occur, such as blade erosion after a long operating time, because of pressure waves initiated by the collapse of vapor bubbles. Instabilities also induce some large pressure fluctuations that may compromise the rotor equilibrium, or interact with the blade structure. In rocket engine turbopump inducers for example, unstable cavitation patterns are associated to significant vibrations, which have been found as plausible explanation for the failure of the Japanese launcher H-II in 1999.

Figure 1. Rocket engine inducer operating in cavitating conditions (LML laboratory, 2005)

Figure 2. Hydrogen inducer of Japanese launcher H-II (after the flight failure)

The PhD is devoted to the theoretical analysis and modelling of cavitating flows. Nowadays, the understanding of the physics of such flows, which involve simultaneously large density and compressibility variations, turbulence effects, and instabilities at various scales, is still beyond the current state of art. Indeed, numerical simulations of cavitation have only slightly evolved in the last 20 years, and the existing approaches do not presently provide the detailed information regarding the physical mechanisms that control the flow properties. The main reasons for this are i) the strong interaction between the biphasic and turbulence effects, which does not enable to improve separately the turbulence and cavitation models, ii) the lack of detailed experimental data to validate the simulations and discuss the efficiency of the models.

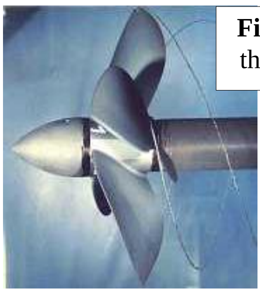

Figure 3. Vortex cavitation on the blades of a naval propeller

Figure 4. Developed cavitation in naval propeller

In the present project, a ground breaking scientific strategy is proposed to address this issue: it is based on i) innovative simulations with DNS and high resolution LES turbulence modelling associated with several cavitation models, ii) the recent development of original experimental techniques such as X-ray imaging, which have generated new appropriate data for validation of the numerical simulations. The basic idea is to separate the spurious effects of inappropriate turbulence models from the errors due to cavitation modelling, in order to assess the capability of different promising cavitation models to reproduce the structure and the dynamics of various cavitating flows.

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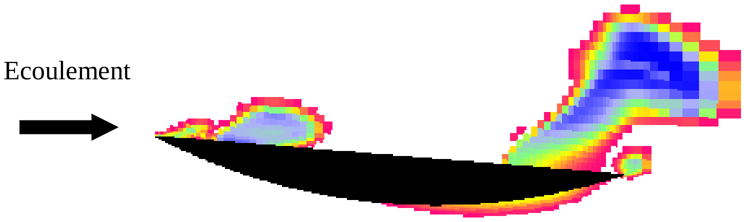


Figure 5 : Example of unsteady simulation of sheet cavity with a homogeneous model based on a barotropic law of state (the colours indicate the density, white for pure liquid and from red to blue when the void ratio increases)

Therefore, DNS simulations will be conducted in a configuration of small-scale flow that has been already used in the last years for the development of experimental techniques such as fast X-ray imaging or time-resolved LIF PIV. At such millimetric scale, moderate Reynolds numbers are obtained, which enables to perform challenging DNS simulations that will enable to get rid of errors related to the use of inappropriate RANS models. For this purpose, an existing code developed in the LML laboratory, providing highly resolved three-dimensional flow states, will be used. This numerical tool, which is based on multi-domain decomposition, high-order compact finite-differences in all three space-coordinates, and massively parallel implementation, will enable to perform as well DNS and LES simulations. Cavitation models will be i) homogenous approaches used presently, which require the knowledge of mixture properties, ii) bubble cloud models based on interaction laws between bubbles.

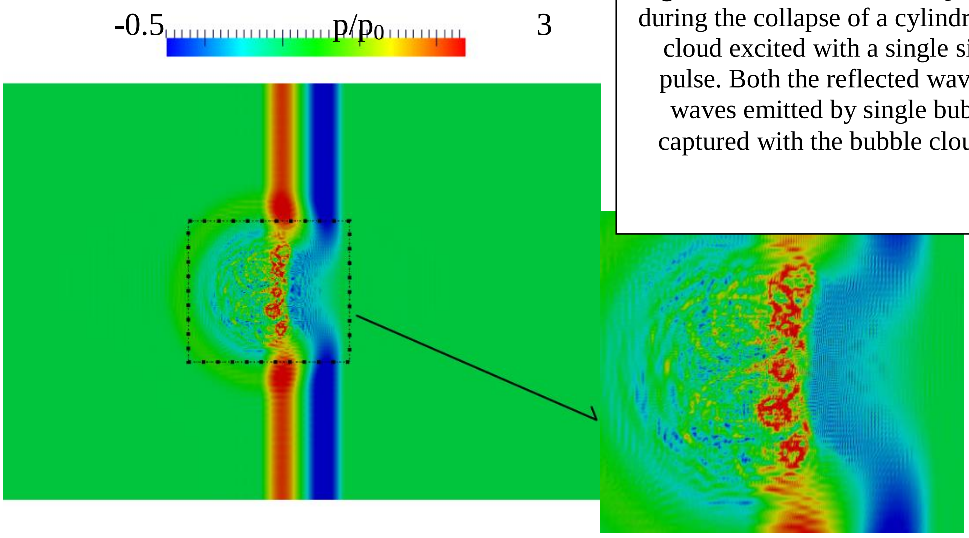
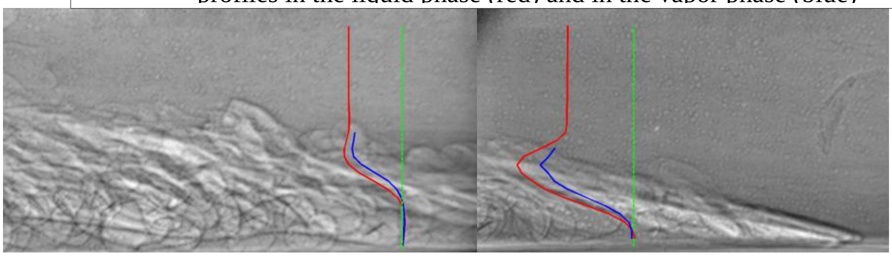


Figure 6 : Non-dimensional pressure field during the collapse of a cylindrical bubble cloud excited with a single sinusoidal pulse. Both the reflected wave and the waves emitted by single bubbles are captured with the bubble cloud model.

The validation of the results, in both cases, will be based on the comparison with the recent experimental data obtained in the same flow configuration, especially the time-resolved velocity fields in both phases, the time resolved local volume fraction of vapor, and the fast visualization of the flow structure. The objective is the characterization of the mechanisms that control the processes of vaporization and condensation, the momentum exchanges between the two phases, and the turbulent properties. In addition, comparisons between DNS and LES results should enable to develop an appropriate strategy for turbulence modelling in configurations of cavitating flows.

Figure 7. X-ray imaging of a cavitating flow in a Venturi type Section, and velocity profiles in the liquid phase (red) and in the vapor phase (blue)



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